# Regional Health Inequalities in Germany

A Spatial and Temporal Perspective of Individual and Contextual Factors of Health

Dissertation

zur

Erlangung des akademischen Grades
doctor rerum politicarum (Dr. rer. pol.)

der Wirtschafts- und Sozialwissenschaftlichen Fakultät
der Universität Rostock

vorgelegt von
Daniel Kreft, geb. 08.06.1984 in Rostock
Wohnhaft in Rostock

Rostock, 22. Juni 2017

https://doi.org/10.18453/rosdok_id00002804

| | |
|---|---|
| Erstgutachterin: | Prof. Gabriele Doblhammer<br>Universität Rostock |
| Zweitgutachter: | Prof. Oliver Razum<br>Universität Bielefeld |
| Disputation: | 13.12.2017 |

**Curriculum Vitae**

## PERSONAL INFORMATION

- Date of birth: June 8, 1984
- Place of birth: Rostock, Germany

## EDUCATION

- **Multinational PhD program in demography (DemoDoc)**
  University of Rostock / La Sapienza – Università di Roma
  2011-2013
- **Master of Science, Demography**
  University of Rostock, Germany
  Date of Graduation: September 2009
  Thesis: Health of Migrants in Germany. A Regional Analysis based on the Microcensus 2005 (grade: 1.3, “very good”)
- **Bachelor of Arts, Social Sciences**
  University of Rostock, Germany
  Date of Graduation: August 2007
  Thesis: Mortality Forecasts on the Level of “Kreise” in MV. A Study based on the Lee-Carter-Method (grade: 1.7, “good”)

## PROFESSIONAL / RESEARCH EXPERIENCE

- Since 2015 **University of Rostock / Rostock Center for the Study of Demographic Change**
  RESPONSE Project (Funded by the Federal Ministry of Education and Research)
  Research Assistant
- Since 2010 **University of Rostock**,
  Chair for Empirical Methods and Demography
  Junior Lecturer / Research Assistant
- Since 2009 **Rostock Center for the Study of Demographic Change**, Rostock
  Research Assistant
- 2009 **Federal Ministry of Economics and Technology**, Berlin
  Internal Project: The Impact of Demographic Change on Small- and Medium-sized businesses in the regions of MV
  Internship
- 2008/2009 **Max Planck Institute for Demographic Research**, Rostock
  Laboratory Policy and Population
  Student Assistant
- 2007 **Rostock Center for the Study of Demographic Change**, Rostock
  Research Project: Forecasts of mortality in MV
  Student Assistant

## PUBLICATIONS

- **Georges, D.; Kreft, D.; Doblhammer, G.** (forthcoming): The Contextual and Household Contribution to Individual Health Status in Germany: What is the Role of Gender and Migration Background? In: Gumà, J.; Doblhammer, G. (Eds.) (forthcoming): Family and Health from a Gender Perspective in Europe. Springer Brief.

- **Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)** (2016): Regionale Disparitäten in Deutschland auf der Ebene von Gemeinden und Kreisen. Expert's report by S. Maretzke and D. Kreft for the seventh Altenbericht der Bundesregierung. Editors: Block, J., Hagen, C. and Berner, F. Berlin: Deutsches Zentrum für Altersfragen.

- **Kreft, D.; Doblhammer, G.** (2016): Expansion or compression of long-term care in Germany between 2001 and 2009? A small-area decomposition study based on administrative health data. Population Health Metrics 14: 24. DOI 10.1186/s12963-016-0093-1.

- **Kreft, D.** (2014): Spatial Patterns in German Long-term Care and their Relationship with Socioeconomic Factors. In: Doblhammer, G. (Ed.) (2014): Health among the Elderly in Germany: New Evidence on Disease, Disability and Care Need. Series on Population Studies by the Federal Institute for Population Research, Volume 46, Opladen, Berlin, Toronto: Barbara Budrich.

- **Kreft, D.; Doblhammer, G.** (2012): Contextual and individual determinants of health among Aussiedler and native Germans. Health & Place 18 (5): 1046–1055. DOI: 10.1016/j.healthplace.2012.05.008

- **Doblhammer, G.; Kreft, D.; Dethloff, A.** (2012): Gewonnene Lebensjahre. Langfristige Trends der Sterblichkeit nach Todesursachen in Deutschland und im internationalen Vergleich, Bundesgesundheitsblatt, 55: 448-458. Doi: 10.1007/s00103-012-1455-x

- **Doblhammer, G.; Kreft, D.** (2011): Länger leben, länger leiden? Trends in der Lebenserwartung und Gesundheit. Bundesgesundheitsblatt, 54: 907-914. DOI: 10.1007/s00103-011-1315-0

- **Scholz, R. D.; Rößger, F.; Kreft, D.; Steinberg, J.; Doblhammer-Reiter, G.** (2011): Bevölkerungsprognose für Mecklenburg-Vorpommern auf Kreisebene bis zum Jahr 2030 (Population forecasts for Mecklenburg-Western Pomerania on the level of „Kreise“ till the year 2030). In: Ross-Strajhar, G. (Ed.): GESIS-IZ Sozialwissenschaften: Bevölkerungsforschung. Bonn: GESIS-IZ Sozialwissenschaften.

- **Steinberg, J.; Kreft, D.; Ziegler, U.; Doblhammer, G.** (2010): Home care arrangements in Europe. Determinants and quality of life. DemoNet report, Den Haag/Brussels.

- **Doblhammer, G.; Kreft, D.** (2010): Trends and Patterns in Life Expectancy in Europe, 2010 Update. DemoNet report, Den Haag/Brussels.

- **Doblhammer, G.; Kreft, D.** (2010): Trends and Patterns in Causes of Death in Europe, 2010 Update. DemoNet report, Den Haag/Brussels.

- **Van der Erf, R.; Kreft, D.; Doblhammer, G.; Van Nimwegen, N.** (2010): Policy Challenges of Demographic Change for European Regions and Cities. Projecting and benchmarking sub-national demographic trends in Europe on the basis of regional and local data sources, DemoNet report, Den Haag/Brussels.

- **Doblhammer, G.; Muth, E.; Kreft, D.** (2009): Trends and Patterns in Life Expectancy in Europe, DemoNet report, Den Haag/Brussels.

- **Doblhammer, G.; Muth, E.; Kreft, D.** (2009): Trends and Patterns in Causes of Death in Europe, DemoNet report, Den Haag/Brussels.

## Eidesstattliche Versicherung

Ich erkläre hiermit, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht.

Die Arbeit wurde bisher weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer Prüfungsbehörde zur Erlangung eines akademischen Grades vorgelegt.

Rostock, 22. Juni 2017

Daniel Kreft

## Acknowledgements

After an intensive period, today is the day: writing this note of thanks is the finishing touch on my dissertation. It has been a period of intense learning for me, not only in the scientific arena, but also on a personal level. Writing this dissertation has had a big impact on me. I would like to reflect on the people who have supported and helped me so much throughout this period.

Firstly, I would like to express my sincere gratitude to my advisor Prof. Gabriele Doblhammer for the continuous support of my dissertation and related research, for her patience, motivation, and immense knowledge. She promoted to develop my scientific and professional skills in an encouraging context, while she always has a sympathetic ear for new research ideas. Her guidance helped me in all the time of research and writing of this dissertation. At all times, she provided me time to evolve new research questions, ideas to solve them, and to realise their implications and methodological problems. This allows me to stepwise increase my scientific self-reliance and confidence.

Besides my advisor, I would like to thank Prof. med. Oliver Razum for accepting the role of co-supervisor of my thesis. Since his research has an inspiring effect on my own research, I appreciate his interest in my dissertation.

My sincere thanks also go to Prof. Nadja Milewski, Prof. Viviana Egidi, Dr. Eva Kibele, and Dr. Sebastian Klüsener, who provided me insightful comments and raised my methodological, health-geographical and epidemiological knowledge that incited me to widen my research from various perspectives.

I must further express my very profound gratitude to Till Wollenberg for providing me with unfailing support - in particular for dealing with technical problems - and continuous encouragement throughout my years of study and through the process of researching and writing this dissertation. This accomplishment would not have been possible without him. Thank you.

In addition, I am grateful to the reviewers of my papers, Rainer Unger, Michael Krämer and all the anonymous reviewers, for their helpful and valuable comments and suggestions, and - of course - for finally recommending to accept the papers for publication to the journal editors.

I specially thank all my long-time colleagues and friends for the encouraging and stimulating discussions, for the dissipations of doubts and stress, and for all the fun we have had during

my time as a PhD student and as a research assistant at the chair for empirical social research and demography.

Last but not the least, I would like to thank my family: my parents, my sisters, my grandparents, my aunts and uncles and their children for continuously supporting me throughout writing this dissertation and my life in general. Unfortunately, the good soul of my family and one of my greatest supporters, my beloved grandmother Helga, does not see this personally memorable day; however I am sure that she would be very proud as she was unswervingly proud of and supportive towards her children, grandchildren and grand grandchildren. Thank you very much, grandma!

Daniel Kreft

Rostock, 22. Juni 2017

## Summary

Health and well-being are major resources of the individuals and the society. Further, individual and public health is a temporally changing status and is influenced by various individual and contextual factors. Since there are differences in the extent to how individual and contextual factors and their complex interplay affect the health states of the individuals, health inequalities occur. These health inequalities are one of the causes of future inequalities in other dimensions of individuals' lives or of the regions. With one of the oldest health security systems in the world, Germany is an excellent setting to evaluate health disparities on an individual and small-area level. Furthermore, the country has experienced many socio-political transitions on small- and medium-area-levels in history and has performed a unique integration policy towards a special group of migrants, the ethnic German migrants also called Aussiedler.

***Health from a spatial perspective:*** The major outcome of this thesis is the detection and identification of profound spatial inequalities. These inequalities differ by the level of spatial aggregation, the selected health indicator, the birth cohort, but only partly by sex. The inequalities are exposed by using established population health measures which depict disparities in an absolute (prevalence, life years with and without care need), relative (Health ratio, odds ratio, risk ratio), or theory-driven perspective (health scenarios).

Concerning the comparison of the influence of individual factors with the influence of contextual factors, the results of the thesis indicate that the health disparities between individuals are far higher than the health disparities between the investigated spatial entities. This may be an indication for the high efficacy of the health care and social security systems in the welfare states. The major cause of inter-individual inequalities in health is the socioeconomic and behavioural individual factors. However, there are also health disparities of the same birth cohorts apart from individual factors. This may relate to the role of health influences (on individual and contextual level) in the young or middle ages of the nowadays elderly population. Thus, assuming a homogenous population of persons at higher ages ignores a high level of health inequalities of persons within a spatial context and between spatial contexts.

The thesis states the effects of socioeconomic characteristics of the regions in terms of both, context and composition. Living in a wealthier region is linked to lower risk of care need or longstanding illness. These conclusions are consistent for both sexes, native Germans and Aussiedler, and persons in the West German regions. For the persons in the East German regions, the effects of socioeconomic context were less pronounced. Factors of social diversity, as well as factors of the health structure show no contextual effects - except of health structure measured by premature mortality on persons in the East German counties. The

variation of premature mortality is higher in the Eastern part due to the spatial varying pace in the historical unique transition (e.g. of the economy and medical technology) in the 1990s and the consequences (e.g. on life style). Urbanity was shown to have a significant, but contrary effect on longstanding illness and care need. The thesis shows a lower risk of care need, but a higher risk of longstanding illness for populations in urbanised regions. This may be the consequence of confounding health effects due to divergent etiological pathways or migration and mortality selection effects.

Aussiedler are a group of persons, who entered within their life time into a new context in terms of socioeconomic conditions, social and cultural norms, values and tolerance, policy regulations, health infrastructure, health-relevant behaviours and various other dimensions. The results of the investigation of the health of Aussiedler show no health disadvantage in the years after the in-migration, but a worse health of Aussiedler with a longer duration of stay. This finding supports the assumption of health deterioration caused by problems with the integration in the labour market, the health care system and the society.

***Health from a temporal perspective:*** The present health situation is a consequence of a complex interplay of influencing factors in the present and the past. An essential conclusion of the thesis is that 1) there is a high heterogeneity of trends in the absolute and relative perspective, 2) there is a partly inconsistent trend in any and severe care level, and 3) there is a higher impact of mortality on absolute change in healthy and unhealthy life time, contrasted by a higher impact of prevalence of care need on the chance to experience a compression of morbidity.

The thesis states different temporal trends in care need among the counties within Germany, they also vary by the severity of care need. While the majority of the county populations show a relative expansion in any care level, there are also counties that experience stability or compression. In instances of severe care level, there is also a high variation among the counties, indicating spatially divergent temporal health trends.

By combining the trends in both care levels, there is a huge group of counties with a very unfavourable trend in care need with an expansion in any and severe care level. The most favorable trend can be found for a smaller, but still large group of counties with compression in any and severe care need. Another large group of counties showed a gain in care need of any care level but a reduction in severe care. This partly favourable trend is described as a dynamic equilibrium and indicates a positive shift from severe to less severe disability in a population. Counties with the most unfavourable trends are concentrated in the North East of Germany for males and in the centre of Germany for females. The most favourable trends show counties in the very North, the West and the South of Germany in both sexes.

The thesis further shows that the higher longevity also results in a prolonging of the life span with care need. With the exception of a few counties, there are higher gains in life years without care need than in life years with care need due to the mortality reductions. However, the reductions in the prevalence was too low (or non-existing) for the majority of counties to compensate for the survival gains. Nevertheless, the health scenarios of the populations within the counties are highly sensitive to marginal changes in the prevalence. Health policy interventions concerning early prevention and efficient treatments may be introduced to influence the future increase in the prevalence.

The findings indicate a complex interference of etiological and epidemiological processes and present interfering, mediating, and suppressing contextual effects. The trends are assumed to be the results of divergent historical and social developments and changes that indirectly affect the behaviour, the psycho-social capacity, and the material situation within the life course of individuals. These influences have unequal impacts on moderate morbidity than on severe morbidity. Continuing processes of selectivity due to mortality and migration affect the populations' composition of the counties and thus, since severe care need is concentrated at the highest ages, spatial varying mortality selection has a higher impact on severe care level than on any care level.

The thesis therefore provides new insights into some aspects of health inequalities from a spatial and temporal perspective. However, further investigations are needed to uncover the underlying mechanisms of healthy ageing, and to understand the causes and to deal with the consequences of the increasing heterogeneity and the ongoing process of ageing of the societies in the welfare states and their regions.

## Zusammenfassung

Gesundheit und Wohlbefinden sind wichtige Ressourcen des Einzelnen und der Gesellschaft. Darüber hinaus ist Gesundheit in individueller wie in gesellschaftlicher Perspektive ein zeitlich veränderlicher Zustand und ist beeinflusst durch zahlreiche individuelle und kontextuelle Faktoren. Da es Unterschiede im Ausmaß des Einflusses und des komplexen Zusammenspiels von individuellen und kontextuellen Faktoren auf die Gesundheit des Einzelnen gibt, werden gesundheitliche Ungleichheiten erzeugt. Diese gesundheitlichen Ungleichheiten sind eine der Ursachen für zukünftige Ungleichheiten in Hinsicht auf andere Dimensionen des persönlichen Lebens oder einzelner Regionen. Mit einem der weltweit ältesten Gesundheitssysteme ist Deutschland ein exzellentes Forschungsfeld, um gesundheitliche Unterschiede auf individueller und kleinräumiger Ebene zu untersuchen. Außerdem hat das Land in seiner Geschichte zahlreiche sozio-politische Transformationen auf kleinst- und kleinräumlicher Ebene erlebt und ist gekennzeichnet von einer einzigartigen Integrationspolitik gegenüber einer speziellen Gruppe von Migranten, den (Spät-)Aussiedlern.

***Gesundheit aus der räumlichen Perspektive:*** Ein Hauptergebnis der Dissertation ist das Aufdecken von ausgeprägten räumlichen Ungleichheiten. Diese Ungleichheiten unterscheiden sich nach dem Niveau der territorialen Aggregation, den ausgewählten Gesundheitsindikatoren, der Geburtskohorte, jedoch nur gering zwischen den Geschlechtern. Die Ungleichheiten wurden aufgedeckt, da etablierte gesundheitswissenschaftliche Methoden und Maßzahlen verwendet wurden, die Ungleichheiten sowohl in absoluter (Prävalenz, Lebensjahre mit und ohne Pflegebedarf) und in relativer (Gesundheitsratio, Odds Ratio, Risk Ratio) als auch in theoriebasierter Perspektive (Gesundheitsszenarien) abbilden können.
Der Vergleich des Einflusses von individuellen Faktoren mit dem Einfluss von kontextuellen Faktoren in dieser Dissertation zeigt, dass die gesundheitlichen Unterschiede zwischen den einzelnen Individuen größer sind als die Gesundheitsunterschiede zwischen den untersuchten Regionen. Dies kann interpretiert werden als ein Anzeichen für eine hohe Effizienz des Gesundheits- und Sozialsystems in den Wohlfahrtsstaaten. Hauptursachen für interindividuelle gesundheitliche Ungleichheiten sind sozioökonomische und verhaltensbezogene individuelle Faktoren. Jedoch bestehen auch Gesundheitsungleichheiten gleicher Geburtskohorten unabhängig von individuellen Faktoren. Dies deutet auf die Bedeutung von gesundheitlichen Einflüssen (auf individueller und kontextueller Ebene) in den jungen und mittleren Lebensjahren auf die nun ältere Bevölkerung hin. Daher ignoriert die Annahme einer homogenen Bevölkerung im höheren Alter die Tatsache, einer hohen gesundheitlichen Ungleichheit von Personen innerhalb eines regionalen Kontextes und zwischen verschiedenen regionalen Kontexten.

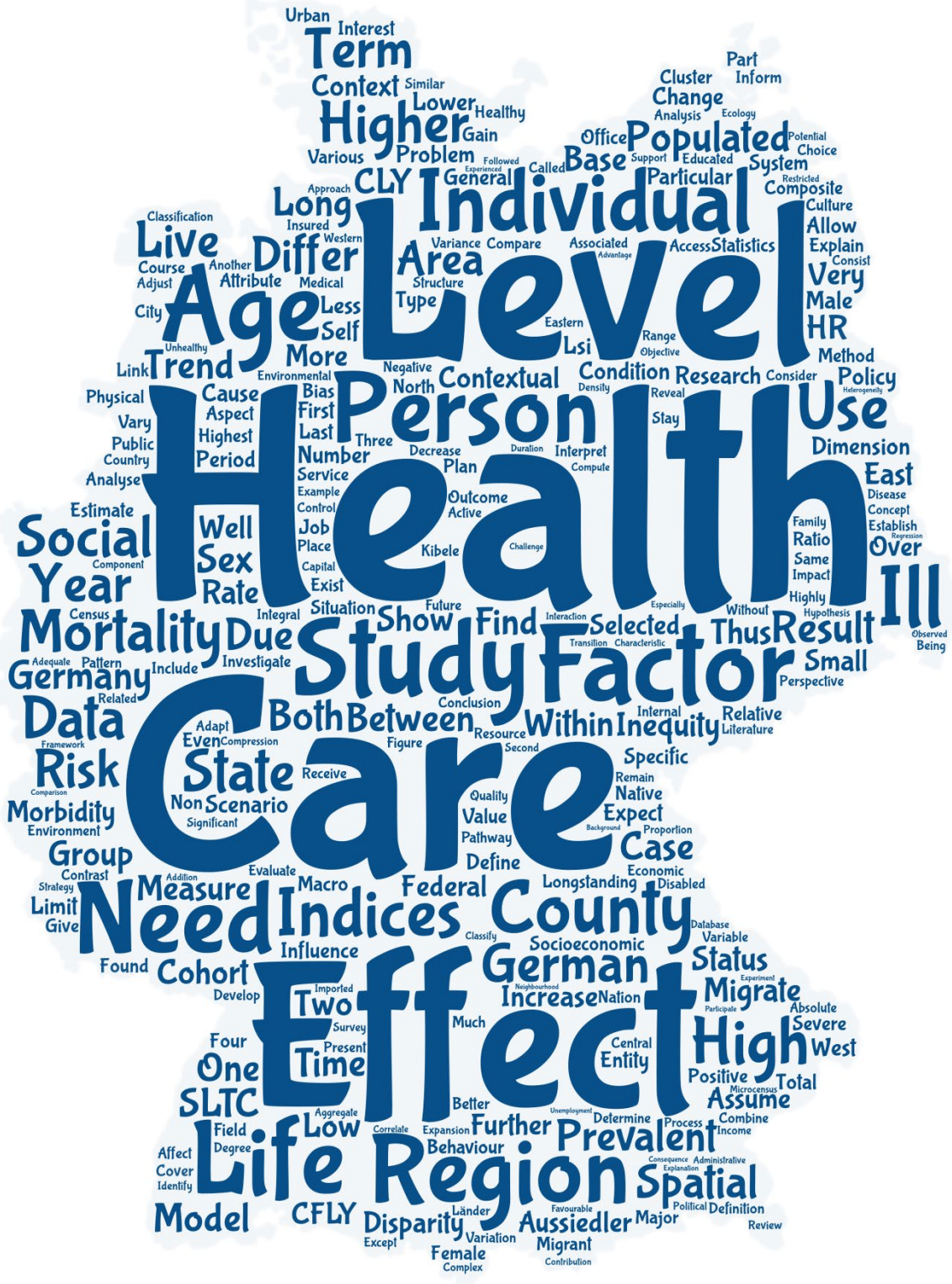
Die Dissertation zeigt Effekte sozioökonomischer Merkmale der Regionen in Bezug auf Kontext und Komposition. In einer wohlhabenden Region zu leben, ist verbunden mit einem geringeren Risiko für Pflegebedarf und langandauernde Krankheit. Diese Ergebnisse sind für beide Geschlechter, Deutsche ohne Migrationshintergrund und Aussiedler sowie für Personen in westdeutschen Regionen nachweisbar. Für Personen in ostdeutschen Regionen sind die Effekte des sozioökonomischen Kontexts weniger stark ausgeprägt. Faktoren der sozialen Diversität und Faktoren der Gesundheitsstruktur zeigen keine kontextuellen Einflüsse – außer der Gesundheitsstruktur - gemessen mittels vorzeitiger Sterblichkeit - auf die Personen in ostdeutschen Regionen. Die Variation der vorzeitigen Sterblichkeit ist höher im östlichen Teil aufgrund des regional unterschiedlichen Tempos in der historisch einzigartigen Transformation (z.B. der Wirtschaft und der medizinischen Technologie) und ihrer Auswirkungen (z.B. auf den Lebensstil) in den 1990ern. Urbanität zeigt einen signifikanten, aber gegensätzlichen Effekt auf langandauernde Krankheit und Pflegebedarf. Die Dissertation weist ein geringeres Risiko von Pflegebedarf, aber ein höheres Risiko von langandauernder Krankheit bei Bevölkerungen in urbanen Regionen nach. Dies können die Konsequenzen von konfundierenden gesundheitlichen Effekten aufgrund von unterschiedlichen ätiologischen Verläufen und selektiven Effekten von Migration und Sterblichkeit sein.
Aussiedler sind eine Gruppe von Personen, die im Verlauf ihres Lebens in einen neuen Kontext in Bezug auf die sozioökonomischen Bedingungen, die sozialen und kulturellen Normen, Werte und Toleranz, die politischen Rahmenbedingungen, die gesundheitliche Infrastruktur, die gesundheitsrelevanten Verhaltensweisen und verschiedene weitere Dimensionen eingetreten sind. Die Ergebnisse der Untersuchungen der Gesundheit von Aussiedlern zeigen, dass es keinen gesundheitlichen Nachteil in den Jahren nach der Einwanderung, aber eine schlechtere Gesundheit von Aussiedlern mit höherer Aufenthaltsdauer gibt. Diese Ergebnisse unterstützen die Annahme der Gesundheitsverschlechterung aufgrund von Problemen bei der Integration in den Arbeitsmarkt, in das Gesundheitssystem und die Gesellschaft.

***Gesundheit aus der zeitlichen Perspektive:*** Die derzeitige gesundheitliche Situation ist die Konsequenz des komplexen Zusammenspiels von Einflussfaktoren in der Gegenwart und in der Vergangenheit. Eine essentielle Schlussfolgerung der Dissertation ist, 1) dass es eine hohe Heterogenität der Trends in absoluter und relativer Perspektive, 2) dass es teilweise inkonsistente Trends im Pflegebedarf allgemein und von schwerem Pflegebedarf und 3) dass es einen höheren Einfluss von Sterblichkeit auf die absolute Veränderung der gesunden und der ungesunden Lebenszeit gibt, wohingegen die Prävalenz von Pflegebedarf einen höheren Einfluss auf die Chance hat, eine Kompression der Morbidität zu erreichen.
Die Dissertation zeigt unterschiedliche zeitliche Trends des Pflegebedarfs in den Kreisen innerhalb Deutschlands, die wiederum nach dem Schweregrad des Pflegebedarfs variieren.

Während die Mehrheit der Bevölkerungen in den Kreisen eine relative Expansion im Pflegebedarf allgemein erfahren hat, gibt es ebenfalls Kreise, die eine Stabilität oder eine Kompression aufweisen. Im Fall von schwerem Pflegebedarf zeigt sich eine starke Variation zwischen den Kreisen, was auf regional unterschiedliche zeitliche Gesundheitstrends hindeutet.
Durch die Kombination der Trends beider Schweregrade zeigt sich eine große Gruppe von Kreisen mit dem unvorteilhaften Trend von einer Expansion im Pflegebedarf allgemein und von schwerer Pflege. Der vorteilhafteste Trend kann für eine kleinere, aber immer noch große Gruppe von Kreisen gefunden werden, die eine Kompression im Pflegedarf allgemein und beim schweren Pflegebedarf erlebte. Eine weitere große Gruppe von Kreisen zeigt einen Anstieg des allgemeinen Pflegebedarfs, aber eine Reduktion von schwerem Pflegebedarf. Dieser teilweise vorteilhafte Trend kann als dynamisches Gleichgewicht beschrieben werden und ist gekennzeichnet durch eine Verschiebung von schwerem hin zu weniger schwerem Pflegebedarf in einer Bevölkerung. Kreise mit den unvorteilhaftesten Trends sind bei den Männern konzentriert im Nordosten von Deutschland und bei den Frauen im Zentrum Deutschlands. Die vorteilhaftesten Trends für beide Geschlechter zeigen Kreise im äußersten Norden, im Westen und Süden von Deutschland.
Die Dissertation zeigt weiterhin, dass eine höhere Lebenserwartung zu einer Verlängerung der Lebensspanne mit Pflegebedarf führt. Außer für wenige Kreise sind die Zuwächse an Lebensjahren ohne Pflegebedarf aufgrund der Sterblichkeitsreduktion größer als die Zuwächse an Lebensjahren mit Pflegebedarf. Aber die Reduktionen in der Prävalenz für die Mehrheit der Kreise waren zu gering (oder nicht vorhanden), um die allgemeinen Lebensjahrzugewinne zu kompensieren. Die Gesundheitsszenarien der Bevölkerungen in den Kreisen hingegen sind sehr sensibel gegenüber auch marginalen Veränderungen der Prävalenz. Gesundheitspolitische Interventionen, die auf die Prävention und effiziente Behandlung abzielen, könnten eingeführt werden, um einen zukünftigen Anstieg in der Prävalenz zu beeinflussen.
Die Ergebnisse deuten auf ein komplexes Zusammenspiel von ätiologischen und epidemiologischen Prozessen und derzeitigen interferierenden, mediierenden und überlagernden kontextuellen Effekten hin. Es kann angenommen werden, dass die Trends das Ergebnis von verschiedenen historischen und sozialen Entwicklungen und Veränderungen sind, die indirekt das Verhalten, die psychosoziale Kapazität und die materielle Lage innerhalb des individuellen Lebenslaufs beeinflussen. Diese Einflüsse haben ungleiche Auswirkungen auf moderate und schwerwiegende Morbidität. Ein kontinuierlicher Prozess von Selektivität aufgrund von Sterblichkeit und Migration beeinflussen die Zusammensetzung der Bevölkerung der Kreise und folglich hat, da der schwere Pflegebedarf vor allem im hohen Alter konzentriert ist, die räumlich variierende Sterblichkeitsselektion eine größere Bedeutung für schweren als für moderaten Pflegebedarf.

Die Dissertation verschafft neue Einblicke in ausgewählte Aspekte von gesundheitlichen Ungleichheiten aus einer räumlichen und zeitlichen Perspektive. Jedoch ist weitere Forschung notwendig, um die unterliegenden Mechanismen gesunder Alterung aufzudecken, deren Ursachen zu verstehen und mit den Konsequenzen zunehmender Heterogenität und des kontinuierlichen Prozesses der Alterung der Gesellschaft in den Wohlfahrtsstaaten und deren Regionen umzugehen.

## Spatial Abstract



## List of figures

# List of tables

## List of abbreviations

| | |
|---|---|
| ADL | Activities of daily living |
| B | Berlin |
| BB | Brandenburg |
| BV | Bavaria |
| BW | Baden-Wurttemberg |
| CFLY | Care need-free life years |
| CLY | Life years with care need |
| EMA | Ecological model of ageing |
| FRG | Federal republic of Germany |
| GALI | Global activity limitations |
| GDP | Gross domestic product |
| GDR | German Democratic Republic |
| HE | Hesse |
| HR | Health ratio |
| IADL | Instrumental activities of daily living |
| ICD | International classification of diseases |
| INKAR | Indikatoren und Karten zur Raumentwicklung in Deutschland und Europa (Indicators and maps of the spatial development in Germany and Europe) |
| IQR | Interquartile range |
| LS | Lower Saxony |
| LSI | Longstanding illness |
| MOR | Median Odds Ratio |
| MV | Mecklenburg Western-Pomerania |
| NRW | North Rhine-Westphalia |
| PP | Percentage points |
| RLP | Rhineland-Palatinate |
| RR | Risk ratio |
| SA | Saxony-Anhalt |
| S | Saxony |
| SH | Schleswig-Holstein |
| SL | Saarland |
| SLTC | Statutory Long-Term Care |
| TH | Thuringia |
| WHO | World Health Organisation |

## List of studies

**Study 1 ©:**

Kreft, Daniel; Doblhammer, Gabriele (2012): Contextual and individual determinants of health among Aussiedler and native Germans.
Health & Place 18 (5): 1046–1055. DOI: 10.1016/j.healthplace.2012.05.008

Contributions:
Daniel Kreft designed the study, acquired the data, carried out the analysis, and wrote the first version of the manuscript. Gabriele Doblhammer helped in the design of the study and revised the manuscript. Both authors read and approved the final manuscript.

**Study 2 ©:**

Kreft, Daniel (2014): Spatial Patterns in German Long-term Care and their Relationship with Socioeconomic Factors.
In: Doblhammer, Gabriele (Ed.) (2014): Health among the Elderly in Germany: New Evidence on Disease, Disability and Care Need. Series on Population Studies by the Federal Institute for Population Research, Volume 46, Opladen, Berlin, Toronto: Barbara Budrich.

**Study 3 ©:**

Kreft, Daniel; Doblhammer, Gabriele (2016): Expansion or compression of long-term care in Germany between 2001 and 2009? A small-area decomposition study based on administrative health data.
Population Health Metrics 14: 24. DOI 10.1186/s12963-016-0093-1

Contributions:
Daniel Kreft designed the study, acquired the data, carried out the analysis, and wrote the first version of the manuscript. Gabriele Doblhammer helped in the design of the study and revised the manuscript. Both authors read and approved the final manuscript.

**Study 4:**

Kreft, Daniel: Spatial inequalities in cohort-specific prevalence of care need and longstanding illness on small- and medium-area level in Germany. A multilevel trend study using the German Microcensuses 2005 and 2009.

## Contents

# I. Introduction

## 1. Health in the course and the context of life

### Health as personal and societal capital

Health and well-being are a major resource within the individual life course but also from a societal perspective. Individual and public health is a fluent changing status over time that is influenced by various factors of individual attributes or characteristics of the living environment. Since different individual and contextual factors and their complex interplay affect the health states of the individuals to varying extents, health inequalities occur. These inequalities themselves cause future inequalities in other dimensions of the individuals' life or of the conditions in the living environments.

From the individual perspective, the life course is affected by continuing processes of decisions, experiences, and behaviours of the individuals that further have direct and indirect consequences on various dimensions of life. Since the individuals are incorporated into social groups on different level of aggregation, from partnership, family, households, networks of friends, neighbourhoods to regions and nations, the life course of individuals is determined by the conditions within these aggregates, their changes and cross-level interactions. These short-term acute or long-term enduring contextual influences mediated by personal capacities and resources cause inter-individual disparities in attributes such as socioeconomic or health status. Of particular interest in this field is the effect of transitions between different contexts, the influence of policy on the context and the role of the social context in terms of discrimination and segregation. These aspects can be observed by analysing the health of international migrants.

From the societal perspective, investigating health inequalities is of further relevance. Various behavioural changes, medical improvements, and enhancements in socioeconomic conditions within the last decades have initiated the historic-exceptional increase in longevity. One of the main challenges in aging societies is to ensure healthy aging and to diminish health inequalities between the individuals and the particular living regions. Since the contextual conditions and selective in- and out-migration have varying effects on the composition of the populations within the regions, the magnitude and the pace of the increase in longevity and thus in the population at the old and oldest ages differ between the regions. Disability and functional limitations, degenerative disorders and diseases, such as sensory disorders, neoplasm, and mental and behavioural disorders, as well as diseases of the circulatory system, the musculoskeletal system and the nervous system, are highly concentrated at these highest age groups.

### Germany and its regional health inequalities

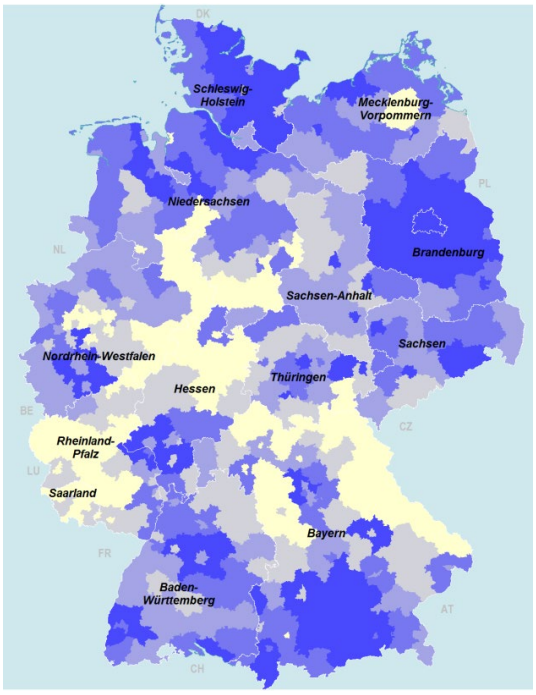
Germany is one of the countries with the oldest health security systems in the world. It has experienced multiple socio-political transitions in the past on small- and medium-area-levels and has performed a unique integration policy towards a very special group of migrants, the ethnic German migrants also called Aussiedler, it is an excellent setting to evaluate health disparities on individual and small-area levels.

Life expectancy at birth increased in Germany from 81.22 to 83.06 years and the life expectancy at age 65 increased from 19.55 to 20.90 years in the period 2002 to 2015 (Federal statistical office, 2017). As a consequence of this increase, the number of persons at age 65 and older has increased by 19.8% from a proportion of 17.5% to 21.1% of the total German population. This increase in the population is not equal for all German regions. There is a higher pace of population ageing in the past and assumed for the future in the Northern regions and large parts of Bavaria and Baden-Wurttemberg.

Disability is of special interest for health research, since it is associated with a high physical burden of the disabled, a high psychological burden of the relatives and financial burden of the health care system. Disability measures a very high level of restrictions in quality of life and of dependence from support of caregivers. Since care need is highly concentrated at the highest ages, early/earlier life conditions, long-term contextual influences and selection effects due to mortality and migration causes higher heterogeneity within and among the regions' elderly populations than for less severe health problems. The health system of Germany is an example of an established welfare system facing the challenge of old-age disability by the introduction of a regulation for evaluation of care need and for supporting the persons in care need and their relatives by financial benefits and care assistance. As a policy regulated, severe dimension of morbidity, care need is of particular interest in this thesis.

Within the last decade and as a result of the gains of persons at older ages, the overall prevalence of care need also increased in Germany. In 1999, the prevalence was 2.5% (2.0 million persons) for Germany in total and increased to 3.3% (2.6 million persons) in 2013. This is an increase of 30% over the period. Further, the gains differ by the federal states. The highest absolute increases were experienced in Brandenburg (59%) and Mecklenburg-Western Pomerania (60%), while Bavaria (12%) and Schleswig-Holstein (9%) showed profoundly lower increases in the same period. As a consequence, there is also a high variation in the overall prevalence on the level of the federal states with the lowest value (2.6%) stated for Bavaria and the highest value (4.5%) found for Mecklenburg-Western Pomerania (Federal statistical office, 2017).

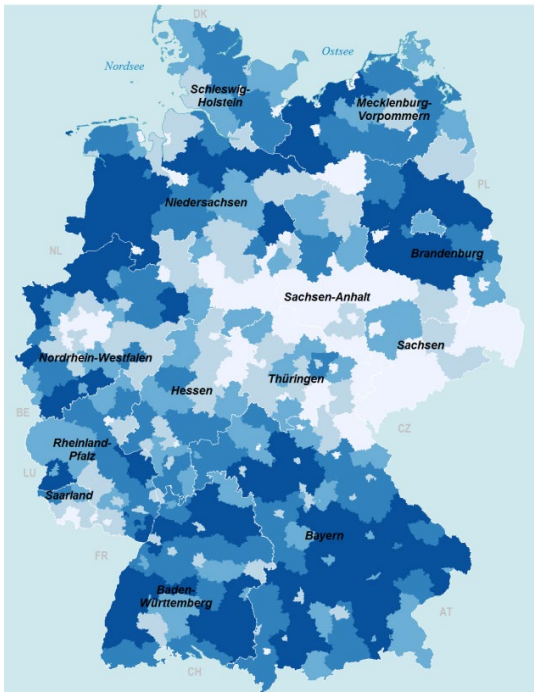
*Figure 1: Past and future change in population at age 65 and above by the counties in Germany*




**Change in population at age 65%**
**2005-2010**

- Under 2.1%
- 2.1% to under 4.3%
- 4.3% to under 5.9%
- 5.9% to under 9.2%
- 9.2% and more

(INKAR 2012, National Statistical Office, BBSR)




**Change in population at age 65%**
**Projection 2009-2030**

- Under 21.8%
- 21.8% to under 29.9%
- 29.9% to under 38.6%
- 38.6% to under 45.3%
- 45.3% and more

(INKAR 2012, Population projection by BBSR)

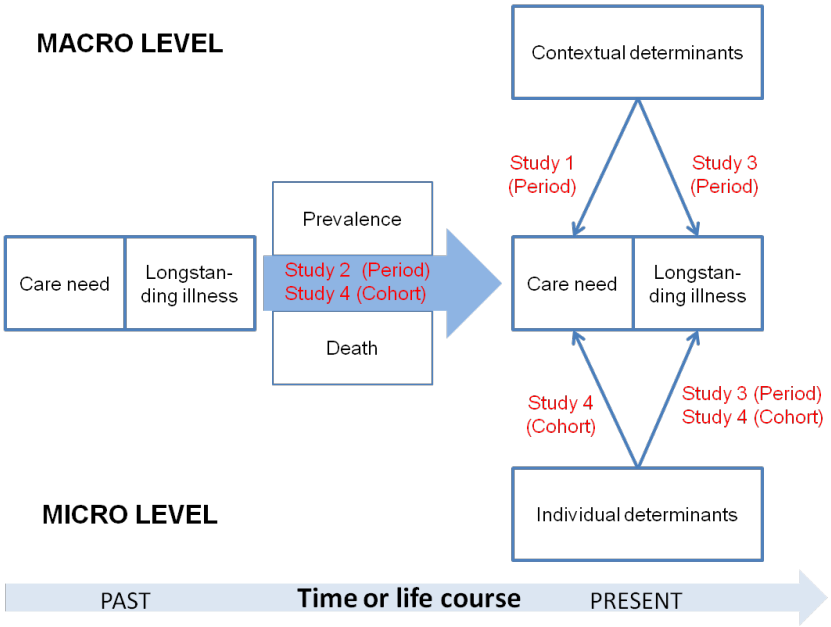
By comparing the trends in ageing and in care need between and within the federal states Schleswig-Holstein and Mecklenburg-Western Pomerania (Figure 1), there is a profound indication that the increase in the share of older persons is not the exclusive driver of a higher prevalence in morbidity. The populations of both states show a very similar pace of ageing, but a very high disparity in the magnitude and increase in the prevalence of care need. Thus, the role of contextual and compositional influences on the health situation becomes obvious.

## The concept of the thesis

The thesis is a cumulative work of four studies from which two are already published in international research journals and one is part of a book consisting of peer-reviewed articles. The fourth study - an extension of the investigations of study 2 - has not been published at the time of the submission of the thesis. The four studies have the main objective of gaining deeper insights into the extent, the pattern, the determinants and the temporal changes of health inequalities from a small-area perspective.

Figure 2 depicts the investigated linkages of the individual and contextual determinants of health by the four studies. In study 1, contextual effects on care need are investigated in a cross-sectional period perspective. For this purpose, established population health measures and data from an administrative register, the Statutory Long-Term Care (SLTC) census, are used. In study 2, the investigations in study 1 are extended by changing into a longitudinal perspective. Also based on the SLTC census, various cross-sectional censuses in a period design are combined for a trend analysis. Advanced and established demographic methods and models are used to investigate the spatial disparities of temporal changes in care need in Germany. One special focus is on the interplay of the trends in mortality and in the prevalence of care need in general and of severe care need. In study 3, micro- and macro-level factors and their simultaneous effect on longstanding illness are investigated in a cross-sectional perspective. The period analysis broadens the insights in the role of individual and contextual influences on health by combining information from various dimensions of individual attributes and of attributes of the individuals' living region. The German Microcensus proved to be an adequate dataset for this objective. A special focus of the study is on the health situation of Aussiedler (also called ethnic German migrants), a group of migrants with a particular specific characteristic in terms of intention of migration and of the context of migration and integration policy. Finally, the findings of study 2 are extended in study 4. As in study 3, the German Microcensus is used for study 4; however, there are two observation periods combined to allow a longitudinal trend analysis. The objective of the study was to investigate the spatial disparities in the prevalence of longstanding illness and (receiving benefits for) care need in very old birth cohorts. By adjusting for various individual-level factors, the effects of selection due to mortality and migration, as well as the consequences of different historical and present contextual conditions on health are revealed.

*Figure 2: Scheme of the objectives of the thesis and the corresponding studies*



## 2. Contributions of the thesis

While there is a long history of study on the effects and interactions of individual attributes, socioeconomic conditions, and bio-genetic factors, the number of studies relating to contextual influences on health of the individuals is significantly lower. In this intention, the four studies are conducted to extend the scope on this field of research. Hereafter, an overview of the general contributions of this thesis is provided. The contributions chapter highlights the key findings of the thesis that are colluded from the particular conclusions of one to all four studies. The contributions are ordered from a broader, more generalised to a focussed, more specialised perspective:

**1st contribution**

**In Germany, significant spatial disparities in morbidity exist in both in long-standing illness and in long-term care need. The selected administrative data sets and data bases proved to be suitable for small-area health analysis.**

The four studies are consistent in terms of the results about the existence of spatial disparities in both used health outcomes. The findings of the studies underline the importance of investigating the association of health and place in demography and health research.

Up till now, the German Microcensus and the Statutory Long-Term Care (SLTC) census have rarely been used for questions of health research. Studies based on these datasets and using advanced statistical methods are rare. Both data sets are a kind of censuses with mandatory participation, covering persons also at the highest ages and living in private households and institutions. Both censuses are repeated regularly and have a high number of persons usable for sub-national analyses. The range of individual-level factors – especially the detailed data about the migration background – of the Microcensus and the non-existing response bias of the SLTC census are further profound strengths.

The two administrative data bases, the Regional Database of the Statistical Offices of the Federation and the Länder and the INKAR database, are highly harmonised and long-time validated sources of data with a wide range of indicators of various dimensions and spatial aggregation levels. Since the regional identifier are standardised, the selected macro factors can be directly pooled to the micro data.

**2nd contribution**

**Regional attributes like the socioeconomic condition, the social integration, the physical environment and the services and resources have significant effects on morbidity apart from compositional effects.**

**However, these effects are less pronounced than those of individual factors.**

There are associations between care need and longstanding illness with the particular conditions of the living area (study 1 and study 3). A further major finding of the studies is that most of the health inequalities are between the individuals, while only a comparable lower proportion of the health variation exists between the selected spatial entities. The macro factors used in the studies show significant effects; however new indicators have to be implemented to further decrease the residual spatial variance.

**3rd contribution**

**The extent of spatial inequalities and their correlations with regional attributes depends on the choice of the health indicator and by the choice of spatial entities.**

The choice of the spatial level and the choice of the health indicator matters when small-area health disparities are investigated (study 4). Considering the overall variability of multiple individual-level factors adjusted cohort prevalence, a higher spatial variation on the level of federal states was stated for care need than for longstanding illness. In contrast, there was a much higher variability of longstanding illness than for care need on the small-area level. These results may be caused by different etiological pathways or by health selection effects due to migration and mortality causing heterogeneity in the elder population.

**4th contribution**

**Considering the micro-macro-level-interplay, particular contextual effects differ slightly by the sexes and do not differ in the comparison of native Germans versus Aussiedler.**

**However, there are pronounced differences in health between East and West German regions.**

**Gender disparities:** The contextual effects are mostly similar for men and women (study 1). Solely the negative effect of longstanding unemployment and the positive effect of urbanity were more pronounced in women than in men, albeit the differences are not statistically significant.

**Ethnic disparities:** The effects of physical environment measured by centrality and the effect of the socioeconomic conditions measured by the gross domestic product per capita are similar or only marginally different for native Germans and Aussiedler (study 3). No consistent effect was found for the proportion of foreigners in both groups.

The gender disparities and the disparities between native Germans and Aussiedler are markedly lower than the disparities in the contextual effects between the persons living in East or West German region.

**East West disparities:** There is a higher risk of care need by increasing socioeconomic wealth of the West German regions, while there was a reverse U-shaped risk in the East German regions with the highest risk of care need in the average wealthy regions (study 1). Long-term unemployment demonstrated negative effects only for person in West German counties and displayed no effect in the East German regions. Premature mortality as an indicator for the health structure showed a stronger effect for persons in the East than in the West German counties. These disparities can be explained by differences in the spatial economic and infrastructural variance within the East German counties compared to the West German counties.

**5th contribution**

**The small-area regions within Germany experienced different health scenarios in terms of expansion versus compression of morbidity. In addition, different health scenarios by the care level indicating an increasing spatial inequality and a shift from severe to any care level.**

Longitudinal trend designs are also used as an analysis strategy (study 2 and study 4). There was a general increase in the prevalence of care need and in longstanding illness from 2005 to 2009 - even after adjusting for multiple individual-level factors (study 4). However, the counties experienced different health scenarios – expansion, stability and compression of care need – from 2001 to 2009. These health scenarios differ markedly by the care level and slightly by the sexes. There is no clear East-West or North-South gap, but high variation within the federal states.

The majority of counties experienced a relative expansion of any care level. For severe care level, the majority of counties experienced a relative expansion or a relative or even an absolute compression. These results indicate an increasing bipolarisation between counties with unfavourable and (very) favourable health trends.

**6th contribution**

**Absolute gains in life years are the main drivers of increases in life years with care need. Slight reductions in the prevalence of care need are sufficient to achieve stability and compression of years with care need.**

The increase in life expectancy is linked to an increase in the absolute number of years with care need, but also to an increase in the absolute number of years without care need (study 2). In an average of the counties, the magnitude of the increase in the life years with care need due to mortality is higher than the increase in life years with care need.

Since the mortality effects on the change of the life years with and without care need are much higher than the effect of the change in the prevalence, the gains in survival are the main driver in the increase of the life years with and without care need.

The health scenarios are sensitive to even slight changes in the prevalence of care need. Much higher effects are stated for changes in the prevalence than for the mortality effects on the life years with and without care need. The effects of the prevalence are further higher for severe care level compared to any care level. These findings are essential especially for the rear guard counties in North Eastern and central Germany to achieve a convergence in care need with the vanguard regions.

**7th contribution**

**Aussiedler in Germany have no health disadvantage towards native Germans, but a health disadvantage of Aussiedler with a higher duration of stay.**

One conclusion is that there is no significant health disadvantage of Aussiedler compared to native Germans – even if it is only controlled for age and not controlled for socioeconomic factors (study 3). One assumption in the literature is that long-term socioeconomic deprivation in the new living contexts leads to a health disadvantage towards the host population that disappears after controlling for the social status. Since Aussiedler show in some respects a health advantage, the group of migrants may have other favourable attributes or contextual supports to ensure the better health situation. A possible explanation is the privileged integration with full access to the job market and health care system. Others are imported healthier life styles, long-term health selection effects due to mortality in the years before in-migration or health selection effects in the decision to migrate or to return-migrate.

Another conclusion of the study is that - after adjusting for various individual-level covariates, there is a health advantage of Aussiedler with a short time since in-migration, in comparison to Aussiedler with a longer duration of stay. Thus, the health situation gets worse, the longer

the duration of the stay which indicates effects of socioeconomic deprivation, adapted unhealthy life styles or inter-individual or societal discrimination.

**8th contribution**

**Spatial variance in health of equal birth cohorts is high even after adjusting for selected individual-level factors.**

By comparing cohort-specific (multiple adjusted) prevalence among the small-area entities for care need and longstanding illness, significant spatial inequalities can be revealed (study 4). The spatial differences vary by the choice of the cohorts and the health indicator. In absolute terms, much higher small-area variation was stated for care need than for longstanding illness in the oldest cohorts, while in the younger cohorts, the variation – at a much lower general level - is higher in the prevalence of longstanding illness. These differences may be an indication for health selection effects of migration and mortality or different intensities of short-term acute or long-term contextual influences over the life course.

**9th contribution**

**Beside the cohort disparities, there are differences in the health effects of age, family status and immigration status between care need and longstanding illness.**

There is an exponential increase of the risk of care need by age, but only a less marked age effect with the risk of longstanding illness (study 4). These disparities may be indications for strategies of coping with health problems or of health selection at the higher ages.

The role of the social integration is more important for care need than for longstanding illness (study 4). While the risk of both, longstanding illness and care need, is lowest in married persons, the negative effects of being single, divorced or widowed are much higher for care need than for longstanding illness.

In the case of migrants, the individual-level disparities between the two used health outcomes are linked to the particular situation within the policy influenced context in the host country (study 4). In the analyses, the risk of care need is highest among German citizens (including the Aussiedler) and is significantly lower for migrants and foreigners. In case of longstanding illness, foreigners and migrants have significantly higher risks than of the health of German citizens. Legal restrictions, barriers due to language, cultural perceptions and missing knowledge may explain these findings.

**10th contribution**

**The healthy life years indicator and the decomposition method are adequate and effective methods for small-area application.**

The healthy life years measure is an established indicator for cross-country and temporal comparisons. Only a few studies have used the indicator for small-area comparisons, although it can be concluded that the adaption is an adequate and effective method. The advantage of the indicator is that it is a composite measure that reflects the level of age specific rates in mortality and morbidity. By computing the unhealthy life years, the relation of both indicators – called the health ratio – can be evaluated. The age-specific health ratio reflects the relation of persons with morbidity (care need) to persons without morbidity (potential care givers) within pre-defined age groups.

Since the healthy life years can be computed for all ages and both sexes, health ratios can be estimated by comparing the life years with and without care need within similar age groups and sexes (e.g. to evaluate the potential of care givers within a partnership) or between different age groups and sexes (e.g. to evaluate the potential of intergenerational care resources). Furthermore, changes in the balance of the health ratio on national or subnational may be evaluated and compared.

Additionally, the decomposition method brings out the particular influences of mortality changes and morbidity changes. The balance of the mortality and morbidity components of the unhealthy life years may provide deeper insights into the populations' health structure and the health care system.

## 3. Structure of thesis

The thesis is divided into six chapters. Following this introductory Chapter 1, a research overview is given in Chapter 2. The literature review illustrates the complexity of defining the construct of morbidity, the health scenarios as a result of the interplay of mortality and morbidity, definitions, concepts, theoretical frameworks, and individual-level determinants of health inequality and the role of the living area on the health of the individuals. At the end of the research review, there is an overview of studies that investigated the prior defined health scenarios in the context of Germany, and there is also a review of the current stage of research relating to the health of Aussiedler in Germany.

In Chapter 3, these multidisciplinary aspects of health, of life course, of individual-level and macro-level factors, and of entering into a new context by migration were colluded in various hypotheses that are in the focus of the thesis. The hypotheses of the four studies are shortly derived and presented.

In Chapter 4, the data and methods chapter, the two used individual-level data sources, the German Microcensus and the Statutory Long-Term Care Census, and the two used macro-level data bases, the regional database of the Statistical Offices of the Federation and the Länder and the INKAR 2007 database, are described. The operationalisation of the health outcomes and of the individual-level, and macro-level factors - classified by the established dimensions - are explained and the diverse applied multivariate statistical methods are described in the following chapters.

Chapter 5 presents the results of the empirical analyses. The chapter is subdivided by the particular study, while the subchapters consist of a short background description followed by the research findings. The findings are, except for study 4, summaries from the findings of the three articles which are included in the appendix.

Chapter 6 completes the thesis by summarising and discussing the results of the statistical analyses. The findings are linked to the hypotheses and a general summary of the thesis in total is provided. Since a range of methods and data sources are used, methodological strengths and limitations have to be depicted and discussed. The thesis concludes with implications for various aspects of health policy and health research in the future.

# II. Literature review

## 1. Introduction

Many studies have stated that there are profound regional disparities in mortality and in various health outcomes in Germany which are correlated with socioeconomic, demographic, social, physical, and environmental characteristics of the regions (Breckenkamp, Mielck, & Razum, 2007; Diehl & Schneider, 2011; Dragano et al., 2007; Kemptner et al., 2008; Kibele, 2012; Kroll & Lampert, 2012; Latzitis, Sundmacher, & Busse, 2011; Maier, Fairburn, & Mielck, 2012; Queste, 2007; Razum, Altenhöner, Breckenkamp, & Voigtländer, 2008; Razum & Voigtländer, 2009; Strohmeier, Schultz, Bardehle, Annuss, & Lenz, 2007; Voigtländer, Berg-Beckhoff, & Razum, 2008; Voigtländer, Berger, & Razum, 2010b; Voigtländer, Berger, & Razum, 2010a; Wolf, 2004). The causes of inequalities in the status and in the trends in healthy ageing of a population are complex. Various biological, contextual, behavioural, and psychological factors were identified that explain the differentials in health and mortality of the individuals. Theoretical frameworks were developed to explain and conceptualise the causes and pathways of health inequality.

Germany is of high interest as a context in which to investigate trends in healthy aging and health inequalities: because of its position as one of the forerunners of population aging (Muszyńska & Rau, 2012) and because it has an extensive social welfare system (Barr, 2004). Marked socioeconomic, demographic, and health disparities in Germany have already been stated by a number of recent studies (Breckenkamp et al., 2007; Diehl & Schneider, 2011; Kroll & Lampert, 2012; Voigtländer et al., 2008; Voigtländer et al., 2010b; Voigtländer et al., 2010a).

In the following chapters, substantial definitions, concepts and theoretical frameworks are described, which are the fundament for the later empirical analysis. The meaning of these theoretical approaches is enhanced by findings from the current stage of findings in the particular associated research fields. The conclusion of the literature review is the hypotheses which are in the focus of this thesis.

## 2. What is Morbidity?

### 2.1. Definition(s) of Morbidity

From an oversimplified perspective, life can be measured in a quantitative or in a qualitative dimension. The quantity of lifetime, or better the length of life, is part of the mortality research that is based on specific death counts, mortality rates, life expectancy, and measures of dispersion between these outcomes separated by cause of death or other indicators. The second dimension, the quality of life, requires a different set of measurements. Quality of life is a

very broad concept that covers dimensions such as perception of partnership, job satisfaction, perception of the social network, standard of living, quality of housing, and - additionally a wide range of missing other aspects - the health status (Ware, 1987).

The definition of health and morbidity is much more complex than the definitions of most of the other research fields in demography. Perhaps the most cited definition of morbidity is the inverted definition of health by the World Health Organisation (WHO). The WHO (1946) defined: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". One of the main criticisms of the WHO definition is the inclusion of the word "complete" because the population in the state of complete wellbeing - especially social wellbeing - is very low and becomes lower by the ongoing progress of improvement in medical diagnoses. On the other side, the definition is not suitable for operationalisation or health policy (Huber et al., 2011).

Another established concept of health is the healthy-disease continuum by Aaron Antonovsky (1979). In his salutogenic theory, Antonovsky neglects the idea of a dichotomous classification with heath versus illness, and developed a "continuum model, which sees each of us, at a given point in time, somewhere along a "healthy/dis-ease continuum" (Antonovsky, 1996). The model of Antonovsky is based on the same idea as the later referred ecological model of ageing (EMA) by Lawton and Nahemow (1973).

A newer definition is given by Huber et al. (2011) in an adaptation of the ecological definition of health of the earth as "the capacity of a complex system to maintain a stable environment within a relatively narrow range" (Rockström et al., 2009) the definition of human health as "the ability to adapt and to self-manage" (Huber et al., 2011). Further, Huber et al. (2011) advise a conceptualisation of health by a bulk of dynamic features and dimensions.

Ware (1987), defined five generic health concepts: Physical health, mental health, social functioning, role functioning, and general health perceptions. The operationalisation can be done by using subjective (individual perception) or objective (external evaluation) measures or a combination of both. Results of subjective and objective measures do not necessarily lead to the same conclusions. An example for this inconsistency and of relevance for the comparability of the results of the following studies is the so called disability paradox (Albrecht & Devlieger, 1999). The disability paradox describes the empirically recorded phenomenon that persons with serious and persistent disability (objective measure) report a good or excellent quality of life (subjective measure). Mechanisms of coping and optimism, as well as the socio-cultural definition of health are intervening factors that have to be considered by comparing objective and subjective health.

Another aspect in the classification of health is the differentiation between specific health problems and the general health situation. For the analysis of particular health problems the International Classification of Diseases (ICD) is widespread and a comparable measure. Established global indicators for general health situations based on subjective measures are

the Self-Rated Health (SRH) measure and the Global Activity Limitation Indicator (GALI) (Berger, van der Heyden, & van Oyen, 2015), while medical evaluations based on the activities of daily living (ADL) score by Katz et al. (1963), or on the instrumental activities of daily living (IADL) score by Lawton and Brody (1969) are objective measures of morbidity and disability. The last measures are also established strategies in health policy to define care need and the level of care need.

## 2.2. Dimensions of Morbidity

Due to the fact that morbidity is a fluid continuum over lifetime, concepts and classifications were established to measure morbidity and health in a comparable way. The number of classifications is high and range from simple types by using the classification tree method to highly complex multi-stage transition models that cover multiple transitions (getting a morbidity, moderating or worsening a morbidity, curing, dying) between various stages. One simple but often cited example of a health transition approach is the morbidity model from Verbrugge and Jette (1994). This approach sub-classified the state of unhealthiness into four dimensions. The first state is the dimension of pathology. Persons are classified into this dimension if they experience the first diagnosis of a disease (biochemical and physiological abnormalities), have an injury, or have problems with congenital/developmental conditions. The pathology is further subdivided into acute (duration usually <3 months) and chronic pathology (progressive diseases, long-term consequences after an injury). One strategy to validate if a person can be classified in this dimension is to assess objective measures like medical diagnoses e.g. by using the International Classification of Diseases (ICD) codes. Another strategy that is more suitable for (health) surveys is to use subjective measures or to ask for the retrospective health history.

The second dimension is impairments. Included in this category are structural abnormalities with significant and long-standing consequences for cognitive, physical or social functioning in a particular body system. Functional limitations defined as restrictions on the basis of daily mental and physical activities are the following stage. The dimension covers problems in fundamental aspects of interacting with the environment like mobility, seeing, hearing, communicating, and processing cognitive and emotional functions. A standard measure of functional loss is the instrumental activities of daily living (IADL) score introduced by Lawton and Brody (1969). The items of the score ask for difficulties with food preparation, housekeeping, shopping, telephoning, laundry, transportation, medication, and handling finances. The last dimension of the main pathway of the disablement process is disability. Disability is defined as having problems with fundamental daily activities due to chronic physical and mental diseases. Katz et al. (1963) established a measure, the activities of daily living (ADL) score, to evaluate the severity of limitations in essential abilities like eating, toileting, getting in and out

of bed or a chair, dressing, and bathing. All of these dimensions are influenced by extra- and intra-individual factors and predisposing risk factors.

In the following analyses, I investigate regional inequalities in morbidity in two dimensions of morbidity. For study 1 and study 2, the health outcome belong to the dimension of disability, while it is further restricted to the subgroup of officially diagnosed disability. Study 3 is based on a subjective retrospective evaluation of the health status. Thus, a dimension of pathology is measured. The difference in the morbidity dimensions has to be considered in the comparison of the study results, but also it enables to get a broader view on the risk factors of morbidity.

# 3. Morbidity and Mortality in Germany

## 3.1. Regional mortality disparities in Germany

Unsurprisingly, the health situation and the level of mortality of a population are highly correlated. Both dimensions of a population's developmental status are results of diverse aspects of individual decisions and determinations and of contextual conditions and changes. Both, morbidity and mortality in a population, experience a continuing change over time since the underlying factors and their complex interactions are variable as well. Behavioural, societal, economic, environmental, political, medical, and infrastructural trends affect the health and the longevity of the individuals. Since these developments are not equal between each individual, as well as not having equal effects on health and on mortality, health and mortality inequalities are the results.

Over the last decades, there has been a growth in the general number, an increase in the coverage, and an improvement in the quality of databases including indicators on small-area level in the welfare states. Due to that trend, the number of studies that investigate regional disparities in diverse aspects like economy, social conditions, environment, migration, fertility, mortality and health have grown as well.

In case of the research field of regional health and mortality differentials, the first studies were published in the 1980s (review based on Kibele, 2012). In the years before the political reunification of the Federal Republic of Germany and the German Democratic Republic in 1990, the dominating institutes in small-area mortality research in Germany were the statistical offices of the German federal states. These studies (e.g. Berndt & M. Gregor, 1975; Birg, 1982; Böing, Martinez, Frentzel-Beyme, & Oltersdorf, 1985; Gatzweiler & Stiens, 1982; Giersdorf & Lorenz, 1986; Gröner, 1983; Heins, 1985; Heins, 1991; Heins & Stiens, 1984; Howe, 1986; Ickler, 1984; Kern & Braun, 1987; Neubauer, 1988; Neubauer, 1990(Neubauer, 1990)) stated regional mortality disparities which are explained merely by environmental factors and less so by socioeconomic conditions and compositions. After the reunification, the investigation of the linkage of mortality with social and economic conditions had grown in

interest (Brenner at al. 1991). Although there was a new perspective in the approach to explain mortality disparities by historical social, economic and political conditions, the focus was on the comparison of both German entities, the West German regions in total and the East German regions in total (Cockerham, 1999; Dinkel, 1992; Vaupel, Carey, & Christensen, 2003). Of high interest was to study the increasing divergence of life expectancy between the East and the West. While both entities showed a parallel trend in life expectancy on a national level until 1970, the spatial inequalities increased: The northern areas dropped behind and the southern regions showed high increases in life expectancy (Kibele, Klusener, & Scholz, 2015). After the 1970s, the gap between the life expectancy of the FRG and the GDR emerged with higher increases mainly due to steep reductions in infant mortality, fatal injuries in young adults and cardiovascular mortality in older ages (Nolte, Shkolnikov, & McKee, 2000).

The first systematic review of mortality on different small-area levels in the 1990s in Germany was published by Cromm and Scholz (2002). They stated profound regional disparities in mortality that were not particularly clear-cut between East and West as expected. Luy and Caselli (2007) concluded a more profound North-South divide in Germany with higher longevity in the South. The regional mortality disparities persisted since the 1990s (Queste, 2007). Up till now, Kibele (2012) gives the most comprehensive and innovative overview of the geography of mortality and cause-of-deaths in Germany. She stated severe mortality and cause-of-death disparities on small-area levels and on the level of the federal states, however the small-area dispersion was stable or shrinking.

### 3.2. Data about mortality and morbidity in (subnational) Germany

The research field of inequalities in mortality and in morbidity has a long tradition. As the awareness of inequalities and their economic, political and ethical implications has grown, the efforts in conducting valuable epidemiological data have increased. As a resulting effect of the objective to detect risk factors of heath inequalities, there was a tendency of comparing different populations to detect forerunners and left-behinds. The problem in comparing measures of health and mortality is the missing harmonisation of the data (e.g. of definitions, basic populations, used measures and time perspectives). One example for a supranational data source with the aspiration of being harmonised is the World Health Organisation (WHO) Global Health Observatory (GHO) Data and the WHO/Europe portal to health statistics (WHO/Europe health statistics, 2016). For analyses of trends in health and mortality for European countries, the Eurostat database (Eurostat, 2016), the Organisation for Economic Co-operation and Development (OECD) database (OECD, 2016), or the European Health & Life Expectancy Information System (EHLEIS, 2016) are good sources of information. For general information about the German health situation, the Information System of the Federal

Health Monitoring (Informationssystem der Gesundheitsberichterstattung des Bundes, Federal health reporting, 2016) is a comprehensive source of information.

In the case of small-area studies in Germany, the regional database of the German Statistical Office of the Federation and the Länder is a suitable source for research of inequalities in mortality on the subnational level; however, the data for other health dimensions is unsatisfactory. Health data on the subnational level for Germany is limited. Surveys like the GSOEP (German Socioeconomic Panel Study), the German Ageing Survey (Alterssurvey), and the German Health Interview and Examination Survey for Adults (Studie zur Gesundheit Erwachsener in Deutschland, DEGS1) are examples that can be used for regionalised health studies, but with the limitation of restricted representativity for small areas, with problems of self-selection bias since the participation is voluntary, and problems of the restrictions of the population under study due to the fact that only persons in private households are included. Register data, also called process-produced data, do not have these problems. Register data is collected for administrative purposes, most registers include a large number of persons and information about the place of residence, participation is (mostly) mandatory, and is not biased by reactivity (social disability bias) or a response bias (lying) since the data is collected without the respondents contribution. For Germany, examples for this source of health registers are the data bases of the health insurances (Krankenkassendaten), the registers of the German Federal Pension Fund (Deutsche Rentenversicherung Bund), the hospital statistics (Krankenhausstatistik), the statistics on illnesses which require registration (Statistik der meldepflichtigen Krankheiten), the statistics about handicapped persons (Statistik der schwerbehinderten Menschen), the cause of death statistics (Todesursachenstatistik), and the Statutory Long-term Care (SLTC) census (Pflegestatistik). Since the data collection for these registers are mandatory and regulated by national law, access to the data on individual levels is highly restricted in Germany. For some of the information, there are aggregated measures offered by the particular institutes, but with limited options to adapt for interesting subgroups or spatial units. Research data centres exist for most of the institutions that offer scientific use files or do remote access analyses.

A last source for regionalised health data are population censuses. In 2011, there was a census conducted for Germany, but with no information about the health status included. As a substitute for regular large-scale censuses, the German government introduced a small-scale census, called the micro census, in 1957 in the Federal Republic of Germany and in 1991 in the reunified Germany. The German Microcensus is a representative survey of 1% of the German population, but the participation is mandatory. The access to the anonymised individual level-data is regulated by the research data centres and small-area analyses are allowed via remote access.

For the analyses of study 1 and study 2, data of the SLTC census, and for study 3, the German Microcensus is used. Due to the mentioned data regulations, remote access analyses were required.

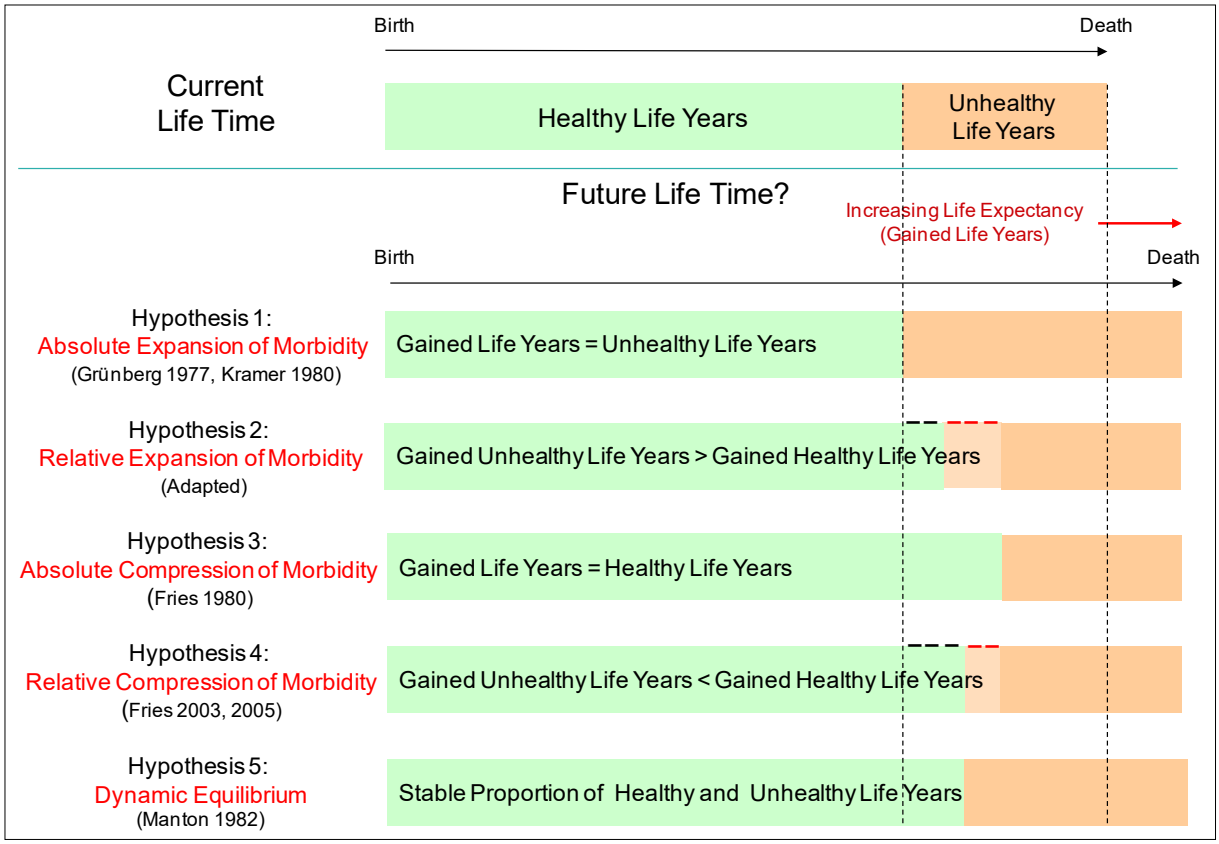
### 3.3. Morbidity-Mortality-Interplay: The Health Scenarios

Kibele (2012), found an increasing life expectancy for Germany in total, as well as for all the counties in Germany. Thus, the quantity of average life time went up. However, these results give no indication as to whether the morbidity has decreased.

For a long time, the linkage of morbidity and mortality has been of high interest in health research. In the scientific community, hypothetical scenarios with contrasting assumptions about developments of morbidity in populations in future were discussed and examined (Figure 3).

The first concept is the so called theory of "Expansion of Morbidity" by Ernest Gruenberg (1977) and Morton Kramer (1980). The scenario assumes an increasing duration of morbidity and frailty and a higher prevalence of most health limitations. The increase is explained by the discrepancy in the efficacy and pace of health improvements due to prevention and recovery in contrast to the pace of the general survival progress. Therefore, the increasing life time results in an increasing life time with morbidity, frailty and multi-morbidity.

*Figure 3: Schematic concepts of the health scenarios*




(own figure, adapted from Gruenberg, 1977, Kramer, 1980, Fries, 1980; Fries, 2003; Fries, 2005; Manton, 1982)

The opposite scenario to the pessimistic theory of "Expansion of Morbidity" is the optimistic "Compression of Morbidity" scenario by James Fries (1980; 1989). The compression scenario assumes a general decrease in the incidence of morbidity due to direct factors e.g. technological and medical advancement, and due to indirect factors, e.g. a healthier life style of the individuals, and interventions in terms of primary and secondary prevention of diseases. As a consequence of the continuing reduced survival rates in combination with the morbidity improvements postponing the unhealthy life years into the very last years of life. The gains in life years are additional life years without morbidity. Thus, the prevalence of chronic diseases and frailty declines in total.

In the following decades, the health scenarios were debated, examined by empirical data and modified. Fries (2003; 2005) evolved in the later years a differentiated compression scenario: the absolute and the relative compression of morbidity. The intervention of the classification was to consider absolute and relative improvements in life time. A total decrease in unhealthy life years is defined as an absolute compression scenario. When the proportion of unhealthy life time to total remaining life time declines, Fries (2003; 2005) termed the development as a relative compression.

To be correct, the relative compression is a special case of absolute compression. The distinction between both scenarios is the development of the unhealthy life years. Absolute compression occurs if the number of unhealthy life years is stable or shrinking. In contrast, the relative compression has to regard the relation of the gains in healthy and unhealthy life years. A relative compression occurs, when the gains in unhealthy life years are lower than the gains in the healthy life years.

The differentiation between relative and absolute increases was later adapted to expansion scenarios: the absolute and the relative expansion of morbidity. While there is an increase in the proportion of unhealthy life time to total remaining life time in the relative expansion scenario, an increase in the total number of unhealthy life years is the only requirement for the absolute expansion scenario.

The last scenario is also based on the concept of relative rather than absolute trends in healthy life years and unhealthy life years: the theory of “dynamic equilibrium” (Manton, 1982; Manton, Corder, & Stallard, 1997).

Manton (1982) developed a scenario that integrates the frameworks of compression and expansion of morbidity. The underlying assumption is that there are simultaneous increases in life expectancy and in years with morbidity. The status of stability - an equilibrium - is achieved, when the share of unhealthy to total remaining life years remains nearly constant. However, there is also an assumption of the internal composition of the population in mor-

bidity. Within the theory, a gain in the quantity of persons with ill-health is expected, but a shift is expected from severe to less and moderate diseases and disability. This shift is explained by medical, technological and behavioural improvements that lead to both, a redistribution of health risks and an increase in longevity (Graham, Blakely, Davis, Sporle, & Pearce, 2004).

The objective of research in this field of science is to prove which of the health scenarios fits best into the population's health status. Thus, summary measures were developed to quantify healthy and unhealthy life years by combining information about morbidity and mortality. One adequate concept is the Sullivan's method that is based on life table estimations and on prevalence rates to compute life years with and without a prior defined morbidity.

In study 1 and study 2, the Sullivan's method is adapted to care need. The indicators of care need-free life years (CFLY), life years with care need (CLY) and the health ratio (HR) - the proportion of CFLY in total life expectancy - were computed; thus, the theoretical health scenarios can be identified by the classification of combinations of the three indicators.

# 4. Health inequality in welfare states

## 4.1. Health inequality = health inequity?

Health inequality has been a central issue in the field of health research for a considerable time. In a simple descriptive definition, the term defines an unequal distribution of health within the individuals or groups of individuals within a population or a particular part of a population. In contrast, health inequities are defined in a "normative concept implying unfairness" (Fors, 2010). They are "systematic", "socially produced" and "unfair" (Whitehead & Dahlgren, 2006).The major point of this definition is the fact that the health disparities are a result of the currently or former existing societal system and not a result of biological determinations or individual decisions and behaviour. A critical point in the definition of Whitehead & Dahlgren is the missing definition of unfairness. There is still no consensus on what health disparities are accepted as fair (Fors, 2010).

In most cases, especially in the early periods of the systematic research in this field, health inequalities were measured by systematic differences in health between groups of different vertical levels (like social or socioeconomic groups) in a society (Fors, 2010). "[N]ot the first major work to address this issue, but [...] a milestone" (Broom, 2000) was the Black report (Black, 1980). Black (1980) gives various substantial evidences for a socioeconomic gradient in worse health and evolves theories that may help to explain the causes.

Although, the health inequality in a vertical societal perspective is still a major body in its field, horizontal health inequalities are to a lesser extent. The horizontal perspective covers

health inequalities by gender, age, cohort, life style, family status, and living context. A special type of subgroup analysis is the study of health of international migrants and their descendants within a society. Varying by the level of societal and cultural incorporation of an individual after the migration (or in the years after the birth in case of the descendants) into a different society or different culture, the health inequalities may exist in a vertical and a horizontal perspective.

Considering the fact that individuals with similar health relevant attributes in the horizontal perspective but with a different position in the vertical perspective show disparities in health, the revealed health inequalities can be interpreted as health inequities. The major issue in this equation is to emerge all attributes that affect the particular defined dimension of morbidity. Missing this clear distinction, health disparities can only be interpreted as health inequalities.

However, the analysis of the determinants of health is an ongoing challenge for medical, psychological, epidemiological, sociological, demographical, and economic research of health disparities. The following four studies face this challenge.

## 4.2. Theories about health inequalities and ageing

As described above, health – even if only one specific dimension out of the universe of health definitions is selected – is a continuously changing, time-varying state over the lifetime. Thus, except for the group of non-curable diseases, an individual may have different health situations at different ages. While from a socio-structural perspective, age is only one of the many horizontal differencing attributes, age has an out-standing position in epidemiologic, sociologic, and demographic research of health. Explanations for the special meaning of age come from, for example, biology and genetics (e.g. puberty, cellular degeneration), sociology (social norms e.g. of life event sequences and the perception of age), and - from both resulting - political and economic conditions (e.g. youth protection laws, retirement age).

The effort to meet the requirements of this unique position results in the conduction of the (now so called) life course approach. The life course approach is a fruitful framework to conceptualise the pathways to health inequality - also for contextual effects on health. The ***life course approach*** combines the three models into a new one, but with a greater focus on the health outcome as a result of an individual's biography (e.g. Ben-Shlomo & Kuh, 2002) in a specific eco-social context (e.g. Krieger, 2001).

One subgroup of life course models are the ***critical period models***. These types of models expect that an exposure to unfavourable situations in utero till mid-life has effects on the "biological programming" and on disease risks in higher ages (Ben-Shlomo & Kuh, 2002). When investigating migration and health, the model of Schenk (2007) integrates the experience of a

migration in life time and the following culture shock as a critical period that may have an effect on the health situation in the short-term, long-term and intergenerational perspective. In case of cardiovascular disease and their risk factors, Hamil-Luker and O'Rand (2007) and Murray et al. (2011) concluded that the socioeconomic situation in childhood has a high impact on health in later life. In contrast, Pudrovska and Anikputa (2014) refuted this approach for the effect of social status in childhood on mortality.

A second group of life course models are the ***accumulation of risks models***. This approach, which is also called the cumulative inequality (CI) theory, considers poor health and premature mortality as a consequence of cumulative damages on the biological system due to the persistent exposure to unfavourable conditions (Ben-Shlomo & Kuh, 2002; Kahn & Pearlin, 2006). A higher premature mortality for individuals with higher health risks is one of the results of cumulative inequality. The non-random mortality selection then leads to a decreasing heterogeneity of individuals in terms of frailty at higher ages. As a consequence of this health selection phenomenon also called cohort inversion (Lynch, 2003), the most robust persons reaches the highest ages, which appears as a levelling down of health inequality in the aggregated population at the highest ages (Ferraro & Shippee, 2009; Hobcraft, Menken, & Preston, 1982; Noymer, 2001). In the case of the old-age mortality gap due to the social status during different periods of life, there are studies that confirm the accumulation approach (Galobardes, Lynch, & Davey Smith, 2004; Pudrovska & Anikputa, 2014; Wamala, 2001).

A third subgroup of life course models are ***capability approaches***. These approaches focus on the balance of non-material and socio-structural factors (capabilities) and challenges over the life course as causes to realise functions such as high wellbeing or good health. In this approach, health inequality is a result of the individual life-long coping abilities, which themselves are driven by the socio-economic position, social connectedness, emotional competences, cultural and societal norms, self-determination, and stress (Hall & Taylor, 2009; Sen, 1985; Sen, 1999; Sundmacher, Scheller-Kreinsen, & Busse, 2011). Sundmacher et al. (2011) established in their decomposition analysis that the capability approach measured by a score computed as the difference between a resources score and a challenges score has - along with the cultural-behavioural approach - the highest power to explain individual health disparities.

A further group of life course frameworks is the ***pathway approach***. Two examples are the biological and psychosocial pathway model by Ben-Shlomo and Kuh (2002) and the biopsychosocial (pathway) model of Lämmle et al. (2013). Both models are based on the same concept that is an extension of the accumulation of the risk model. The main assumption is that the family background is connected with later life health status; however the pathways are complexly mediated by various exposures or behaviours over the life time. The pathway

model by Lämmle et al. (2013) bases on an established group of approaches in psychological and clinical research. The authors extended that classical concept by using complex modelling strategies and by differentiating between distal and proximal causal factors to analyse the pathways to physical fitness and subjective health. The model further allows complex interactions between different levels of these distal (societal and environmental) and proximal (intra- and inter-personal) factors. Numerous studies (Lämmle et al., 2013; Montez, Hayward, Brown, & Hummer, 2009; Pudrovska & Anikputa, 2014; Singh-Manoux, Ferrie, Chandola, & Marmot, 2004) concluded the efficacy to explain health and mortality differentials by these types of models.

The life course approach(es) can also be adapted to conceptualise small-area health differentials. Many authors (e.g. Ben-Shlomo & Kuh, 2002 and Krieger, 2008) developed models that cover selected aspects from the original approaches and additionally consider the historical and current living context as an influencing factor. Based on these frameworks, individuals that live in a common societal and particular ecosystem (the same household, the same neighbourhood, and the same region, Krieger, 2008) are assumed to be exposed to common contextual conditions. The multigenerational schema by Ben-Shlomo and Kuh (2002) - an extension of the framework of Hertzman et al. (2001) - additionally integrates the theoretical classification of effects by the chronological timing (period effects), the timing in the individual's biography (cohort effects), by the generational linkages (genetic and/or social influences) and by the level of living context (household, neighbourhood, nation). All of these effects are complexly interfered and inter-correlated (Diez-Roux, 2000). Some individual- and household-level characteristics may modify the contextual effects directly (e.g. material resources) or indirectly (e.g. capabilities and coping strategies) with diverging health outcomes over the life course, but with an assumed special impact in critical biographical periods and with longer duration of exposure.

To conclusively evaluate the explanatory power of the different approaches, longitudinal panel data with a multi-dimensional and regularly repeating set of information is needed that covers the total life span of an individual. Since up to now not even register-based data, as well as the data that is used for the analyses in the following chapters meets these requirements, the approaches cannot be validated. However, both used health outcomes of study 1 to study 3 reflect the results of positive and negative life course events. Only the accumulation of risks model is assumed – if it could be verified – to have a higher impact on the results of study 1 and study 2, because the population under study is on average in the older age groups than in study 3.

### 4.3. Determinants of inequalities in healthy ageing

The causes of inequalities on the status and on the trends in healthy ageing of a population are complex. Various biological, contextual, behavioural, and psychological factors were identified that explain the differentials in health and mortality of the individuals. Theoretical frameworks were developed to explain and conceptualise the causes and pathways of health inequality. These frameworks are useful to classify these factors into specific categories (Bartley, 2004).

In addition to the life course approach, three groups of models of aetiological pathways are established: 1) Behavioural and cultural explanations, 2) the psycho-social model, and 3) the materialist model (for an overview and a systematic review see Bartley, 2004). These approaches are focussed on explaining health gaps on the individual level, but can partly be adapted to explain regional disparities.

Although, these dimensions are often used in health research, there is and there surely will be limited consensus about the classification of individual level factors into predefined categories. Most of the factors are highly correlated and interfere with the pathways of more than one dimension. Thus, the provided classification of Bartley, (2004) is a selected suggestion for a classification and there is no clear operationalisation and categorisation of indicators of these dimensions. In respect of these interrelationships and the missing consensus, a deterministic evolution of indicators from the particular dimensions is implausible and thus, one individual-level factor (e.g. family status) may be interpreted in terms of more than one dimension (e.g. as a material, behavioural and psychosocial factor).

#### 4.3.1. Material factors

In the ***materialist model***, health disparities are assumed to be the result of the different socio-economic positions in the societal hierarchy. Divergent positions have access to different to material resources and exposed to differential conditions (like noise, pollution, working conditions) (Sundmacher et al., 2011). Some studies additionally defined neo-material factors as determinants of an individual's resources of health production - e.g. diverse aspects of public infrastructure (Lynch, Smith, Kaplan, & House, 2000; Smith, 1996).

Two pathways of causation of the health effects of social status are established in the literature: The social causation mechanism and the social selection mechanism. The causation mechanism assumes that individuals that are born in or achieved a high social status have more material resources to promote their health, to socially participate, to freely develop their personality and to improve their living conditions than individuals of a lower status. The social selection mechanism, in contrast, is based on the idea that the individuals that have a better physical and mental constitution have a higher chance of achieving a high social position

(reverse causality). Studies have concluded that – in the case of Germany - the social causation is of higher importance (Mielck, 2005).

Mielck (2005), provides a broad overview of the social gradient of health in Germany and concludes that, with the exception of particular diseases like allergies, the risk of morbidity and the prevalence of risk factors are higher for persons of lower social status.

### 4.3.2. Behavioural and cultural factors

The ***behavioural and cultural explanation***, inequality in health is assumed to be the result of specific life styles (e.g. smoking, drinking alcohol and physical inactivity), health behaviours (e.g. acceptance of and access to cigarettes and alcohol or physicians), and of psychological resources of the individuals (e.g. self-regulation, high education and social capital) (Bartley, 2004).

The body of research that is focussed on the effect of behaviour and culture on health is as large as or maybe larger than the number of studies that investigate material factors. The amount of studies is a result of the multidisciplinary interest, since it implies aspects of the fields of biological, chemical, medical, epidemiological, sociological, socio-ecological, psychological and demographic research. In a comprehensive literature review based on various international studies, Spring et al. (2012) stated higher risks of morbidity and mortality for: 1) consumption of a diet high in calories, fat and sodium, and low in nutrients, 2) low levels of physical activity and high levels of sedentary activity, 3) smoking cigarettes, 4) abusing substances including alcohol, prescription and illicit drugs, and 5) engaging in risky sexual behaviours. Three protective behaviours were detected: 1) being physically active, 2) eating fruits and vegetables, and (3) being adherent with prescribed medication. The authors assume – what should be interpreted with caution - that the elimination of these health risk behaviours would prevent 80% of type 2 diabetes, stroke and heart disease, and 40% of cancers (Spring et al., 2012).

Sundmacher et al. (2011) decomposed the variations in physical health of approximately 20,000 individuals in Germany into particular effects of selected proxy indicators for each of the four frameworks. In case of behavioural-cultural indicators, the authors stated that these factors have the highest power in explaining the overall health disparities, but especially in the youngest (16 till 35 years) and oldest age groups (56 till 65 years). The key contributors are being overweight in the case of women and alcohol consumption in the case of men (Sundmacher et al., 2011).

### 4.3.3. Psychosocial factors

Further, the ***psychosocial model*** expects that persons are of poor health if there is low social support and cohesion, high self-assessed job strain and high subjective effort-reward job

imbalance (Bartley, 2004). Studies stated that persons of a low socio-economic position have a higher risk of poor health since they have a higher risk of negative life events (White, 2002), less social support (Elstad, 1998), a lower job autonomy (Marmot, Ryff, Bumpass, Shipley, & Marks, 1997; Marmot & Wilkinson, 1999), and less security of work place (Marmot, Allen, & Goldblatt, 2010). An enduring high level of stress and perceived missing (or lost) appreciation for work are the mechanisms that lead to a reduced resilience and an increased vulnerability to morbidity (Kelly, Hertzman, & Daniels, 1997).

The marital status can be interpreted as an indicator for the gradient of psychosocial support, however material and cultural factors may have an influence. Since the dominating cultural perspective in Germany refuses arranged marriages with the exception of particular ethnic groups within Germany, the marital status base - on one hand - on a free individual decision or - on the other hand - on a lack of an adequate partner. There are two hypotheses about the association of marriage and health that are very close to the social status mechanisms. The marriage selection hypothesis assumes that persons of better health have higher chances to get married. In contrast, the marriage protection hypothesis expects a positive, preventive, and curing effect of the social support offered by the partner. Brockmann and Klein (2002) found evidence that there is a protective effect of marriage in Germany.

Sundmacher et al. (2011) concluded that these factors have only a limited contribution in explaining inter-individual health disparities. However, the choice and validity of the indicators is more controversial in the case of the psycho-social model than for the other approaches.

### 4.3.4. International/-cultural migration and morbidity

The study of health of persons that experienced a (international/-cultural) migration and of their descendants, following named as persons with migration background, is of high interest in international health research. One explanation of this growing interest is that the awareness of the situation of the population with migration background in most welfare states has increased, also due to the ongoing growth in the size of that population. Like in the host population, also in the population with migration background the number of persons in high ages continuously is rising. Another explanation is the special role of that population in terms of social inequalities in a horizontal, as well as from the vertical perspective. To study how these social disparities are reflected in health disparities allows the evaluation - although only to a limited extent - the health care barriers and the efficacy of the health care system.
However, the study of disparities between the health status of the host population and the population with migration background has to consider some specifics in the methodological and epidemiological perspective. Even if the following theoretical explanations cannot totally

be excluded for health research of internal migration, the main focus is on international and intercultural migration (review based on Kohls, 2010).

**Approaches in the methodological perspective (composition):** A major methodological problem in this field is the selection process at immigration and remigration. Early studies (Lee, 1966; Ravenstein, 1885) have already found evidence for an effect of (self-)selection at immigration, this is now commonly termed as the **healthy migrant effect**. The healthy migrant effect describes a process that starts with a selection of persons in good health who migrate to another country. In the next years after the migration, the health status is better than in the host population. With increasing length of stay in the host country, the health and mortality advantage lowers. The deterioration of the health advantage is a result of living in a lower socioeconomic status and in poorer residential areas (Elkeles & Mielck, 1997; Kliewer, 1992; Razum & Rohrmann, 2002). The healthy migrant effect is assumed to be influenced by three factors:

First, the selection effect varies by the economic, cultural and geographical distance between the origin and the destination country. The selection bias (e.g. in terms of age, mental and physical conditions) is higher, the higher the cultural, geographical and economic distance (Jasso, Massey, Rosenzweig, & et al., 2004; Kohls, 2008).

Second, the degree of the effects is expected to be influenced by the proportion of out-migrating persons of a particular sub-population within the country of origin. If the majority or the complete ethnic group move (or is promoted and is legally allowed to move) to a destination country, there is no or only a marginal selection effect. In the case of the Aussiedler, for which it is assumed that almost the complete population of Aussiedler have moved to Germany in recent decades (Information for political education, 2000), Kyobutungi et al. (2006) expected that the healthy migrant effect would fade.

Third, the healthy migrant effect decreases with the duration of stay (Chaturvedi & McKeigue, 1994; Williams, 1993). The health of the descendants should not (or only marginal) be influenced by the selection bias; however, social deprivation may have an effect on the health of the children of the migrated persons (Razum, 2006; Razum & Rohrmann, 2002). Closely connected to the healthy migrant effect is the so named **healthy worker effect**. The healthy worker effect explains, like the healthy migrant effect, a lower migrant mortality (Razum, Zeeb, Seval-Akgün, & et al., 1998) due to the selection process of the job market where working persons are on average of better health than unemployed persons (Fox & Collier, 1976; McMichael, 1976). However, since the selection bias due to the migration is (in most cases) before the beginning of working in a destination country, Kohls (2008) interpreted the healthy worker effect as a consequence of the healthy migrant effect.

Simultaneously to the selective immigration, the population with migration background is also changing due to selective out-migration. This phenomenon is called the **salmon bias**

(Abraido-Lanza, Dohrenwend, Ng-Mak, & et al., 1999; Palloni & Arias, 2004; Turra, Elo, Kestenbaum, & et al., 2005) or the **unhealthy-remigration** effect (Razum et al., 1998). The salmon bias is the assumption that migrated persons with poor health return to their countries of origin because they (expect to) receive better health care and psychological and familiar support in these countries (Courbage & Khlat, 1996; Dietzel-Papakyriakou, 1987; Razum et al., 1998; Weber, Abel, Altenhofen, & et al., 1990). The salmon bias can also be adapted to other life changing events (e.g. pension age, psychological problems due to discrimination, long-term unemployment, or unfulfilled ambitions (Abraido-Lanza et al., 1999; Fabian & Straka, 1993).

**Approaches in the epidemiological perspective (context):** The second group of approaches to explain health disparities between persons with migration background and the host population is based on different epidemiological situations in the country of origin and the destination country. Contrary to the selection approach that explains the health disparities as a result of the composition of different attributes of the individual, the **(health) transition theory** describes the health disparities as a result of contextual influences on the individuals in the country of origin. The health transition theory is based on the macro-level model of the epidemiological transition by Omran (1971) which explains a development of health and mortality patterns from high prevalence of infectious diseases and high infant and mother mortality to a high prevalence of chronic, degenerative, non-infectious diseases and low infant and mother mortality (Dinkel, 1989; Omran, 1971; Schimany, 2003). Countries like Germany are classified on the final stage of the model, while less developed countries are in earlier stages of the epidemiological transition (Razum & Twardella, 2002).
The health transition theory transfers the epidemiological transition model to the micro level. Health disparities are explained by imported, (partly) remaining, or internalised health behaviours ("imported risk" assumption) and attitudes towards health care utilisation from the country/culture of origin. In the case of migrants from Eastern Europe, evidences for remaining health behaviours are found for smoking and alcohol consumption (Aparicio, Doring, Mielck, & Holle, 2005; Robert-Koch-Institut (RKI), 2008; Schenk, 2002; Settertobulte, 2005; Zeeb, Baune, Vollmer, Cremer, & Krämer, 2004; Zeeb, Razum, Blettner, & et al., 2002), and for remaining health care utilisation for less often cancer screenings, vaccinations, dental health visits (Collatz, 1989; Kentenich, Reeg, & Wehkamp, 1984; Lechner & Mielck, 1998; Schenk, 2007). Schenk (2002) explains the lower participation in medical checks to prevent diseases by the unusualness of preventive checks in their countries of birth. Barriers in the access to health care like problems with the language, lack of information, and cultural differing health perceptions will further increase the disparities (Aparicio et al., 2005; Duncan & Simmons, 1996; Robert-Koch-Institut (RKI), 2008; Zeeb et al., 2004). Up till now, less attention has

been given to investigating the effects of the small-area context in which the persons with migration background live in the destination country on the health status.

### 4.4. Residential context as a determinant of inequality in health

The main contribution of the studies presented in the following chapters is to give some new evidence for small-area disparities on health. Beforehand, a general distinction between definitions that sounds very similar is needed to avoid confusion. In health geography, the context and the composition of a population and their linkage to health are of interest (contextual versus compositional effects of health). Compositional effects are defined as health differences due to different compositions of the compared populations. By statistically eliminating the compositional effects, the contextual effects can be revealed. Contextual effects themselves are defined as effects of attributes of the living area on the health status of the residing individuals. The context in return can be measured by compositional factors and contextual factors which are defined in more detail in the next subchapters. Thus, it is necessary to carefully distinguish between compositional effects and effects of compositional factors. To briefly summarise, contextual effects that are of interest are defined as effects of contextual and compositional factors and can solely be investigated by controlling for compositional health effects.

Numerous findings from the literature indicate that the living context is an influential determinant for health disparities; however, these effects have generally been found to be smaller than the individual-level effects (e.g. reviews by Pickett & Pearl, 2001 or Riva, Gauvin, & Barnett, 2007). One problem has to be considered in health research in general: the publication bias. The publication bias describes the preference of researchers and editors of scientific journals for research outcomes that are desirable in the established tendency and with high statistical significance (Easterbrook, Gopalan, Berlin, & Matthews, 1991). In the case of contextual effects, a publication bias can be assumed to have a selection effect in terms of insignificant results; however, the amount cannot be quantified.

In this chapter a selection is presented after giving a general overview of the theoretical background of this field of research. Like in other disciplines of social research, there is a high number of challenges to face and deal with when finding reliable and valid results that can be used for health interventions. Ignoring the problems of data availability and accessibility, some of the main challenges in this field include, the choice of the spatial units, the dimensions that represent health relevant characteristics of the spatial units, the proxies/indicators that themselves represent these dimensions and to explain the causal pathways between the latent contextual attributes and the individuals health situation (Diez Roux, 2003).

The next subchapters give - in chronological order - an overview of selected conceptual frameworks of the pathways between characteristics of the living area, an introduction into the general classification of macro factors, a review of the research by selected dimensions of regional characteristics and the interplay with individual-level factors, ending with an explanation of the methodological and operational problems of the definition of groups or the choice of spatial entities.

### 4.4.1. Conceptual framework of health and place

Besides the approaches that give causal explanations for health disparities among individuals, there is a rapidly growing number of studies that investigate the role of the living context on the health state. Simultaneously, the demand to establish frameworks of the causal pathways has increased. Due to the very high number of models, frameworks and concepts that were established over a long period, only four selected frameworks should be concisely presented. One of the first and most influential concepts based on the long-time work about ecological impacts on ageing of M. Powell Lawton (Lawton, 1974; 1980; 1983; 1990; Lawton, Kleban, & Carlson, 1973; Lawton & Nahemow, 1973; Lawton, Patnaik, & Kleban, 1976; Lawton & Simon, 1968). Lawton introduced the ecological model of ageing (EMA, Lawton et al., 1976; Lawton, 1980; 1983; 1990; Lawton & Nahemow, 1973). The model describes the person-environment fit, which is described as a dynamic continuum of demands from the environment (social and physical press) and the ability of the individuals to handle these demands (personal behavioural competence). In the underlying perspective, the EMA shows notable similarities to the nearly simultaneously published "health-ease versus dis-ease continuum" by Antonovsky (1979).

Various so called extra-individual factors (macro or ecological factors) are related to the environment, but were not described in detail. The competence is the individual upper capacity limit to be in good physical and cognitive health, perception, and mobility. The behavioural competence can be indirectly measured by scores like the geriatric depression score (DGS) or the morale scale (Glass & Balfour, 2003). Well-being of the individuals is achieved when the competence and the press are in balance and the individual’s behaviour is adaptive. This balance is assumed to be a zone that is separated into two areas: If the environmental press is slightly above the perfect balance but the individual shows still an adaptive behaviour, Lawton and Nahemow (1973) defines this situation as a zone of maximal performance. If the competence is slightly higher than external press, the individual is in the zone of maximal comfort. Both dimensions, competence and press, are highly flexible over time and place. Persons can easily emphasise with the concept of these zones and their variability when thinking about situations in a job, writing a thesis, or holding a disputation. However, the concept can be transformed to every condition in everyday life. Negative effects are assumed to be the results of maladaptive behaviours. Maladaptation’s are the consequence of much

higher press than competence (mental overload, isolation, withdrawal) or of much less press (mental underload, boredom, atrophy). Both lead to morbidity and disability. This concept is one of the bases of the "use it or lose it" hypothesis (Glass & Balfour, 2003).

Glass and Balfour (2003) point out some limitations of the model: it is hard to operationalise in epidemiological research, positive aspects of the neighbourhood are ignored, the time dimension is not directly included, and the causal and etiologic pathways are not explained. However, they value the model by using it as an origin for their extended EMA model. The extended EMA consists of four components that are in causal and temporal order: 1. Neighbourhood factors/characteristics, 2. person-environmental fit, 3. adaptive/maladaptive responses, and 4. the outcome.

The neighbourhood characteristics are classified by Glass and Balfour (2003) into four dimensions. These dimensions that are potentially modifiable are socioeconomic conditions, social integration, physical aspects of place and services and resources. The socioeconomic conditions themselves are expected to affect the three other dimensions directly and indirectly. Socioeconomic and socio-structural factors are the most recognised indicators of health inequalities, while Glass and Balfour (2003) consider that the causal interdependencies with the other dimensions are underestimated. The neighbourhood characteristics determine the positive environmental buoying and the negative environmental press within the person-environmental fit continuum. Examples for the buoying are social support by social integration, accessibility of health infrastructure or to recreational areas. Negative examples are physical barriers, social stress, and high air pollution. Like in Lawton's concept, the personal competences of the individuals should be in a good balance with environmental press; however, in the extended EMA, environmental characteristics (buoys) support the personal competences. These competences themselves are continuously affected by general or specific health problems termed as "exacerbaters" (like mobility limitations, depression, cognitive impairments). These health problems may result in a critical threshold (a "tipping point") that leads to dramatically reducing or stopping the direct interaction outside the home (Glass & Balfour, 2003). As a consequence, some constraining and supportive neighbourhood characteristics may lose influence (e.g. crime or recreational areas), some grow in importance (e.g. availability of home-care services or air pollution in the neighbourhood), and for other characteristics, the health effects are inverted (e.g. remote rural regions with low noise pollution, but a crucial lack in medical infrastructure).

The next component on the pathway are the adaptive/maladaptive behavioural responses, that are separated into physical activity versus passivity, social engagement versus isolation, active versus passive coping, and health service utilisation versus unmet medical needs. All these dimensions reflect to various aspects the physical, cognitive, psychological and social domains of living. These domains themselves affect the health and the functioning of the individuals.

A heuristic model was developed by Krieger (2008). Krieger defined class inequality, racial/ethnical inequality and gender inequality and their intervening effects as the factors of health inequality which are themselves determined by the political economy and ecology. Further, the model considers a continuing influence of the historical context, as well as of the divergent levels of the societal and ecosystem of the individuals. These influences have varying effects over the individuals' life course and the embodied consequences of the eco-social context manifesting as health inequalities.

A much simpler model is the framework of Diez Roux and Mair (2010). The first dimension of the framework is residential segregation in terms of socioeconomic position or by ethnicity that has a direct and mutual linkage to inequalities in resource distribution. These components have an influence on the next stage of the physical and social environments of the neighbourhood. Physical aspects are environmental hazards, built environment, services, quality of housing, food and recreational resources, and aesthetic quality. Social environments are described by norms, local institutions, social cohesion and safety. The physical and social environments can cause or reduce stress via behavioural mediators. The result of these coping strategies is the health status. Included in the model are also effects of personal characteristics that are not reduced only to behaviour. Thus, biological attributes, material and psychosocial resources have an influence on the effects of the social and physical neighbourhood (Diez Roux & Mair, 2010).

To sum up, the four models highlight the importance of considering macro structural factors of the living context of the individuals. All authors of the presented frameworks commonly concluded that the living context is a complex construct consisting of multiple latent dimensions. When looking at factors that measure the specific latent and multifaceted conditions within a region, consecutively named macro factors, two major groups have to be distinguished which are explained in the next subchapter: Compositional factors and contextual factors.

### 4.4.2. Compositional factors

Factors of the composition of a population are aggregations of individual level attributes. The group is also termed derived or analytical factors (Diez Roux, 2003). If it is a meaningful indicator or not, every particular measureable attribute of the individuals can be combined to compositional factors by mathematical transformations. Important pre-conditions to generate valid, reliable, and comparable indicators are to ensure the harmonisation of the used definitions and the used aggregation measure, and the standardisation of the indicators to eliminate the effect of different sizes of populations. Established measures are means, medians,

proportions, dispersion measures, and composite measures like scores and indices of individual level or of aggregate level factors themselves (Kibele, 2012).

The underlying assumption of compositional factors is that a health disadvantage of an investigated population is the result of a high concentration of individuals with unfavourable health-related attributes. Consequently, the compositional explanation of health inequalities is that persons with these unfavourable attributes have worse health independently from their place of residence. Therefore, health policy and health research should focus on promoting health of the individuals solely (Macintyre & Ellaway, 2003; Macintyre, Maciver, & Sooman, 1993).

The problem in the interpretation of compositional factors that has to be avoided is to incorrectly identify the detected correlations between composite measures on associations at individual level. This problem is known as the ecological fallacy. A compositional factor should be correctly interpreted as a proxy for the social and physical environment of an individual or a subpopulation, defined as the ecological perspective (Macintyre & Ellaway, 2003).

Another problem in using compositional factors solely is that the complex underlying conditions at the present and the past state are ignored. The composition of a population is a result of systematic continuing processes or acute impulses of non-random selection by mortality (e.g. Lynch, 2003 and Zajacova & Burgard, 2013) and by internal intended or external influenced migration (e.g. Tong, 2000 and Kibele & Janssen, 2013). Then, the problem is to interpret the effect of social selection as social causation (Kawachi & Berkman, 2003). The extent of the compositional effects of these processes and impulses is mostly higher, the fewer the number of individuals within the observed spatial setting. Examples for these systematic or acute influences are – in case of mortality – famines or epidemics, and – in the case of migration – socioeconomic (like gentrification and ghettoisation) or ethnical segregation. As a result, the population in these regions are assumed to be more homogenous in specific genetic, behavioural, cultural or socioeconomic aspects than in the comparison regions. Ignoring the historic social context will lead to false conclusions. Thus, results from models including compositional factors should be interpreted in respect of the context of the regions.

### 4.4.3. Contextual factors

The second major group of macro factors are contextual factors. Context factors have in common that they do not have a straightforward linkage to individual level variables. More explicitly, all individuals living in the defined context are exposed to the common contextual factors independently from their individual attributes. The underlying assumption of contextual factors (contextual explanation) is that a health disadvantage is the result of differences

between the places. The health policy implication regarding the contextual explanation would be to promote the various health relevant conditions and services within a region to reduce health inequalities and to improve the health situation simultaneously for all inhabitants (Kawachi & Berkman, 2003).

Context factors are a class of group-level characteristics that can be subdivided into integral factors, environmental factors, and structural factors (adapted from Diez Roux, 2003). Integral factors are factors that describe the long-term constructed social, normative, and political context. Examples for the social environment are legislation, cultural traditions, historical background, health policy measures, or the availability of health care facilities.

Environmental factors are conditions of the ecosystem of the living context (Morgenstern, 1995). Factors of the ecosystem are climate, air pollution, noise, sunlight exposure and temperature. These factors are primarily not directly modifiable in terms of health policy measures. However, exceptions are modifications of the built environment or ecological policy regulations that in return affect the environmental conditions. Examples are the establishment of care-free areas or new recreational areas in cities, prohibition of unfiltered emissions (air, water, noise) of cars and factories, and local, national, and global ecological interventions.

Structural factors are attributes of the context that describe the interactions and networks of the individual within the groups in a region (Lazarsfeld & Menzel, 1971). Structural factors are mostly aggregates of individual attributes like compositional factors; however, they are more than a measure of concentration and density. Structural factors indicate the interpersonal cohesion, the social capital, the organisation and regulation of interaction, the transportation and the homogeneity/heterogeneity of norms and values of the individuals within a context. These factors have a positive or negative health effect in all persons living in the same context. Some examples for indicators of the group are size and composition of the households, average distance to next relatives, network size, and density of childless persons or volunteers within a region.

In conclusion, compositional and contextual factors are direct or indirect indicators of a universe of characteristics of the living context. Although, the conceptual distinction of the macro factors into compositional and contextual factors is an established approach, the interrelationship of these factors is very high. Compositional factors like the proportion of foreigners in a neighbourhood are highly correlated to, for example, the structural interaction, the cultural diversity, the built infrastructure and the range of facilities of a region. Furthermore, the health effects of population density – as a composite measure – can be explained by environmental, structural and integral characteristics. In addition, there exist reciprocal interrelationships for some of the factors (Blalock, 1984). In the case of these factors, individual-level variables influence group-level characteristics. One example is the density of pharmacies in

a region that is affected by health behaviours of the individuals. Thus, it is nearly impossible to identify the unmediated effects of compositional or contextual factors (Diez Roux, 2003).

The challenge of analysing the health influence of regional attributes, if they are measured either by compositional factors or by contextual factors, is to isolate the pure effect of the context. To achieve this objective, the compositional effects should be separated from contextual effects. Ecological studies are studies in which aggregates of individuals, e.g. subpopulations or small-area entities, are used as units of analysis. Study 1 and study 2 are ecological studies. The ecological design is an adequate method to investigate the variation among groups or regions (Diez Roux, 2003). From a public health and a local policy perspective, the ecological association between measures of population health and macro factors are of interest, as well as the comparison of groups and regions to quantify and classify the level of inequality. The problem of ecological studies, however, is that confounding individual-level variables and (in most cases) effects of compositional differences cannot be avoided. Further, the ecological fallacy is a problem in the interpretation of the results. In study 1 and study 2, the health outcome – long-term care need – is adjusted for age, sex and severity solely. The macro factors included in study 1 will be treated as attributes of the regions themselves and should not be interpreted as associations on individual level.

A research strategy that is able to examine groups or spatial entities and individuals simultaneously is the multilevel analysis. That design can estimate the individual-level (within-group-variability) and the group-level variability (between-group variability), and allows investigating the group-level variance after adjusting stepwise for individual characteristics (Diez Roux, 2003). In other words, compositional disparities are marginalised and contextual effects are highlighted. Study 3 is based on a logistical multilevel regression model. Up and till now, multilevel models have been the best choice, but these models have to deal with problems as well. The main challenges are the theoretical associations of the group-level and the individual-level constructs, the definition of relevant groups and the number of aggregation levels, and problems of model specifications.

Two examples for model specification problems are under-control and over-control.[1] In a multilevel model, contextual effects are detected as residual effects after adjusting for individual attributes. Under-control occurs when influential individual-level variables are missing (endogeneity problem), and over-control occurs when individual-level variables are included in the models that are on the causal pathways between area and health. Controlling for lifestyle factors which can be confounding but also intervening factors to explain regional mortality differences is an example of over-control (Ecob & Macintyre, 2000; Subramanian, Duncan, & Jones, 2001; Yen & Kaplan, 1999). Thus, the area effects are more weakened than

[1] For a detailed discussion of multilevel models see Subramanian, Jones, & Duncan 2003

necessary, but regional health inequality is immense if they remain also in over-controlled models (Macintyre & Ellaway, 2003).

### 4.4.4. Dimensions of macro factors

One of the main objectives in the study of geographical variations in relation to health is to reveal the etiological pathways of ecological determinants of health. Albeit, there is no clear consensus about the dimensions of the attributes of a living place that are of etiological significance (Macintyre & Ellaway, 2003).

An example for classification that uses etiological pathways on the individual level as categories for contextual factors is the socioecological typology (Bartley, 2004). The typology is mainly focussed on explaining the contextual wealth effect differentiated between a psycho-social, a behavioural, and material/neo-material dimension. In the psycho-social dimension, it is assumed that the psychological well-being of the individuals and the self-awareness of their role in the living context has an effect on health. A relative low role/status will cause stress. Low trust will further cause a bad quality of social relationships. The behavioural dimension explains unhealthy behaviours as a result of collective social reward/self-regulation. Individuals in a lower perceived position in society in relation to others are assumed to be less motivated to promote their health status and their social capital. Crime, homicide, and suicide are side effects of the negative self-perception. The material dimension explains the health situation as a consequence of the quality of public and social services like education, public transport, housing and health care (Bartley, 2004).

The operationalisation of the typology by Bartley (2004) is problematic. Another classification is the hierarchy of Cummins et al. (2005). Based on the Maslow (1968), Cummins et al. (2005) developed an extended hierarchy of human needs that should be covered by potential dimensions of features of the social and physical environment. The needs are - listed in dwindling importance: air quality, water quality, adequate food supply, having a shelter, security of locality, hygienic conditions, getting education, access to care facilities, access to housekeeping resources (e.g. food access, storage, preparation or cleaning of people, clothes and homes), gainful labour, places for (financial) exchanges, access to information (e.g. books, newspaper, communication services), private and public transport, the personal network (e.g. families, partners, friends), places for religious practices, places for social interaction (e.g. restaurants, sport clubs), places for political participation (e.g. social/political capital within a political organisation/party), and places of social, cultural, and physical recreation (e.g. cinemas, theatres, parks). This theorised typology can be used as a baseline standard to classify the quality of neighbourhoods. When the classification should be used for neighbourhoods in welfare states, the variation of the regions in terms of the fundamental human needs is assumed to be much lower than in the developing countries. In the case of

Germany, the regional variance is expected to be more pronounced in the higher level needs.

Another suggestion for a more consolidated classification is given by Macintyre et al. (1993) (1993). They defined five dimensions of neighbourhoods (discussed in Macintyre & Ellaway, 2003):

1. Physical aspects environment (e.g. air and noise),
2. Healthy aspects of environment at home, work, and play (e.g. secure and non-hazardous housing, employment, and play areas for children),
3. Service aspects of a locality (e.g. education, transportation, policing, health care),
4. Sociocultural aspects of the locality (e.g. political, economic, ethnic features), and
5. Aspects of reputation of the locality (e.g. perception of the residents or of investors).

As already mentioned, this classification is not complete since integral measures of material and social capital are missing (Macintyre & Ellaway, 2003).

Glass and Balfour (2003) focussed on the domains of neighbourhood that are potentially independent aspects that effect health of the elderly and that are potentially modifiable by health interventions. They identified four dimensions: Socioeconomic conditions, social integration, physical aspects of place, and services and resources.

Very similar to the concept of Glass and Balfour (2003) is the classification by Kibele (2012). She used four aspects to investigate spatial mortality inequalities (in adapted order): Socioeconomic conditions, demographic structures and composition, environmental conditions, and medical care provision.

In the next subchapters, an overview of findings in the literature should be given based on the classifications of Glass and Balfour (2003) respectively Kibele (2012).

#### 4.4.4.1. Socioeconomic conditions

The socioeconomic structure and performance is by far the most often investigated dimension of regional attributes (Glass & Balfour, 2003; Kibele, 2012). The wealth of a region indicates multiple aspects of health effects. From the administrative perspective, wealthy regions are assumed to have more options to introduce health promotion programs or to make investments into health infrastructure. These measures affect the individuals mostly independently from their individual social status. Prosperity further indicates better living conditions, better job opportunities, and improvements into the built environment, as well as in the cultural environment. If it is not solely caused by automatization or fundamental structural transition of the economy, economic growth has positive effects on occupation and reduces unemployment. High levels of the average household income may be interpreted as a higher potential to invest in social activities and healthy lifestyles. Educational composition is associated with the risk of poverty and job opportunities. In addition, the extent of social inequality

is a determinant of health independently from the general level of wealth. The social status of a subpopulation is assessed by the individual in relation to the social status of other subpopulations within the same region. Relative deprivation causes psychosocial stress due to the competing atmosphere that further leads to higher morbidity and mortality (Marmot, 1994; Siegrist, 2000; Wilkinson, 1992; 1998).

In the international literature, there is an enormous body of studies that highlight the negative health effects of the socioeconomic conditions and of high social heterogeneity of the living context (e.g. reviews by Pickett & Pearl, 2001, by Riva et al., 2007, and by Yen, Michael, & Perdue, 2009).

In comparison, the number of studies investigating contextual effects on health, health-related behaviour and mortality for Germany is relatively low, but increasing nevertheless.

In the case of mortality, economic wealth has been shown to be positively associated with a lower risk of mortality in regions of Bavaria and Baden-Württemberg (Gaudecker & Scholz, 2007; Kuhn, Zirngibl, Wildner, Caselmann, & Kerscher, 2006) and in German regions in total (Brzoska & Razum, 2008). Kibele (2012) found a positive association of life expectancy with average disposable income per capita and GDP per capita.

However, there are also contrary results. For the period 1984 to 1986, no evidence for effects of regional deprivation on cardiovascular mortality was found by Breckenkamp et al. (2007), as well Schwierz and Wübker (2010) stated no effects of contextual socioeconomic factors on ischemic heart disease in Germany between 1996 and 2004.

An unfavourable situation in the case of unemployment and type of occupation has negative impacts on general mortality (Albrecht, Naplava, & Schloosch, 1998; Grobe & Schwartz, 2003; Queste, 2007) and for postneonatal mortality (Nolte, Koupilova, & McKee, 2001). The GDP per capita (females), unemployment rate, and the proportion of employees with university degrees (both sexes) were shown to be associated with the mortality of people aged 65+ in 1998 to 2004 in Germany (Kibele, 2008). The proportion of school graduates without any degree was associated with the level of life expectancy, but was not linked to the trend in life expectancy (Kibele, 2012).

In the case of morbidity, Wolf (2004) showed worse physical health in urban districts of Cologne with weaker socioeconomic conditions. Diehl and Schneider (2011) stated statistically significant higher odds of poor self-rated health for individuals living in regions with a high unemployment rate. Voigtländer et al. (2010b) found evidence for a significant association between regional deprivation, measured by the average purchasing power of the street section, and physical health, measured by the SF-36 score - even after adjusting for age, gender and individual income.

Further, higher unemployment rates are also linked to a higher risk of type 2 diabetes (Müller et al., 2013), a higher prevalence of obesity of non-German youths (aged 13-15 in the city of

Kiel in northern Germany; Lange et al., 2011), and cardiovascular risk factors like smoking and coronary artery calcification (Dragano et al., 2007; 2009b).

Negative effects on self-rated health and health behaviours (e.g., physical inactivity, alcohol consumption, obesity, unhealthy diet) due to socioeconomic disparities measured by indicators such as the proportion of persons leaving school with a higher education entrance qualification or the disposable household income were stated for the Bavarian regions (Kemptner et al., 2008).

#### 4.4.4.2. Social integration

The social organisation of neighbourhoods is one of the oldest research fields concerning individual wellbeing. Durkheim (1951) investigated in his study "Suicide: A Study in Sociology" how individuals are linked to the society and identified two types: attachment and regulation. Attachment is achieved due to stable ties with other members of the society and regulation is the control of individual behaviour due to societal norms, values and beliefs. Further, he established a 4-group-classification of types of suicide from which two types are assumed to be influenced by the degree of social integration. By focussing on the health of elderly, Glass and Balfour (2003) sub-classified the dimension of social integration into three groups: social capital, fear and crime, and age concentration.

The concept of social capital of the neighbourhood is a broad field; however, due to the complexity in the operationalisation, the findings are hard to compare. Social capital is associated with residential stability, inter-individual trust, willingness and ability to exercise control in the neighbourhood (Greenberg & Schneider, 1997). It is assumed that high social capital causes low environmental press and high buoying. For the elderly, social capital may be the willingness to assist if they need help, feel secure, and offer opportunities for social activities and participation (Glass & Balfour, 2003). Beard et al. (2009) stated positive effects of collective efficacy on disability of the elderly.

Fear of crime is the second aspect; however the results in the literature are inconsistent. Fear is linked to psychological stress and reduces well-being. Bazargan (1994) found a lower well-being and lower mobility of elderly with fear of crime, but no effect on the self-rated health status. Krause (1993) concluded that distrust and social isolation is promoted in elderly living in self-perceived unsecure neighbourhoods. In return, social isolation has a negative effect on health (Balfour & Kaplan, 2002). Homogeneity in terms of age is the third aspect of Glass and Balfour (2003), which will be extended to other individual attributes in the following. Age homogeneity also showed inconsistent health effects. For older people, living in a region with a high older age concentration is assumed to be associated with a higher density of services or of social support networks that influence the knowledge and the access to services. Also negative effects are stated and were explained by the perceived burden that is the consequence of the high need of supporting the neighbours (Glass & Balfour, 2003).

In the case of Germany, Pollack and dem Knesebeck (2004) suggested an association of a lack of reciprocity with poorer self-rated health, and a correlation of a lack in participation with poorer self-rated health and depression. A distant relationship to the neighbours also shows a positive association with self-rated health Pollack (2004), as well as a high social support is linked to life satisfaction and mental health, but not to physical or self-rated health (Eibich, Krekel, Demuth, & Wagner, 2016).

The heterogeneity of the composition of a neighbourhood has become a separate research sector in health research. Heterogeneity is achieved by residential segregation that is defined by the five geographic patterns: isolation, centralisation/peripheralisation [2], clustering, concentration and unevenness (Acevedo-Garcia, Lochner, Osypuk, & Subramanian, 2003; Massey, White, & Phua, 1996). Two types of residential segregation are of special interest: Racial segregation or social class segregation. Although, both types are based on divergent socio-structural characteristics (horizontal versus vertical perspective of social structure), they are highly correlated. Since social class segregation is assumed to be merely linked to socioeconomic conditions, the racial segregation is of higher interest in the following. The extent of racial segregation varies by the amount of migrants within a country, the cultural distance between the migrants and the host country and the level of inclusion and discrimination. However, also choices and preferences, due to the existing or expected social capital within the community networks, which may cause chain migration to segregated areas (reviewed examples for the USA in Acevedo-Garcia et al., 2003). Racial aggregation is assumed to have a bipolar impact on the health of the ethnical groups. The most frequently discussed point is the problem of the high correlation of racial segregation with the socioeconomic segregation, since ethnic groups are often in a derivate situation. In addition to the economic perspective, social isolation in terms of absence of ties to individuals and institutions that promote social participation and interaction - which in return may also provide economic opportunities - is assumed to be one mechanism of deteriorating health (Wilson, 1996). On the other side, segregation may have a protective effect since segregated communities have the beneficial effect of providing support and sociability, their members are of close distance (availability), and have a higher internal feeling of solidarity (Wellman & Leighton, 1979). While Markides and Coreil (1986) considered a health advantage of segregated Hispanics in the USA in comparison to the non-Hispanic counterparts of the same socioeconomic status (called the Hispanic or epidemiologic paradox), the most later studies show no protective effect of structural social capital for Hispanics and foreigners in the US (Acevedo-Garcia et al., 2003).

[2] Centralisation as concentration in the city centre is a dimension of segregation of ethnic groups in the USA, where the housing quality in the city centre is low. In European countries, the urban periphery is the dominant location of ethnic or low social class segregation (process of peripheralization).

#### 4.4.4.3. Physical environment

Another dimension of regional attributes is the build and natural environment within the region. This dimension covers effects of ecological conditions like sunlight exposure or temperature, as well as human influenced environmental conditions such as noise and air pollution. The last group of environmental conditions are the direct and indirect result of the physical structure of the living region, e.g. in terms of housing density, land-use diversity, traffic and trash aspects, and proximity to heavy industry. Besides the direct biomedical effects of intoxication, environmental conditions affect the health status by causing cardiovascular stress (Cohen, Krantz, Evans, & Stokols, 1981), causing a less active lifestyle and reducing the wellbeing (Lawton, Nahemow, & Tsong-Min-Yeh, 1980). This is assumed to be a more influential factor for persons with constrictions of life-space diameter (range of daily activities), especially persons with mobility limitations (Glass & Balfour, 2003).

In the case of mortality, Heins and Stiens (1984) concluded that 16% of the overall mortality in the 1980s in Germany was caused directly or indirectly by environmental factors. In contrast, recent studies suggest no or inconsistent environmental effects on mortality which may be a problem of the interference with the socioeconomic context (Cischinsky, 2005; Gatrell & Elliott, 2015; Gaudecker, 2004; Kohlhuber, Mielck, Weiland, & Bolte, 2006; Peters et al., 2000).

In health research, Heinrich et al. (1999) detected regional disparities in health that reflects the regional patterns of air pollution. Like for mortality, environmental effects and socioeconomic effects on health are severely interrelated. Pollack et al. (2004) concluded that perceived noise and perceived air pollution have a mediating effect on the pathway from housing tenure to self-rated health. Voigtländer et al. (2010b) stated that the effect of economic deprivation on health after adjusting for environmental characteristics of the neighbourhood (perceived air pollution, perceived noise and perceived distance to recreational resources). However, the effect of deprivation does not completely disappear. Additionally, the distance to major roads shows to have a negative impact on coronary artery calcification (Dragano et al., 2009a).

#### 4.4.4.4. Services and resources

Closely related to the physical aspects of the living area are aspects of services and resources. Blake et al. (1975) defined three dimensions that are perceived as the favourable neighbourhood: relationship with the neighbours, access to sources of personal development (e.g. parks, sport areas, entertainment facilities), and the availability of high-quality and varied goods and services (e.g. health facilities, public transport, stores, jobs, schools, restaurants). Carp and Carp (1982) found that the last dimensions are of highest importance for persons at age 25 and older. Distance to school, job and freeway are of high importance for younger adults, while the elderly prefer a short distance to the next bus stop. Availability of

high-quality services was highly rated by persons at all ages. Centrality to the city centre (measured as a proxy for access to services) was positively linked with well-being (Carp, 1975).

Studies about the situation in Germany have found that a high degree of rurality is associated with a higher risk of poor self-rated health (Diehl & Schneider, 2011). The authors assumed that the more vibrant social life and cultural richness in regions with a high degree of ethnic diversity may promote health. Lower levels of infrastructure (Voigtländer et al., 2008) and a higher degree of isolation of the elderly (Brody, 1979; Cassel, 1996), which may affect their ability to reach their physicians or participate in social events, are explanations for the detrimental effects of rurality.

In contrast, urbanised regions and its infrastructure may have negative health effects. The social structure and the local infrastructure is correlated with lifestyle factors like obesity, media consumption, and eating and snacking habits. Lange et al. (2011) stated a significantly higher prevalence of obesity for non-German youths (aged 13-15 in the city of Kiel in northern Germany) and for youths in general who live in areas with a high traffic density, and a high density of fast-food restaurants, kiosks, takeaways and bakeries.

In the case of the health infrastructure, an egalitarian access to the health care system is officially guaranteed to all citizens of a member of the European Union by law in Germany. Emergency medical services are open to all persons in Germany. Besides the official regulations, there may be differences by factors of availability, provision, access to, utilisation and quality of the medical care (Curtis, 2007). In a rationalised perspective, the density of physicians is lower in East German regions (Kopetsch, 2004) and the specialised high-quality medical facilities are condensed in urban areas (Kibele, 2012). While the density of physicians has increased from 1995 to 2005, some counties (almost without exception in East Germany) showed a decrease in the density (Voigtländer et al., 2010a). However, the effects on health and mortality are inconsistent. Studies suggest a positive association (Kibele, 2012), no direct or counterintuitive findings (Albrecht et al., 1998; Cischinsky, 2005; Eibich et al., 2016; Gaudecker, 2004; Kibele, 2012; Kuhn et al., 2006; Lhachimi, 2008; Young, 2001). These results may be explained by reverse causality. Since the supply in services is a self-regulating or policy-influenced process, a high density of service providers may also be a response to a high need in services. Additionally, the persons with need for better medical aid can be transferred to regions with a better health service structure and are not limited to their living regions (Kibele, 2012; Young, 2001). When considering the health of migrants, additional barriers to the health care services have to be considered. In general, the access of migrants in Germany is stated to be worse than for the non-migrant population (Razum, Geiger, Zeeb, & Ronellenfitsch, 2004). For large urban areas with established ethnic communities and with services offered by or sensible to members of these ethnic groups, it can be assumed that the barriers are lower than in other regions.

### 4.4.5. Micro-Macro-Level Interaction

In the previous literature review, various studies found evidence for positive, negative or ambiguous effects on the health of individuals due to individual-level attributes and context-level attributes. As already mentioned, the particular dimensions of micro-level characteristics (e.g. in a socioeconomic, behavioural/cultural, socio-psychological or life course perspective) are highly interrelated as well as are the contextual factors (e.g. the socioeconomic conditions, the grade of social integration, the attributes of the physical and environmental context or the access to services and resources). To correctly reflect the real complexity of the determinants of health inequalities, the interaction between micro-level factors and macro-level factors also have to be considered.

In a deterministic framework, the assumptions may be that individual factors have a universal effect on health that is common ("fixed") in all contexts (e.g. the social gradient of health). Additionally, the effect of the contextual attributes are assumed to be common for all individuals within the context – meaning that the level of health is different between contexts of different attributes, but the relative health positions of the individuals among the particular contexts is fixed as well. Vice versa, it is expected that there is a universal effect of context (e.g. high employment rate) on all individuals independently from their individual attributes (e.g. unemployed). Depending on the used theoretical approach (e.g. biomedical or genetic deterministic pathways), the assumption may be adequate. However, the literature gives evidence for a complex variable interplay of micro and macro level factors (Pickett & Pearl, 2001; Riva et al., 2007).

The framework of Glass and Balfour (2003) considers such a cross-level interaction. In the causal model of neighbourhood effects on ageing, the personal competencies have a substantial position in the reciprocal interplay with the environmental press and buoying. Individual attributes determine the personal competencies and are themselves affected by health problems. The personal competencies are the individual's resources to modify the contextual effects (e.g. by coping strategies). As a result, the individual-level effects may vary by different contextual influences.

However, the concept of estimating cross-level-interactions is assumed to be fruitful, the requirements in the database are high. Pickett and Pearl (2001) and Riva et al. (2007) reviewed multilevel studies that stated insignificant but also significant cross-level-interactions. The significant results indicate a more marked effect of bad socioeconomic conditions on health, unhealthy behaviours and mortality of persons with a low individual socioeconomic status and among women.

### 4.4.6. Challenge in the definition of spatial units

A key issue in the research of contextual effects in both ecological and multilevel studies is the definition of relevant spatial units. The definition can be based on historical, geographical, shared identity or administrative criteria Diez Roux (2003). The definition and operationalisation should be in line with the presumed underlying pathways of the contextual effects of health and should correspond to the geographical distribution of the causal factors. In return, the choice of the spatial units depends on the choice of the contextual variables that are of interest, and also on the availability of these data. For instance, perceptions of social capital are more relevant for self-defined neighbourhoods, while the density of health service facilities is meaningful at higher levels of aggregation (Subramanian, Jones, & Duncan, 2003). The homogeneity of the population composition is also an aspect that should be considered. A very high level of homogeneity within the spatial entities makes a contextual analysis irrelevant. In contract, a very high heterogeneity, limits the plausibility of compositional factors like averages and medians (Pickett & Pearl, 2001). Directly associated with the compositional homogeneity is the method of sampling of the individuals and the spatial entities. If complete surveys of all individuals and all regions are not used, the selection must be representative on the regional level and additionally on an individual level within the regions. Further, the general assumption (exchangeability criteria) of multilevel models is that the sampled spatial units are drawn from a single basic population for which inferences are of interest (Subramanian et al., 2003).

A last general challenge in the choice of the spatial entities is the so called proximity problem. The problem of the operationalisation of living contexts is the assumed discrepancy between prior defined spatial entities and actual spatial spheres of interaction of the individuals. For most of the sub-national entities, the external defined borders like administrative borders are mostly fictional and independent from the action space of the individuals. When contextual factors are analysed, mostly the sole effect of one defined context of individuals are considered. However, the individuals can be affected by factors of the surrounding contexts depending on the individual mobility options and the efficacy of the infrastructure. One example is health care facilities in urban regions that also have positive effects on the health of the suburban regions. In the case of older people, it can be assumed that there is an ongoing decrease of the action space (Glass & Balfour, 2003).

## 5. The case of Germany

### 5.1. Historical specifics in terms of health policy

Since health is a continuing changing status, present health inequalities between subpopulations are also a result of past contextual influences and their changes over a wide time per-

spective. Based on the concepts of the life course approach, the causes of a poor or good health status at middle and higher ages may be explained - besides genetics and individual behaviours - by contextual conditions at a particular (or critical) period of lifetime. Thus, a historical overview provides arguments as to why the German case is of broader general interest for international research, as well as for the evaluation of the national and sub-national health care system.

As a country in the centre of Europe and as a reflection of the chequered and the closely interlinked European history, Germany is an interesting field for investigating spatial inequalities in health due to various aspects (in historical order):

1) The long tradition of the welfare system and the principles of solidarity and subsidiarity of the health care policy.

2) The high level of territorial and political segmentation of the regions that are on the area of the nowadays Federal Republic of Germany and were of highly different economic and technological stages of development.

3) The reintroduced historical political separation of the former two parts of Germany after the Second World War that was finished by a systematic breakdown and restart in the Eastern part.

4) The long-time in-migration of (Spät-)Aussiedler, former out-migrated ethnic Germans and their families, with an unexpected high increase in the in-migration in the years of the breakdown of the German Democratic Republic (GDR) and with a privileged access to the social security and health care system compared to other migrants in Germany.

5) Finally, the almost high and increasing proportion of persons at higher ages that lived for a long time in peace and with economic growth.

### 5.1.1. The German health care system

The German health care system is the world's oldest and one of the most extensively developed and most comprehensive systems (Porter & Guth, 2012). It was introduced in 1883 under the leadership of Chancellor Otto von Bismarck. Bismarck expanded the reach of existing mutual-aid societies that existed since the time after the Middle Ages. The Health Insurance Act initiated a statutory (mandatory and compulsory) health insurance (Kamke, 1998).

Further, mandatory health plans were established called the Bismarck system or Bismarck model. The social security system was enhanced by introducing the workmen's compensation insurance (1884), the pension insurance (1889), the unemployment insurance (1927), and the long-term care insurance (1995). The long-term care insurance is - with a long temporal gap compared to the other welfare programs - the fifth column of the German Social Code (Sozialgesetzbücher) and the newest of the health security reforms. The health system bases on contribution-funding and these contribution funds are earmarked, and thus, not tax-funded and independent from the control of the state. Solidarity and subsidiarity are the fundamental principles of the German health care system. The principle of solidarity means that all members of a society are responsible to ensure an adequate level of well-being of all other members of the society (Kamke, 1998). From a financial perspective, the contributions are linked to the ability to pay. The participation is mandatory (89.7% in 2010) unless a citizen is covered by the private system (10.2% in 2010). Premiums that are equally financed by the employers and the employee (pay-as-you-go system) depend on gross income and not on medicals risks or health care utilisation. Only private health plans are allowed to reject applicants (Porter & Guth, 2012).

The second principle, the subsidiarity, limits the responsibility of the state. The idea is that the state should not be responsible for functions that could be better or at least equally well solved by the individual, the family or private self-organisations (Kamke, 1998). Based on the subsidiarity principle, the principle of administrative autonomy of the statutory health insurance was established which implies that there is no governmental agency involved in the health insurance. This is in contrast to centrally directed systems like the health system in the United Kingdom. Concerning the health policy, the Federal Ministry of Health is the major instance in the health policy in the federation as total (Institute for Quality and Efficiency in Health Care (IQWiG), 2015). Tasks of the ministry are to plan new laws in the health sector, to control the health care providers and the quality of health care by administrative guidelines, and to supervise institutes that are responsible for health issues on a national level like vaccines, approving of pharmaceuticals, or narcotics and addiction risk prevention. Concerning aspects of the statutory health insurance, the federal ministry is only a regulator of independent, statutory, and semi-statutory health agencies (Kamke, 1998). The highest federal-level entity of self-government of the statutory health insurance system is the Federal Joint Committee (Gemeinsamer Bundesausschuss, GB-A). This committee consists of five representatives of the health plans, five representatives of the providers, and three independent representatives from which one is chairing the committee. All members have equal voting power. Accredited patient organisations can participate but have no voting rights (Porter & Guth, 2012).

Of particular interest in the following analyses is the German long-term care system (overview by Institute for Quality and Efficiency in Health Care (IQWiG), 2015*)*. In 1995, the 5th

pillar of the social security system was introduced as a mandatory insurance (Social Code Book, Part XI). At this point of time, all public health insured persons in Germany were also public long-term care insured, while private insured persons were engaged to accede a private long-term care insurance. The main objective of the statutory long-term care (SLTC) system is to support the persons in need of care and their families to live as long as possible in private households by reducing the physical, mental, and financial burden of providing care. One additional effect is to establish a market of health service providers that offer assistance to the care givers. The benefits from the SLTC insurance include financial support, counselling for persons in need of care, training courses for family care givers, in-kind benefits or co-payments for nursing homes. Recipients of cash benefits were only visited by a professional care giver twice a year to ensure an adequate quality of care. The benefits are legally independent from age, sex, income and wealth; but, only vary by the grade of care need, named as care level. The care levels are defined by the type, the frequency and the amount of time of the assistance in (at least two) activities of daily living (ADL) and an (additional) instrumental activity of daily living (IADL) when the assistance is required over a long period. Persons with care level 1 need support at least once a day in one or more ADL (hygiene, feeding, and mobility) and additional one IADL in several times a week for at least 90 minutes a day from which 45 minutes are used for personal care. Care level 2 covers persons who need support at least three times a day in two or more ADL and additional one IADL several times a week for at least three hours a day from two hours for personal care. Into care level 3 and hardship cases are persons classified who need to be assisted in at least two ADL around the clock and need additional help in IADL several times during the week for at least five (seven in case of hardship) hours per day with four hours needed for personal care or - in the case of hardship - at least two hours during the night or basic care by more than one helper at the same time. The evaluation of the care level is conducted by the Medical Advisory Board of the Statutory Health Insurance Funds and the medicproof GmbH is responsible for the evaluation of private insured persons. The guidelines for the assessment procedures are nationwide harmonised and the assessment is done in-home (at home or in the nursing home) households together with the care givers by geriatric-trained physicians and nurses. In the case of a negative decision or in the case of an expected change in the care level, reassessments can be applied for without negative consequences (Institute for Quality and Efficiency in Health Care (IQWiG), 2015).

The choice of the health plans and health providers is free (except for inpatient rehabilitation facilities). Outpatient care is provided by self-employed doctors, dentists, psychotherapists and other professionals (predominantly) with a statutory health insurance accreditation (Kassenzulassung). Inpatient care is offered by hospitals independently from whether the patients are statutory or private ensured. Hospitals are financed by the federal state, the city or the municipality, by private semi-public or non-profit-making organisations like the Red Cross or

religious groups, or by profit organisations (Institute for Quality and Efficiency in Health Care (IQWiG), 2015). By law, all German citizens have an equal excess to fundamental inpatient and outpatient care independently from individual attributes; however, with some restrictions to access specialised hospitals or to get specific expensive health services that are only for private insured persons.

The present-day health security system is also a result of the political, economic and societal history of Germany. Therefore, an overview of the German history is of interest.

### 5.1.2. A history of territorial segmentations and unifications

At the beginning of the 20th century, most of the German Empire was agrarian - however - with some urban concentrations. Due to the rapid industrialisation there was an ongoing trend of urbanisation, but also problems in terms of hygiene conditions in the big cities. This resulted in an increase in urban morbidity - especially infectious diseases - and mortality - especially infant mortality (Woods, 2003). An outstanding overview on the regional mortality disparities is given by (Kibele et al., 2015). In the study, the highest life expectancy in 1910 was stated for the northern and central German regions and the lowest values for south-eastern regions (Bavaria) and Silesia. These patterns are driven and consistent with the geographic patterns of infant mortality of the period (Klüsener et al., 2014). In the 1980s, Kintner (1987) already suggested a link between infant mortality and the prevalence of breastfeeding. It is assumed that breastfeeding has a protective effect on health of the new-borns, while feeding with meal pap has a negative effect due to diseases in the used water. The tradition of feeding meal pap was practiced over a long time in Bavaria and is also expected to affect health over the long period at higher ages (Klüsener & Scholz, 2013). This is an example of cultural and religious differences even with regions that are now part of Germany.

Further, Kibele et al. (2015) found evidence for a positive correlation of the economic condition measured by the GDP with the level of life expectancy, but with the exceptions of the cities of Berlin and Hamburg. Economic development was lower in the southern regions that was landlocked and far away from the access to harbours, where societal development and economic growth earlier spreads over the country (Klüsener & Zagheni, 2014). Environmental disparities with their effects on harvest variability are also assumed to explain the mortality disparities (Kibele et al., 2015). Bad weather conditions such as extreme heating or cold are expected to be more frequent in southern than in northern regions.

In the years after 1910, there was a high increase in life expectancy, mostly due to decline in infant mortality. On the regional level, Kibele et al. (2015) stated a convergence of infant mortality in the 1920s and 1930s.

After the Second World War and more than 70 years after the unification in 1871, Germany was again socially and politically departed. The Federal Republic of Germany (FRG) was

established in the western part and the German Democratic Republic (GDR) in the eastern part. The two German states - with the same experience of the Bismarck model of the health security system - rebuilt different health care systems after their founding. The health system of capitalistic oriented West Germany was continuously reformed but unchanged in its fundamentals and was adapted to the health system of the unified Germany (Simon, 2005). In contrast to the decentralised system in the FRG, the health system of the communistic/socialistic oriented East Germany showed particular differences. The health system was a centralised and state-run delivery system (Altenstetter, 2003). The improvements in health of children and workers was prioritised in the GDR while the support in curative and preventive treatments for persons at older ages was higher in the FRG than in the GDR (Kibele, 2012). Further, financial problems in the later years of the GDR lead to a lack in medical technologies and infrastructure (Swami, 2002). Other explanations for context-originated health differences are differences in environmental hazards, in job and living conditions and in psychosocial stress. The higher air pollution in the mining and industrial areas in the GDR than in those of the FRG is assumed to cause health differences (Brüske-Hohlfeld et al., 2006), however, also contrary results in the case of higher life expectancy in the more polluted south were stated (Dinkel, 2000; Luy, 2004). Differences in life style and job conditions are controversial cases of East-West health inequalities. Health effects of work were found, but with less explanatory power for the health disadvantage of the East (Lüschen, Niemann, & Apelt, 1997). The decrease in cardiovascular diseases was explained by favourable changes in the diet like more fresh fruits and vegetables (Nolte & McKee, 2000).

It is assumed that political repression and unfavourable living and working conditions lead to psychosocial stress which in turn resulted in cardiovascular diseases, addiction to alcohol and tobacco, and in a higher risk of suicide. The opposite argument is that social and job security in the GDR resulted in lower stress. Up till now, both arguments are not proven to be true (Kibele, 2012).

In addition to these contextual explanations, there are also methodological (political influence on data, disparities in definitions, level data quality) and compositional (selective migration) explanations, which were discussed in Kibele (2012).

In the small-area perspective, the disparities in mortality, in morbidity due to traffic accidents, in cancer prevalence, in stroke incidence, in alcohol-related morbidity, and in the prevalence of infectious and parasitic diseases was higher in the FRG than in the GDR, and higher for men than for women (Becker & Wahrendorf, 1998; European Communities; Giersdorf & Lorenz, 1986; Jöckel, 1989; Nowossadek, 1994). Rural-urban disparities were not pronounced in the GDR, but there was a disparity in the FRG. Those are explained by behaviour-related, environmental and occupational factors (Kibele, 2012).

In the period around 1990, the situation has dramatically changed in the regions of the former GDR and there were also effects on the regions of the FRG. By the reunification of

Germany, the political and economic system, as well as the health care system of the FRG was adopted by the East German regions. These multidimensional changes is an outstanding example of a natural experiment in health research, where the results of the drastic breakdown of the economy, the introduction of a new social security system, the psychosocial stress due to the subjective insecurity, and the immense long-term improvements in the health infrastructure can be investigated. There was a temporary decrease (Bobak, M., Marmot, M.; Watson, 1995) followed by a steep increase in life expectancy at all - even the highest - ages in the years after the reunification (Gjonca, Brockmann, & Maier, 2000; Scholz & Maier, 2003; Vaupel et al., 2003). The introduced public social security transfers in the East caused a reduction in the health inequalities between East and West, while the unequal pace in the medical modernisation - with the higher pace in the East German university cities - resulting in an increase in spatial health inequalities (Vogt & Kluge, 2015; Vogt & Vaupel, 2015).

### 5.1.3. Internal migration, international migration and ageing

At the beginning of the 1990s, Germany experienced an extraordinary high level of migration to and within the reunited nation. Due to the fall of the Berlin Wall, the citizens of the former GDR were allowed to move to any other region of the country. Thus, there was a high level of migration from almost every region in eastern Germany to regions in western and southern Germany. Most of these internal migrants were young people who hoped to gain a better job opportunity. As a consequence of the healthy (internal) migrant or healthy worker effect, the population composition of the regions in the West German regions was more favourable in terms of health and mortality or in terms of health and mortality related attributes (Cischinsky, 2005; Kuhn et al., 2006; Lhachimi, 2008; Luy & Caselli, 2007; Schneider, 2005).

Furthermore, international in-migration rapidly increased in the early 1990s due to two historical processes. First, the Yugoslav Wars started during which time a high number of asylum seekers especially from Bosnia-Herzegovina and Croatia moved to Germany to escape from war. Most of them returned to the new founded republics in the years after the end of the war (Herbert, 2003). Second, the in-migration of ethnic Germans repatriates, in the following called Aussiedler, rose due to the political transition in the Eastern European countries. The Aussiedler migration was not a new phenomenon, since there was a continuous inflow since the 1950s (Federal Office for Migration and Refugees, 2013). However, the extent in this short period was unexpected. The attributes of this particular group of population is of interest in health research and will be discussed in a separated subchapter.

Ongoing internal and international migration affects the composition of the respective regions in diverse aspects. Studies (Bucher, Schlömer, & Lackmann, 2004; Höhn, Mai, & Micheel, 2007) concluded that there was a bipolarity between growing and rejuvenating regions, predominantly in the economic flowering regions in western Germany and shrinking and aging

regions in eastern Germany but also in mainly old-industrialised regions like Bremen, the Ruhr and the Saar region, where natural decrease were not compensated by internal and international in-migration (Bucher et al., 2004; Höhn et al., 2007).
In sum, Germany is an interesting case to study the trends and factors of health inequalities on the small-area level but also for particular subgroups with a privileged status in the health care system.

## 5.2. Time trends in the health scenarios in Germany since 2001

Whether the increase in life expectancy is linked with a gain in healthy or unhealthy life years is of high interest in theoretical and in empirical health research. Due to the enduring improvement in the availability of health data over a long period, the number of international studies is very high. Three reviews, for example (Christensen, Doblhammer, Rau, & Vaupel, 2009; Crimmins & Beltran-Sanchez, 2010; Freedman, Martin, & Schoeni, 2002) stated inconsistent trends by severity of a health problem in the highest developed countries. The results show a dynamic equilibrium with expansion in mild health problems and stability or compression in severe disability. These conclusions fit the dynamic equilibrium scenario. The authors add for consideration that the conclusions are limited due to comparability problems, since there are differences in the characteristics of the population under study (e.g. age groups, inclusion of institutionalised persons), in the choice of the health indicator (e.g. incidence, prevalence or composed measures), in the design of the data (survey or administrative), and in the choice of the time perspective (short-time versus long-time perspective, effects of societal, political and medical changes).

In the case of Germany, fourteen studies published since 2001 were identified which focussed on health trends over the last decades in relation to people living in Germany (Table 1). The studies differ by the dimensions of health. The picture of the health trends is inconsistent.

The majority (eight) of the selected studies found a decreasing incidence (Ziegler & Doblhammer, 2008), prevalence (Unger, 2006) and a compression of long-term care, functional limitations and disability (Häcker & Hackmann, 2012; Hackmann & Moog, 2009; Klein & Unger, 2002; Kroll, Lampert, Lange, & Ziese, 2008; Pinheiro & Krämer, 2009; Unger, 2010). The results of four studies can be interpreted as evidence for the dynamic equilibrium hypothesis (Gärtner & Scholz, 2005; Pattloch, 2010; Unger, Müller, & Rothgang, 2011; Unger & Schulze, 2013). Two studies (Doblhammer & Kreft, 2011; Trachte, Sperlich, & Geyer, 2015) were unable to differentiate between compression and dynamic equilibrium, and only one study (Hoffmann & Nachtmann, 2010) found a relative expansion.

*Table 1: Selection of studies investigating the health scenarios in Germany, since publication year 2001*

| Study | Type of health | Ages | Country/ region | Time | Results | Regional comparison | Type of data |
|---|---|---|---|---|---|---|---|
| Ziegler & Doblhammer, 2008 | Long-term care (incidence) | 60+ | West Germany | 1986-2005 | Decrease[3] (cohort and household perspective) | 2 regions | Survey |
| Unger, 2006 | Disability (ADL), health satisfaction (prevalence) | Cohorts 1921, 1927, 1933 | West Germany (until 1991), Germany (since 1991) | 1984-2003 | Improvements mainly for younger cohorts | no | Survey |
| Klein & Unger, 2002 | Chronic disease | Cohorts 1917, 1922, 1927 | West Germany | 1984-1999 | Absolute Compression (cohort perspective) | no | Survey |
| Kroll et al., 2008 | Limitations in daily activities | 16+ | Germany | 1995-2003 | Absolute Compression | no | Survey |
| Hackmann & Moog, 2009 | Long-term care (in general; incidence) | All ages | Germany | 1998-2006 | (Slight) **Compression** | no | Administrative |
| Pinheiro & Krämer, 2009 | Long-term care (in general and severe) | All ages | North Rhine-Westphalia | 1999-2005 | Compression | no | Administrative |
| Unger, 2010 | Disability | Cohorts 1900-1950 | Germany | 1984-2001 | **Compression** | no | Survey |
| Häcker & Hackmann, 2012 | Long-term care | All ages | Berlin / Germany | 2000-2009 | **Compression** (but: policy influence assumed) | no | Administrative |
| Gärtner & Scholz, 2005 | Subjective health | 45-69 | West Germany | 1984-1998 | Relative expansion | no | Survey |
| | Health problems | | | | Relative compression | | |
| Pattloch, 2010 | Long-term care (by severity) | All ages | Germany | 1999-2007 | Dynamic equilibrium (Expansion for all types and stability for severe types of care) | no | Administrative |
| Unger et al., 2011 | Long-term care (by severity of disability) | 60+ | Germany | 1999-2008 | Dynamic Equilibrium (Expansion for all types and stability for severe types) | no | Administrative |
| Unger & Schulze, 2013 | Subjective health problems | 40-104 | Germany | 1989, 1999, 2009 | Dynamic Equilibrium | no | Survey |
| Trachte et al., 2015 | Subjective health, functional limitations (prevalence) | 65-89 | Germany | 1997-2010 | **Compression or dynamic equilibrium** | no | Survey |
| Doblhammer & Kreft, 2011 | Disability (ADL) | 65+ | Germany | 1995-2001; 2005- 2007 | **Compression** or dynamic equilibrium | no | Survey |
| Hoffmann & Nachtmann, 2010 | Long-term care | 60+ | Germany | 1999-2005 | Relative expansion | no | Administrative |

Note: Words in **bold** letters indicate that the results are interpreted with a direct link to the health scenarios

For the analysis of trends in long-term care in Germany, six of these studies are of particular interest. Hackmann and Moog (2009) and Häcker and Hackmann (2012) found a compression of disability, however the studies were not based on the Sullivan method. Age-standardised prevalence of care need were computed based on data from the German Min-

[3] Due to problems with the study design, identification of the morbidity scenario can be misleading, see Kroll, Lampert, Lange, & Ziese 2008

istry of Health for the years 2004/06 by Hackmann and Moog (2009). In the next step, incidence rates were estimated by assuming a stable internal age structure of prevalence (status quo assumption) for the prior years and stated a decrease in the incidence of care need from 1998 to 2006.

### 5.3. Health of Aussiedler – why is it of interest?

As described in the preceding chapters, the migration history of Germany in the 1990s shows a remarkable increase in in-migration by refugees and by ethnic German repatriates, so called Aussiedler. While most of the refugees of the former Yugoslavia left Germany after the end of the Yugoslav War, the Aussiedler stayed in Germany. With almost 4%, Aussiedler constitute the second largest group of migrants in Germany. Different from, for example, Turkish migrants, Aussiedler are a distinct group of migrants. In health research, the particular interest in this topic results from the unique German policy.

Since the introduction of the Aussiedler initiation law in July 1990, the Aussiedler family has to make an application for recognition of the Aussiedler status before the in-migration. After the incoming application, the German Federal Office of Administration (Bundesverwaltungsamt) examines the requirements and sends a decision letter to the family. If the decision is positive, the spouses and their descendants are legally recognised as “Germans by status”, even if they are not Aussiedler in tighter definition. The requirements to be recognised as an Aussiedler were stepwise extended, especially with the introduction of a second Act (Kriegsfolgenbereinigungsgesetz) in December 1992 with some new constraints of the definition of Aussiedler (from then on termed Spätaussiedler). The latest tightening was in 2005, where the requirement was introduced that all members of the Aussiedler family have to verify basic knowledge about German language. As a result, the in-migration of Aussiedler further decreased (Federal Office for Migration and Refugees, 2016).

With the positive decision letter and at the end of a registration procedure in Germany, Aussiedler directly acquire citizenship by law and, thus, they are entitled to fully participate in the health and welfare system, with all its rights and responsibilities. Until 2009, the Residence Allocation Act restricted the free choice of the living area of the Aussiedler families to counter the challenges of region-specific attractiveness for chain migration. This is of particular interest in the study of spatial disparities. The law affects all Aussiedler except the Aussiedler who find a job before or shortly after in-migration. Aussiedler who requested social benefits were assigned to one of the various regions of Germany based on an official quota system. Ronellenfitsch et al. (2006) considered the assignment as a quasi-random procedure; however, it can be assumed that systematic trends of trans-regional migration (especially the migration flows from eastern to western Germany) leads to compositional disparities of the

regional Aussiedler population in terms of socioeconomic characteristics (Haug & Sauer, 2007).

In the 1990s, there was a change in the immigration and integration policy in Germany. The internal policy called for the permanent integration of Aussiedler until the 1990s. Temporary integration was the objective of integration policy for most of the so-called "guest workers" (labour migrants, like Turkish migrants). Policy promoted the integration and social participation and offered access to the full range of government assistance programmes (financial transfers, government-funded integration programmes and language courses, etc.).

In terms of health research, these benefits may be an effective measure to reduce some of the negative effects on health due to socioeconomic deprivation, problems of integration and migration stress. Most of the other immigrant groups (especially non-EU migrants) do not have that privileged legal status (Kosubek, 1998).

A further specific characteristic of the Aussiedler is that they are not as densely concentrated in highly urbanised regions as other groups of migrants, such as Turkish migrants. Aussiedler live in urban and peripheral areas, while the proportion of persons with migration background in general is very low in rural regions. In a small-area perspective, Dietz (1999) assumes a trend towards increasing segregation has been observed among Aussiedler since the mid-1990s; however on a lower level than for the persons with a Turkish migration background. The tendency of segregation is explained by restrictions of the communal (social) housing market but also by individual preferences, such as a desire to live close to friends and relatives (Haug & Sauer, 2007).

The number of studies about the mortality and morbidity of Aussiedler has increased over the recent years; however with greater focus on mortality. In comparison to native Germans, studies stated lower levels of overall, cardiovascular, ischemic heart disease, and prostate cancer mortality in Aussiedler (Deckert, Winkler, Meisinger, Heier, & Becher, 2014; Ronellenfitsch et al., 2006; Winkler, Holleczek, Stegmaier, & Becher, 2012), the same level of all-cancer mortality for male Aussiedler, but higher lung cancer mortality, lower all-cancer mortality (especially lung and breast cancer mortality) for female Aussiedler (Kyobutungi et al., 2006). Also a significantly higher risk of non-natural mortality for male Aussiedler, especially in suicide (Kyobutungi, 2006; Winkler, 2008) and in suicide when migration was in puberty (Deckert, Winkler, Meisinger, Heier, & Becher, 2015). The latter seems to be an indicator of significant mental health problems that decreases with increasing lengths of stay (Becher et al., 2007; Kyobutungi et al., 2006).

The results of studies of the health of Aussiedler have so far been inconsistent. Aussiedler have worse self-rated health and a higher number of reported complaints shortly after immigration, but a lower frequency of visits to practitioners and specialists compared to native Germans (Wittig, Merbach, Siefen, & Brähler, 2004). Of particular high interest is the study of

psychosomatic health problems. Studies have found evidence for psychological distress (Kornischka, 1992) and stress disorders (Lukaschek et al., 2013) in Aussiedler.

There are inconsistent results about physical health problems. The incidence of myocardial infarctions is higher in male Aussiedler than in native Germans (Deckert et al., 2014), the incidence of stomach cancer is higher for both sexes, the incidence of lung cancer is higher for men, but lower for females, and the incidence of colorectal cancer and prostate cancer was lower (Jaehn, Holleczek, Becher, & Winkler, 2016; Winkler et al., 2012; Winkler, Holleczek, Stegmaier, & Becher, 2014).

The duration of stay in Germany has been found to have inconsistent effects on health and life style factors as well. The health satisfaction of immigrants from Eastern Europe deteriorated (Ronellenfitsch & Razum, 2004), while Aussiedler in Augsburg (Bavaria) reported better self-perceived health with increasing duration of stay (Aparicio et al., 2005). Regarding the life style, Reiss et al. (2010) and Reiss et al. (2015) found an adaption of smoking habits in Aussiedler from those of the native Germans. Thus, female Aussiedler show an increase in smoking prevalence, while there was a decrease in the prevalence of smoking among male Aussiedler. These trends were interpreted as a “health transition”. In contrast, Kuhrs et al. (2012) showed that the reported prevalence in risk factors like alcohol consumption, high cholesterol, diabetes and smoking (women) was lower in Aussiedler than in the native population. This provides evidence in favour of the “imported risk” or rather the “imported chance” assumption.

As yet, studies, that investigate the effect of the living context in the host country as a determinant of Aussiedler health, are very rare and mostly in a qualitative design. One exception is the study of Reiss et al. (2013), where the mortality rates and (age and sex) standardised mortality ratios were estimated for Aussiedler populations among clusters of counties in the German federal states North Rhine Westphalia. The study found an unfavourable high mortality in the cluster of poor counties and low mortality in prospering or heterogeneous counties.

In conclusion, the findings about health and mortality of Aussiedler are very heterogeneous. Some outcomes show an advantage (e.g. many causes of death), others a disadvantage (e.g. psychological distress, incidence of some types of cancer) in relation to the host population. The deprivation of the living area may have a further negative effect on mortality. The diverging trends in the adaption of the lifestyle of the native population or the preservation of the former lifestyle - together with unchanged, traditional health-seeking behaviours and the negative effects of the migration experience - may explain these paradoxical results.

# III. Hypotheses

## 1. Study 1: Small-area care need disparities

The first study has the objective to investigate the regional inequalities in care need. The study is a cross sectional ecological study and is based on established measures of population health and data from an administrative register. The literature review highlighted some earlier studies that detected health disparities for Germany by using various definitions of health. In this study, an objective measure of health, officially registered care need as a type of disability based on medical diagnosed limitations of daily activities, is the health outcome. Kibele (2012) identified a cluster of high low mortality in South West Germany and of high mortality in central, in North East Germany and (for males) in the Ruhr region and in the Saarland. Based on these findings and the wide range of studies concerning regional disparities in various dimensions of morbidity in Germany and in other welfare states, it can also be assumed that:

Hypothesis 1:
*Profound regional inequality among the counties exists with consistent patterns to those for mortality.*

If there is a high regional disparity, the model of Glass & Belfour (2003) and Kibele (2013) proved the importance of various dimensions of regional attributes to have contextual health effects. Based on these findings, two hypotheses were formulated:

Hypothesis 2:
*The health situation is better in regions with a higher socioeconomic performance, a better socioeconomic composition of the population, and a more favourable health care situation.*

The physical environment showed an inconsistent effect on the health of the individuals. On one hand, urbanised regions are faced with a higher environmental burden like noise, air pollution and stress than rural areas and offer many services that have negative health effects like cigarette slot machines, snack bars, bakeries and fast-food-restaurants. On the other hand, there are various services with positive health effects like pharmacies, physicians, and places of social participation. Thus, the following hypothesis was formulated:

Hypothesis 3:
*Urbanity as a measure of physical environment may have positive and negative effects on health of the individuals.*

## 2. Study 2: Trends in care need-free life expectancy and in the health scenarios

Study 2 has the main objective to get deeper insights into the small-area disparities in health by analysing the trends in long-term care need. Study 2 is also an ecological study, but has a longitudinal trend design with pooled cross-sectional census data.

In prior studies, the health scenarios were investigated on the level of countries; however, up till now, there have been no studies that have analysed the health scenarios on the small-are level. Based on the results of study 1, the following hypothesis was formulated:

| Hypothesis 4: |
| --- |
| *Profound small-area disparities in the health scenarios exist that are unobserved when data for higher spatial entities is used.* |

Prior research results point towards a compression or equilibrium scenario (Hoffmann & Nachtmann, 2010; Ziegler & Doblhammer, 2008) and assuming that the conclusion based on the aggregation of results of lower levels and is driven by the majority of these sub-national entities, the following hypothesis was formulated:

| Hypothesis 5: |
| --- |
| *The compression or equilibrium scenario is the predominant scenario for most – but not all counties.* |

Assuming that regional disparities are observed, the driving factors are of interest. Since the health scenarios are an indirect measure of morbidity and prevalence, the particular influences of these determinants should be revealed. A priori it is not obvious whether the same factor drives the absolute changes in life years with and without care need, and the resulting health scenarios. A comparable analysis of trends in ADL in France concluded that the compression found was predominantly the result of changes in the disability prevalence rather than in mortality (Cambois, Blachier, & Robine, 2013). Thus, the hypothesis was formulated:

| Hypothesis 6: |
| --- |
| *The prevalence of the care need is the main driver of the health scenarios on small-area level in Germany.* |

In the last part of the analysis of regional disparities in long-term care, spatial data analysis will be used to identify spatial pattern of the morbidity and the mortality component, especially for the challenging absolute numbers of life years with care need.

## 3. Study 3: Contextual effects on the health of native Germans and Aussiedler

Study 1 and study 2 focus on small-area disparities in long-term care need and are in an ecological perspective. This perspective is of high interest in public health since it enables policy makers to classify the regions into different levels of policy challenges. Due to the restriction in the used ecological design it is not possible to differentiate between contextual and compositional effects on the health situation of a population.

Study 3 faces the problem by using a cross-sectional design based on micro and macro data from a mandatory large-scale survey. The dataset allows to compute multilevel models that include individual and contextual factors of long-standing illness on a small-area level. The advantage of that design is that compositional effects are diminished and the effects of compositional and contextual factors that indicate different dimensions of the regions' attributes. Further, effects of multiple factors can be interpreted within a single multivariate model.

In conclusion of the literature review, a wide range of contextual influences on various dimensions of residential characteristics were identified.

Transferred to the selected health indicator and the population under study, the following hypothesis is formulated:

Hypothesis 7:

*Contextual effects of socioeconomic conditions, of physical environment and the regional social capital on longstanding illness exist even after adjusting for individual determinants.*

One special focus of study 3 is on the health situation of Aussiedler. Aussiedler are a group of international migrants that experienced a substantial change of living context in their life course. In contrast to other migrants, Aussiedler have - after the official recognition - a privileged status with (by law) unrestricted access to the German job marked and health care system. Only for Aussiedler that receive social transfers, mobility was restricted over a longer period in the past. Since almost the total population of Aussiedler moved to Germany and obtained that privileged status, Aussiedler population is a precedence and is in a sense of a natural experiment (Reiss et al., 2013) with the objective to indirectly evaluate the German health care system and other contextual conditions.

Considering the particular characteristics of the Aussiedler, the investigation of contextual effects on the health allows deeper insights into the impact of context transitions and of policy influenced contextual conditions.

Lorant et al. (2008) analysed individual and contextual effects on the health of migrants in Belgium and detected profound evidence for positive and negative effects of the living context of migrants that are similar to the native population. In the case of Germany, there is a lack of studies concerning the contextual effects on the health of migrants. However, in the

case of mortality, Reiss et al. (2013) suggested for Aussiedler in North Rhine-Westphalia a higher mortality in poorer living areas similar to the results of prior studies about health of the overall population. Thus, the hypothesis is:

Hypothesis 8:

*Living context has a universal effect on longstanding illness of native Germans and of Aussiedler.*

Within the population of Aussiedler, the duration of stay in Germany has been found to have inconsistent effects on health. The health satisfaction of immigrants from Eastern Europe deteriorated with increasing duration of stay (Ronellenfitsch & Razum, 2004), while better self-perceived health by increasing duration of stay was reported for Aussiedler in Augsburg (Bavaria) (Aparicio et al., 2005). In the literature and among the theories about health of migrants, health selection of migration is assumed to have an effect on the composition of the population of international migrants. By combining these facts, the hypothesis is:

Hypothesis 9:

*The healthy migrant effect with better health at the time of the in-migration and deteriorating health by duration of stay does not exist for Aussiedler.*

## 4. Study 4: Sub-national cohort inequalities in care need and in longstanding illness

In the prior three studies, the focus is on investigating disparities in long-term care need and in longstanding illness between the spatial entities. The special interest of the studies is in the role of the composition of and contextual health influences on the German population and on Aussiedler in particular. The investigated population is composed of various subgroups and thus the population is a heterogeneous group in terms of current attributes and of life course experiences. Due to the lack of data, individual-level factors are only considered as variables in a cross-sectional design to control for compositional spatial disparities or to identify health inequalities between population subgroups. The problem in the cross-sectional perspective is that the used covariates are (mostly) time-varying attributes (like income) or socially affected (like gender). An approximation for a time-stable attribute indicating the life experiences is the birth cohort which is an indicator for persons with at many points similar life courses, however in their particular case mainly differing life contexts and personal circumstances.

Study 4 is an extension of the findings of study 2 and study 3. While the prior studies were based on a period perspective to investigate the health situation in a trend (study 2) or cross-sectional (study 3) design, a longitudinal trend analysis in a cohort perspective is conducted in study 4. The study has the objective to investigate health disparities between particular birth cohorts and also between particular types of living regions. The study is based on individual-level data of a representative sample of persons at age 65 and older for two observation years. A further methodological characteristic is that the study covers health outcomes of two different dimensions of morbidity: objective diagnosed disability (receiving SLTC allowance) and subjective perceived illness (longstanding illness).

The literature review mentioned the disability paradox which describes the discrepancy between the objective health situation and self-rated health. This paradox is not assumed to be present in this study, since the subjective health outcome measures rather the health situation than the subjective well-being.

| Hypothesis 10: |
| --- |
| Bio-demographic, psychosocial and socioeconomic factors affect the risk of receiving SLTC allowance and the risk of longstanding illness similarly. |

Another objective of the study is to investigate the spatial health inequalities by the level of different spatial entities. In the case of mortality, Kibele (2012) stated a higher heterogeneity between the smaller counties than between the large federal states. Voigtländer et al.

(2010a) showed a much higher variation in subjective health among neighbourhoods than among counties. Based on these findings, the following hypothesis is derived:

Hypothesis 11:

*Comparing the level of territorial entities, the spatial health inequalities in both indicators are higher on the level of small regions than on federal states.*

Another hypothesis evolved by the literature review. If it is assumed that ageing is a general biomedical process that is inherent and ever-present in all human beings but is influenced by various individual material, socio-psychological, cultural, and behavioural factors, the health outcomes are expected not to differ significantly between persons of the same birth cohort but living in other regions. However, the theoretical frameworks about healthy aging over the life course covers effects of acute contextual influences (e.g. war times in critical periods) and of persistent contextual influences (e.g. living in environmental hazardous regions). Further, health disparities are assumed to be caused by unobserved heterogeneity of the region-specific cohort population due to acute or long-term selection effects by mortality and (internal and external) migration.

Thus, the following hypothesis is formulated:

Hypothesis 12:

*Comparing the regions, the health of the same birth cohorts significantly differs even when the effects of age, period and other individual factors are adjusted for.*

# IV. Data and methods

## 1. Data

### 1.1. German Microcensus

In 1957, the German Microcensus was introduced in the former Federal Republic of Germany as a program to get a deeper insight into the composition of the West German population and to monitor the changes of the composition. After the German reunification, the population under study also included the persons in the East German regions. For the Microcensus, a 1% random sample of the households in Germany is drawn. The underlying so called Microcensus law constitutes that the participation is mandatory, while the response to some of the questions is optional. The basic population of the Microcensus are all residents living in private households and in public institutions, but with the exceptions of homeless persons, persons without a registered place to live, and diplomats and members of foreign armed forces and their families, who are not included in the basic population. German nationality is not required. The households are selected by using a cluster sampling method and information about all persons of the household are collected. For new-borns, children and functionally limited persons, a proxy has to give the mandatory information (Federal statistical office, 2011).

The German Microcensus is conducted in an annual frequency and persons that are sampled are obliged to participate in the program for four years. The multi-purpose questionnaire generally consists of two parts: the mandatory basic module that includes socio-demographic and labour marked information, while the second part goes into detail on diverse topics on occupation. For health research, additional modules are of interest which alternate in a four-year frequency. Two of these modules cover detailed information on individuals' health status, risk factors, and about migration background. By concluding a user contract, information about the living regions of the individual can be matched to the main survey and analyses can be done via remote access (Federal statistical office, 2011).

The survey is accomplished by interviewers through paper and pencil interviewing (PAPI) or through computer-assisted personal interviews (CAPI). Since 2005, the interviews are not conducted in a determined period of weeks in a year, but spread over the course of the year (Federal statistical office, 2011).

Study 3 bases on the survey year 2005 of the German Microcensus (hereafter referred to as Microcensus 2005). Due to the option to get information about the place of residence, the high number of persons included in the survey, the mandatory participation, and the wide range of information about general socio-demographic, economic and behavioural aspects of life as well as information about health and migration background, the Microcensus is well-suited for the analyses. Spatial planning regions (Raumordnungsregionen) are defined as the

spatial entities to ensure an adequate case number per region and to meet the requirements of the German data protection law. The analyses in study 3 are limited to persons living in West Germany and Berlin (the eastern and western parts of the city) due to the very low number of Aussiedler in the East German regions.[4]

Study 4 combines data of the Microcensus of the survey years 2005 and 2009. Thus, the new dataset is in a longitudinal design that allows the investigation of cohort trends. The population under study is limited to the birth cohorts 1910-1945.

### 1.2. Statutory Long Term Care Census

For study 1 and study 2, data from the German SLTC census ("Pflegestatistik") is used. The SLTC census is an official mandatory register of all care and care allowance recipients, all care facilities, and all mobile nursing services in Germany. The register is conducted in a 2-year turn and covers data from more than two million persons in need of care living in private households and institutions in each particular year. Long-term care is officially defined by the German Social Code Book XI and measured during a home examination by members of the German medical service of health insurance. The SLTC census was introduced in December 1999 as a part of the SLTC Census Act (Pflegestatistikverordnung) included in the German Social Code Book XI.

The objective of the census is to get an overview of the supply and demand side of care services and their temporal trends. Imbalances should be detected and avoided by planning and reforming of the Long-term Care Insurance Law.

The SLTC census consists of two data sources: The survey about the inpatient and outpatient care provider (receiver of care and benefits, attributes of the care facilities, count of staff) and the register about persons with care need of the Federal Association of Long-term Care Insurance Funds (Spitzenverband der Pflegekassen) and of the Federal Association of Private Health Insurance Funds (Spitzenverband der privaten Krankenkassen). The survey is conducted by a standardised questionnaire. The data is digitalised and edited by the Statistical Offices of the Länder and afterwards is delivered to the Statistical Office of the Federation by data storage devices or by online questionnaires. The reference date of the survey about the inpatient and outpatient care facilities is the 15.12. and for the data about the persons in care need it is the 31.12. of the survey year.

Apart from demographic information about sex, year of birth, and care level (level 1 to 3/case of hardship) on December 31st of each year, the official ID of the residential county of the recipients is included. The information about the type of care (inpatient and outpatient care)

[4] The number of cases for West German regions ranges from 978 to 16,353 native Germans (mean=4,304) and from 18 to 653 Aussiedler (mean=134), while the numbers for East German regions are from 1,579 to 6,811 native Germans (mean=3,809) and from 6 to 38 Aussiedler (mean=17).

is covered by the dataset, but it is not allowed to use the information separated by sex, age, care level for counties. No other socio-economic or demographic information is available.[5] The level of counties is of interest because at this level some of the most influential health policy decisions are made.

Study 1 uses the German SLTC census of the year 2009, the latest observation year at the point of publication of the study, to extract the number of care (allowance) recipients. The counts are differentiated by year of observation, county, sex, and age groups ('under 60', '60-69', '70-74', '75-79', '80-84', '85+'[6]). The age categories are chosen by the assumption of a specific age distribution of disability. Pfaff (2010) stated a nearly stable risk on a very low level up to the age 60 and a high increase in prevalence above the age of 60.

Study 2 bases on the German SLTC censuses for the years 2001, 2003, 2005, 2007, and 2009. The individual micro data is aggregated by the year of observation, county, sex, and age groups (see above), but additionally by care level (level 1+ versus level 2+).

An advantage of the census is the adequately high number of persons in need of care at the county level. Further, the SLTC census is not biased by non-response because participation is mandatory. To ensure data privacy, the total sample is used via remote access by the Research Data Centres of the Statistical Offices of the Federation and the Länder. Since it is highly restricted to match other data to the census data, the counts by the subgroups (by age, sex, care level, county, and year) are extracted and used for further calculations.

### 1.3. Spatial units and territorial changes between 2000 and 2010

The Federal Republic of Germany (FRG) is separated on various levels and also by different aspects. The first aspect is **administration**. The highest level of administrative authority within the German federation is the level of the federal states referred to as Bundesländer. Since the German reunification in 1991, there have been three city-states (Stadtstaaten, Berlin, Hamburg and the two-city-Bremen) and 13 area states (Flächenländer). Five of these federal states and the Eastern part of Berlin formed the German Democratic Republic from 1949 to 1990 and joined the FRG in 1990. The federal states have a high level of authority on various fields of policy, but only a minor role in health policy. Some important health care providers like health insurers, associations of statutory insurance physicians/dentists (Kassen(zahn)ärztliche Vereinigungen), the German Hospital Federation (Deutsche Krankenhausgesellschaft), the chambers of physicians, dentists, psychotherapists and pharmacists, the public health service (Öffentlicher Gesundheitsdienst) and the pharmacy associations are

[5]Due to that fact there are no studies up to now that are focused on social inequalities in receiving help from the German stationary long-term care insurance.
[6]Protecting privacy is important, especially when doing research in small-area level. To prevent groups with too few cases, I define the last interval as '85+'.

subdivided into state-specific subgroups. However, there is a high level of segmentation due to the federal system, the health care framework is equal on a national level. The borders of the states are defined by historically political agreements conducted by policymakers of Germany but also by policymakers of the USA, the UK, France and the Soviet Union after the Second World War. During 2000 and 2010, the borders of the 16 federal states remained unchanged.

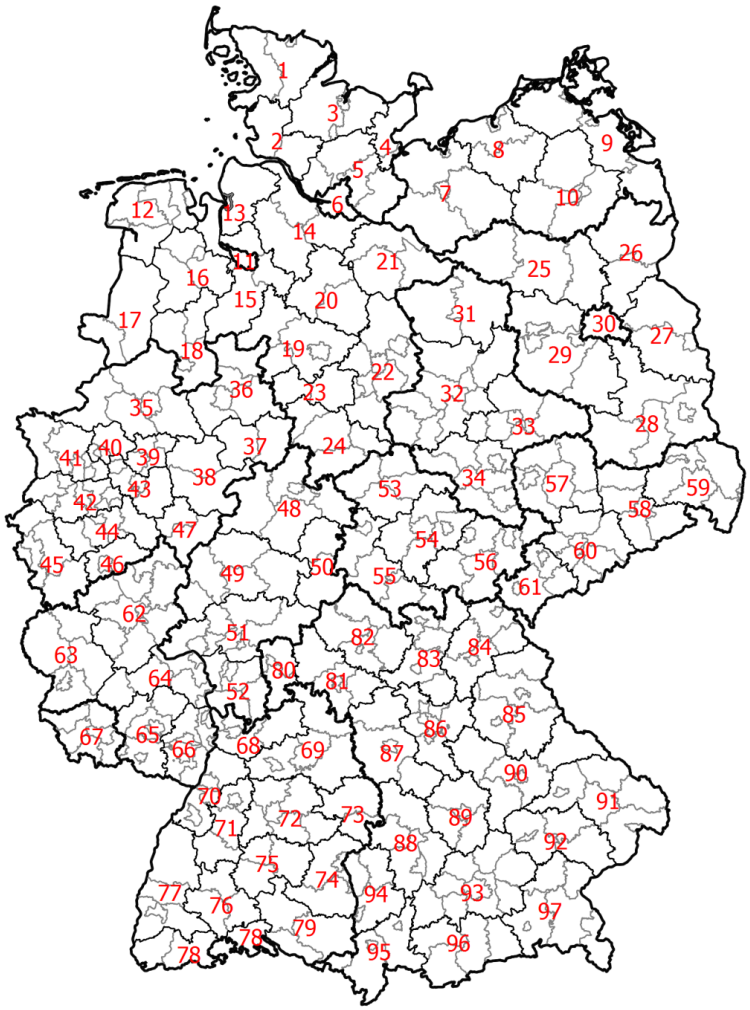
The next lower administrative level is the level of governmental districts (Regierungsbezirke). They are established in only a few federal states and have no legislative function. Thus, these administrative entities are of lower interest since there is no influence on health policy and health infrastructure.

Each federal state except the city-states Berlin and Hamburg are separated into counties/districts (Kreise), which are classified as district-free cities or urban districts (kreisfreie Städte) and rural districts (Land-/Kreise). Berlin and Hamburg are urban districts themselves and Bremen consist of two urban districts. The rural counties themselves are aggregations of municipalities (Gemeinden) to have a coordinated policy. Concerning the health management within a region, the administration of the urban and the rural counties (or jointventure of counties/Kreisverbände) are responsible for planning, building and financing of the public hospitals. In 2000, there were 117 district-free cities and 323 rural areas in Germany. Until 2010, the number of urban counties decreased to 111 district-free cities and 301 rural districts. There were two large - Saxony-Anhalt in 2007 and Saxony in 2008 - and two small reforms - Hanover in 2001 and Aachen in 2009 - of the counties were carried out. Most of these reforms were fusions of counties. For six counties in Saxony-Anhalt[7] the reform of the counties fundamentally changed the geographical entities. This has to be considered in the later data management.

Besides these territorial subdivisions by administrative aspects, various classifications based on other aspects were established. One concept is the **functional linkage among regions**. Spatial planning regions (Raumordnungsregionen) are defined by the extent of commuting flows between the counties, where counties with high flows are classified as one planning region. The official classification is developed by the Federal Institute for Research on Building, Urban Affairs and Spatial Development within the Federal Office for Building and Regional Planning. Thus, the 97 spatial planning regions (96 since the union of two planning regions in Saxony in 2008) are on a medium level between counties and federal states, but they are not administrative entities. The spatial planning regions are used for analyses of regional developments and future planning, e.g. in terms of improvements in traffic or medical infrastructure or of public investments and funding of the regional economy.

[7] The counties are Harz, Salzlandkreis, Jerichower Land, Anhalt-Bitterfeld, Wittenberg, and Dessau-Roßlau.

*Figure 4: Borders of the spatial planning regions (light black), the counties (grey) and the federal states (bold black) in Germany*




| ID | ROR | ID | ROR | ID | ROR | ID | ROR | ID | ROR |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Schleswig-Holstein Nord | 21 | Lüneburg | 41 | Duisburg/Essen | 61 | Südwestsachsen | 81 | Würzburg |
| 2 | Schleswig-Holstein Süd-West | 22 | Braunschweig | 42 | Düsseldorf | 62 | Mittelrhein-Westerwald | 82 | Main-Rhön |
| 3 | Schleswig-Holstein Mitte | 23 | Hildesheim | 43 | Bochum/Hagen | 63 | Trier | 83 | Oberfranken-West |
| 4 | Schleswig-Holstein Ost | 24 | Göttingen | 44 | Köln | 64 | Rheinhessen-Nahe | 84 | Oberfranken-Ost |
| 5 | Schleswig-Holstein Süd | 25 | Prignitz-Oberhavel | 45 | Aachen | 65 | Westpfalz | 85 | Oberpfalz-Nord |
| 6 | Hamburg | 26 | Uckermark-Barnim | 46 | Bonn | 66 | Rheinpfalz | 86 | Industrieregion Mittelfranken |
| 7 | Westmecklenburg | 27 | Oderland-Spree | 47 | Siegen | 67 | Saar | 87 | Westmittelfranken |
| 8 | Mittleres Mecklenburg/Rostock | 28 | Lausitz-Spreewald | 48 | Nordhessen | 68 | Unterer Neckar | 88 | Augsburg |
| 9 | Vorpommern | 29 | Havelland-Fläming | 49 | Mittelhessen | 69 | Franken | 89 | Ingolstadt |
| 10 | Mecklenburgische Seenplatte | 30 | Berlin | 50 | Osthessen | 70 | Mittlerer Oberrhein | 90 | Regensburg |
| 11 | Bremen | 31 | Altmark | 51 | Rhein-Main | 71 | Nordschwarzwald | 91 | Donau-Wald |
| 12 | Ost-Friesland | 32 | Magdeburg | 52 | Starkenburg | 72 | Stuttgart | 92 | Landshut |
| 13 | Bremerhaven | 33 | Dessau | 53 | Nordthüringen | 73 | Ostwürttemberg | 93 | München |
| 14 | Hamburg-Umland-Süd | 34 | Halle/S. | 54 | Mittelthüringen | 74 | Donau-Iller (BW) | 94 | Donau-Iller (BY) |
| 15 | Bremen-Umland | 35 | Münster | 55 | Südthüringen | 75 | Neckar-Alb | 95 | Allgäu |
| 16 | Oldenburg | 36 | Bielefeld | 56 | Ostthüringen | 76 | Schwarzwald-Baar-Heuberg | 96 | Oberland |
| 17 | Emsland | 37 | Paderborn | 57 | Westsachsen | 77 | Südlicher Oberrhein | 97 | Südostoberbayern |
| 18 | Osnabrück | 38 | Arnsberg | 58 | Oberes Elbtal/Osterzgebirge | 78 | Hochrhein-Bodensee | | |
| 19 | Hannover | 39 | Dortmund | 59 | Oberlausitz-Niederschlesien | 79 | Bodensee-Oberschwaben | | |
| 20 | Südheide | 40 | Emscher-Lippe | 60 | Chemnitz-Erzgebirge | 80 | Bayerischer Untermain | | |

(Source: Bundesamt für Bauwesen und Raumordnung 2005, own figure)

In comparison to counties, on the one hand, the spatial planning regions are more similar in area and population size. Thus, the comparability of the spatial planning regions among the other spatial planning regions is higher. On the other hand, the higher the level of aggregation of the individuals, the higher the reduction of diversity within the regions. Thus, the con-

ditions within the spatial planning regions are assumed to be more heterogeneous than the conditions within the counties.

### 1.4. Regional database of the Statistical Offices of the Federation and the Länder

In study 1 and study 2, aggregated SLTC census data is colluded with the vital data (population and death counts) of the official regional database of the Statistical Offices of the Federation and the Länder. For study 1, data for the counties in the boundaries of 2009 is used. County-specific mortality rates by age show a high variability. Thus, the data on death counts and on average resident population of the years 2006 till 2010 are colluded to diminish the impact of short-term random fluctuations.

Although the database has a wide range of indicators and a high level of harmonisation, there are two problems in the data management process when comparability of county-specific data in a longitudinal design should be achieved. This is the case for study 2.

The first problem is based on the age stratification of the population counts. For 2001, the last age group in the county-specific population statistics is the abridged age category 75+, while there is the highest age group 85 years and older in the later years. A further stratification of the population data at the ages 85-89, 90-95, 95+ is available on the level of federal states and on the national level, but prohibited on the county level due to data privacy laws. To consider the exponential increase in the prevalence at the ages above 75, an estimation strategy was conducted. The population number for the 5-years age groups was estimated by using the available population counts for 2003 to 2009 and by assuming a linear change of the population proportions among persons at age 75+. This is done separately for both sexes and all counties from 2001 to 2009. By using the estimated proportions, the age group-specific (75-79, 80-84 and 85+) population counts are extrapolated in 2001.[8]

The second problem is caused by the above mentioned territorial changes within the observation period. To ensure comparability with the results of study 2 and to have a higher relevance for policy-makers, the spatial entities are defined in the administrative borders in the last observation year (2009). For the counties that were consolidated into a new county, the data of the affiliated counties are pooled. In the case of the newly created six counties in Saxony-Anhalt in 2007, an individualised data management strategy was evolved.

The strategy is also based on stratification by using population weights. For the years 2001 to 2006, total population counts are available for the old and the new regional entities. For each single year, the (positive or negative) difference between the population of the entities

[8] For instance: If there is a $\%P_{Men,85+,county\ 1,2003}$ (proportion of men at age 85+ to all men at age 75+ in county 1 in 2003) of 15% and a $\%P_{Men,85+,county\ 1,2005}$ of 16%, the estimation of $\%P_{Men,85+,county\ 1,2001}$ is 14%.

in the new and in the old ($P_{old}$) borders equals the population that experienced an administrative chacnge ($P_{change}$). In the last step, the population weights were computed by $P_{change}$ divided by $P_{old}$.

The assumption that underlies the strategy is that the death counts and the care receivers were not concentrated in specific parts and were equally distributed within the area of the counties.

### 1.5. INKAR 2007 database

For study 3, data on macro level was also included in the analysis. For this purpose, the INKAR database of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) is an adequate data source. The INKAR (Indikatoren und Karten zur Raumentwicklung in Deutschland und Europa / Indicators and maps of the spatial development in Germany and Europe) database is a comprehensive tool for data on various regional and national levels. For data on spatial planning regions, which are non-administrative entities and used in study 3, the database is the best choice. The indicators of the INKAR dataset are standardised and aggregated measures based on extractions from various official databases like the regional database of the statistical offices of the Federation and the Länder, but also from direct calculations and surveys by the Institute staff (BBSR, 2007). The database was published annually via orderable data storage devices about two years after the particular observation year. As a new feature; the data is now available online (www.inkar.de). The data for the year 2005 was obtained from the INKAR 2007 database. Due to territorial changes, the database is regularly updated to the current regional entities; however, older INKAR versions can be requested via personal contact.

### 1.6. Health outcomes

#### 1.6.1. Care need and care level

The health outcomes for study 1 and study 2 are defined as officially diagnosed disability. As mentioned in the description of the German SLTC insurance system, care need is measured by the intensity of restrictions in basic and instrumental activities of daily living (ADL and IADL) as a chronic state. Care need is further differentiated between several care levels. The care levels are classified by the frequency and the time consumption of care assistance by non-professionals: Persons with care level 1 need assistance at least 90 minutes in total for general help and at least once a day that takes more than 45 minutes for essential personal care. Persons in care level 2 and higher are not further stratified. Persons in care level 2 and higher need help for at least 180 minutes in total for general help and at least three times a

day that takes 120 minutes or longer for essential personal care. Members of the German medical service of the health insurance specify the intensity of care that is specified during a substantial home examination (Arntz, Sacchetto, Spermann, Steffes, & Widmaier). Due to the data protection law, the differentiation between inpatient and outpatient care on sub-national level is not permitted.

The problem of the health outcome is that only official registered care need is used and thus, there may be under coverage of care need in general. This can be true due to a lack of knowledge or high barriers of entry - for example for persons with a migration background. However, it can be assumed that there is also a continuing (perhaps policy driven) change of assessment of the potential beneficiaries by the medical services in the observation period (Häcker & Hackmann, 2012). Further limitations are potential county-specific differences between East and West German counties, in terms of individual acceptance of social benefits as well as socioeconomic differences in terms of private financial resources to compensate public benefits. In addition, there could also be (illegal, therefore hidden) differences in the evaluation process, as lobbyism towards the medical services and the financial resources of the insurance agencies may vary within Germany.

In study 4, a divergent indicator of care need is used as a proxy for the broader care need definition in study 1 and study 2. In the Microcensus, the persons were asked whether they received allowance from the SLTC insurance. Since there is no clear definitional differentiation if they were receiving SLTC allowance due to receiving or providing care need, the validity of the proxy is higher, the higher the age-specific risk of care need - or (in other words) the higher the age of the persons. Furthermore, there is an under coverage of persons in inpatient care facilities who did not receive the SLTC allowance directly or for persons who forgot that they received the SLTC allowances. However, this restriction affects the interpretation of the general level of the prevalence compared to the results from the official register, the response error is assumed to be not associated with place of living.

### 1.6.2. Longstanding illness

Both, study 3 and study 4, are based on individual level data from the Microcensus. In addition to the standard program, the Microcensus program integrates a regularly repeated module with a limited set of indicators of health, and risk factors of health. In the questionnaire of the Microcensuses 2005 and 2009, two questions are suitable to identify long-standing illness. The general health question asks for: “Have you been ill or had an accidental injury within the last four weeks [before the interview]?” To avoid defining persons with short-term illnesses (e.g. flu or other infections) as unhealthy in a long-term perspective, a second question was used to have a more specified definition of health: “How long lasts (did last) your illness or your injury?” For the health indicators, both of the information is combined and

longstanding unhealthy persons are defined as all persons with an illness that lasts (lasted) at least four weeks.

## 1.7. Operationalisation of the covariates

### 1.7.1. Individual level covariates

**Migration status:** The Microcensus Law 2005 reformed the former Microcensus law in various points. One aspect was that a module with a wide range of information about the migration history was introduced. The Microcensus 2005 was the first wave that included information on country of birth, year of immigration, naturalisation status and previous and present citizenship. Since the Aussiedler status was covered by the Microcensus questionnaire for the first time in 2007, the Aussiedler status had to be computed for the Microcensus 2005. The operationalisation is consistent with the method that was used for the official publications of the Statistical Office of the Federation (personal correspondence).
The information about country of birth, year of immigration, naturalisation status and previous and present citizenship were combined to approximate the migration status. Native Germans are defined as persons holding German citizenship not acquired by an act of naturalisation, and who were born in Germany in its present boundaries. Also classified as native Germans are German citizens who moved to Germany before 1949. Aussiedler are foreign-born persons with German citizenship (as well as with additional citizenships) that is not acquired by an act of naturalisation, and who moved to Germany after 1949 (Federal statistical office, 2007). Persons with additional/former citizenships of countries outside of Eastern or Central Eastern Europe were excluded from this group.[9]
To analyse the health disparities between the different in-migration cohorts, the Aussiedler are further stratified into different groups by using the information about the date of in-migration. The groups are Aussiedler with an in-migration before 1975 (30 and more years in Germany), Aussiedler with an in-migration between 1975 and 1990 (16 to 30 years in Germany), and Aussiedler with an in-migration in 1990 and later (15 years and less in Germany). Aussiedler with a missing date of in-migration were classified in a separate category.

**Control variables:** When analysing contextual effects on individual health outcomes, the effects of personal characteristics will be controlled for. Based on the literature review, these individual level variables are selected to cover different dimensions of etiological and biological pathways:

[9] These countries are Poland, the Czech Republic, Slovakia, Slovenia, Hungary, Romania, Bulgaria, the Russian Federation, Estonia, Latvia, Lithuania and other countries of the former Soviet Union, which are the legally recognised main resettlement regions ("Aussiedlungsregionen"). Ethnic Germans/persons of German origin from other regions than these resettlement regions are not defined as Aussiedler by German law.

1) age (in 10-year age groups),
2) sex,
3) family status (single, married – living together, married – living apart, divorced, widowed),
4) education (no degree = no degree and not in education, low degree = *Haupt-/Volksschulabschluss*, medium degree = *Realschulabschluss/ PTO-Abschluss*, high degree = *(Fach-)Hochschulreife*, in education/missing[10]),
5) net equivalent income (up to €450, more than €450 to €640, more than €640 to €1040, €1040 to €1600, more than €1600),
6) body mass index (underweight = body mass index of less than 18.5, normal = BMI up to 25, light overweight = BMI up to 30, high overweight = BMI of more than 30) and
7) smoking habits (never smoker, former smoker, (current) smoker, missing)[11].

The choice of the indicators is directly based on the established etiological pathway frameworks mentioned in the prior chapters. The first two factors, age and sex, are substantial biodemographical and socio-normative determinants of health. The outstanding positions of these factors in demography and sociology are a consequence of the role as proxies for biological (natural) and societal (man-made) determined experiences and hazards over the life course.

The health effects due to these factors can be explained by genetic predispositions and medical processes of immunisation, coping and degeneration, as well as by internalised norms of social desired behaviour and roles (gender and age roles). Thus, these determinants may be assumed to be partly psychosocial factors as well.

The family status is also a determinant of the dimension of psychosocial factors. The factor indicates the social capital in terms of the daily social network and the social resources in case of hard times. Family status may only be interpreted with caution in regards to the complex construct of social capital, since other dimensions of social capital like density and familiarity of the family and the friends, as well as the presence of a (individually differently defined) partner are missing.

The fourth and fifth indicator, education and income, may also be allocated to at least two dimensions of the pathway frameworks. On the one hand, education and income are psychosocial factors, because they indicate higher security, higher authority, less stress, and higher acknowledgment in the job. Furthermore, education may be interpreted as the capability of health consciousness, coping and self-regulation - which is additionally covered by the framework of behavioural and cultural factors. On the other hand, both indicators are

[10] *Haupt-/Volksschulabschluss* = lower secondary degree; *Realschulabschluss/ PTO-Abschluss* = secondary degree; *(Fach-)Hochschulreife* = higher education/university entrance qualification. In case of the additional results, the last two degrees are separated into higher and highest degree.
[11] Income, body mass index and smoking habits are not included in the models in study 4.

mostly considered as material factors. Thus, a high education and/or a high income are proxies for a high level of resources to promote the health status and a healthy life condition.
The last two indicators, the body mass index and the smoking habits, are behavioural factors. They are assumed to be on the direct pathway between personality of the individuals within a social context and health situation of these individuals as the outcome. These linkages are explained by biological, chemical, genetic and medical predispositions and reactions on individual activities or missing individual activities.
To control for the seasonal effects of health, the quarter of the year of the interview will be included in the models.

### 1.7.2. Macro level covariates

**Regional database:** The analysis of study 1 includes information indicating particular dimensions of the regional attributes like the economic performance, the social composition, the grade of urbanisation, and the health care structure. Based on the "causal model of neighbourhood effects on aging" (Glass & Balfour, 2003), that defines four dimensions ("socioeconomic conditions", "social integration", "physical aspects of place", and "services and resources"), four indicators were chosen:

1) The disposable income of the private households (indicating the socioeconomic conditions),
2) The long-term unemployment rate (indicating the social composition and integration),
3) The regional population density (indicating the physical aspects of place), and
4) The level of premature mortality in age 1-44 (indicating the health structure).

The disposable income and the population density were taken from the database of the regional database of the statistical offices of the Federation and the Länder. Both factors indicate the socioeconomic context and composition of the population within a region.
The long-term unemployment rate and the level of premature mortality were computed based on indicators of the database. In the used definition of premature mortality, death counts at infant age were excluded and the sum of death counts at all ages up to Germany's population mean age of about 44 years were covered.
A high disposable income is a proxy for a favourable economic condition, higher tax income of the public communities, and thus more financial resources to invest into the local infrastructure. A high long-term unemployment rate in contrast, indicates a poor economic performance and a higher concentration of persons with reduced social participation and low material resources. Thus, long-term unemployment causes lower social capital and social isolation and lower self-esteem. In combination, regions with a high disposable income and a high long-term unemployment rate are assumed to be regions with higher income inequality.

The population density is an established indicator for a higher density of services and resources, as well as for aspects of environmental burden and higher options and a higher reachability for social participation. However, studies stated that urbanity is also associated with a higher use of facilities related with unhealthy life styles such as fast-food restaurants and cigarette machines.
The level of premature mortality is a construct that indicates the health situation in the region. The health situation is a combination of the health problems caused by health related behaviours of the individuals and of the medical infrastructure in terms of prevention, diagnosis and (acute) treatment in the region. A severe imbalance causes a high level of premature mortality.
The indicators were categorised into quartiles. The first category (lowest disposable income, lowest long term unemployment rate, lowest population density, and lowest premature mortality level) was set as the reference group.

**INKAR 2007:** For study 3, the dimensions of the regional context of the persons are also derived from the model of Glass and Balfour (2003); but with respect to the findings in the literature. The dimensions are - as also done in study 2 - socioeconomic conditions, physical environment/services and resources, and social capital. The choice of the indicators of these dimensions is based on their frequent use in prior studies and on the high validity in terms of cross-regional comparability. Thus, the results can be interpreted in the context of the findings from earlier studies.
The three contextual factors are:

1) gross domestic product (GDP) per capita (indicating the socioeconomic conditions),
2) centrality of regional population distribution (indicating the physical environment and the density of services and resources), and
3) proportion of foreigners in a region (indicating the social capital).

The gross domestic product (GDP) per capita is estimated by the working group "Regional Accounts" (Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder) which is a cooperation of the federal statistical office, the statistical offices of the Länder and of the statistical office of the city Frankfurt am Main. The GDP of a region is assumed to be a proxy for the economic performance of the region, as well as for the structure of the regional economy. Further, it can be seen as an indicator for the (financial) scope of action of local policy administration which is expected to have a general contextual effect on the health of the inhabitants independent from their individual socioeconomic status.
The centrality of the regional population distribution is an indicator measured directly by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR).

The centrality is the proportion of the regional population who live less than a 30 minute journey away from the next regional centre (Oberzentrum). Regional centres are defined by the BBSR as cities with an influence area that covers at least 200.000 to 300.000 persons (BBSR, 2012). There are more than 100 cities in Germany classified as regional centres. Centrality indicates the settlement structure, the level of peripherisation or agglomeration of the population, but also for the potential social capital and the quality of the traffic infrastructure.

The proportion of foreigners is an indicator that is generated by the statistical offices and measures the share of persons without a German citizenship. The factor indicates the attractiveness of the region as an immigration destination (e.g. economic opportunities, social capital like established ethnic communities, or favourable social climate versus discrimination) or of challenges and impulses due to cultural diversity.

Each of the three factors were separately categorised into three groups: 10% of the regions with the lowest GDP per capita[12]/the lowest centrality[13]/the lowest share of foreigners[14] versus 10% of the regions with the highest GDP per capita/the highest centrality/the highest share of foreigners. The remaining 80% of the regions for each factor are pooled in a separate category. The reference categories are each groups with the lowest values.

## 2. Methods

### 2.1. Healthy life expectancy and health ratio

To measure small-area disparities and their determinants, an established concept of population health has a high adequacy: the healthy life expectancy. The concept of the healthy life expectancy is the quantification of years in a prior defined dimension of health. The approach is that the quantity of life time can be subdivided into the quantity of life time with low quality of life and into the quantity of life time with a high(er) quality of life. In contrast to Antonovskys concept of a health-diseases continuum, the Health Expectancy concept defines only dichotomous states (health versus morbidity).The Healthy Life Years measure is a composite measure that integrates mortality and morbidity of a population or a population's subgroup into one. The meaning of the indicator is underlined by the inclusion in the set of the European structural indicators of the European Union (Lisbon strategy) in 2004. The advantages of the health measure are the relatively low data requirements (no longitudinal data

[12] Regions with the lowest GDP: Hamburg-Umland-Süd, Emscher-Lippe, Lüneburg, Bremen-Umland, Westpfalz, Ost-Friesland, Bremerhaven, Hildesheim; regions with the highest GDP: Mittlerer Oberrhein, Düsseldorf, Industrieregion Mittelfranken, Stuttgart, Bremen, Rhein-Main, München, Hamburg.
[13] Regions with the lowest centrality: Emsland, Südheide, Schleswig-Holstein Süd-West, Arnsberg, Ostwürttemberg, Oberland, Hamburg-Umland-Süd, Ost-Friesland; regions with the highest centrality: Südlicher Oberrhein, Industrieregion Mittelfranken, Rhein-Main, Bochum/Hagen, Hamburg, Bremen, Berlin, Düsseldorf.
[14] Regions with the lowest proportions: Schleswig-Holstein Süd-West, Oberpfalz-Nord, Ost-Friesland, Schleswig-Holstein Nord, Main-Rhön, Oberfranken-West, Hamburg-Umland-Süd, Donau-Wald; regions with the highest proportions: Dortmund, Bremen, Berlin, Unterer Neckar, Hamburg, Rhein-Main, Stuttgart, München.

needed), the clarity of the interpretation to a public audience, and the adaptability to diverse health outcomes and also for small-area populations. The arguments justify the usage of the indicators for study 1 and study 2.

The estimation method of the healthy life expectancy is based on two methods in three steps.

In the first step, the abridged age-, and sex-specific life tables for the 412 counties were computed by using the Chiang method (Chiang, 1984). Since the death rates are assumed to be very sensitive to low increases or decreases in death counts and the estimations were preferred to be based on empirical data than on smoothing methods, averaged death rates were used. For study 1, the years 2006 till 2010 are pooled, while for the study 2, the data of the particular year is pooled with the data of one year before and one year after.

In the second step, the county-specific prevalence rates of care need are separated by sex, age group (‘under 60’, ‘60-69’, ‘70-74’, ‘75-79’, ‘80-84’, ‘85+’) and were estimated. The number of persons in long-term care is assumed to be less influenced by short-term changes. The prevalence was computed separately for each year in study 1 and 2 (study 1: 2009; study 2: 2001, 2003, 2005, 2007, 2009). Additionally, for the trend and decomposition analysis in study 2, the counts of persons in care need for the first two years (2001/2003) and the last two years (2007/2009) were averaged.

In study 1, care need was investigated in general, while in study 2 there was a further stratification into any care level (1+) versus severe care level (2 and higher).

In the third step, the life table estimates and the prevalence are combined to compute the care need-free life years (CFLY) by using the Sullivan's method (Sullivan, 1971). The Sullivan's method is based on period data and has the similar underlying stationary assumptions as the life table: 1) The age-specific rates (mortality and prevalence rates) are stable over time, 2) the birth rate is stable over time, and 3) net migration is 0 over time (Imai & Soneji, 2007).

The adapted formula is (Sullivan, 1971);

$$ {}_{i}CFLY_{x} = \frac{1}{l_x} \sum_{a=x}^{\omega} \left(1 - {}_{i}\pi_{a}\right) \; {}_{i}L_{a} \,, \qquad (1) $$

where i is the size of the age interval, x is the age for which the remaining life years are computed, a are the ages above age x till age ω, π is the estimated prevalence rate, and L is life table component that measures the number of person-years lived.

By subtracting the CFLY from the remaining total life expectancy (LE), the life years with care need (CLY) are calculated. The proportion of CFLY in the total remaining LE is called the health ratio (HR).

For study 1, the CFLY is used to estimate the HR for both sexes, for all 412 German counties in 2009. The standard errors σ of the HR are calculated by assuming that the LE is a scalar variable and that the CFLY is a random variable (Jagger, Cox, Le Roy, & EHEMU team, 2006). Furthermore, the age-standardised prevalence rate (ASP) was computed by using the old European standard population as direct standardisation method.

For study 2, the LE and the CFLY, the CLY and the HR are computed separately for both sexes, for the five observation years, for the counties in the fixed assumed borders of 2009, and additionally for the two types of care level ($CFLY_{any}$, $CFLY_{severe}$, $CLY_{any}$, $CLY_{severe}$, $HR_{any}$, $HR_{severe}$). The results were presented for the persons at age 65+. The age 65 was used as a threshold since the age-specific prevalence rate of care need exceeds at nearly this age the level of the raw overall prevalence rate of care need of about 3% in 2009.

In the time trend analysis in study 2, the changes are calculated separately for each indicator by subtracting the indicator values of the pooled first two years from the values of the pooled last two years. A positive (negative) difference in an indicator was defined as an increase (decrease), and the stability is defined as a difference of the vales in the range of -0.1 life years to 0.1 life years. These results of the indicator-specific temporal changes were used to classify each county into the five established health scenarios. Counties with a decrease in LE were not classified into the health scenario concepts.

## 2.2. Decomposition method

As mentioned, the CFLY and the CLY are composite measures of particular age-specific patterns in mortality and in morbidity. The proportion of persons with morbidity, also termed the prevalence, is defined as the number of morbid persons divided by the number of living persons with and without morbidity, but who are in the potential risk of getting this morbidity. This proportion is calculated for a particular point in time (point prevalence) or a time interval (period prevalence), which are the most frequently used prevalence definitions. An objective in study 2 like in the study of the prevalence as well as of the CFLY and of the CLY in general, is to investigate the temporal changes and their underlying driver.

Contrary to mortality as an irreversible event, the change in the number of prevalent persons is the result of 1) the level of new diagnosed morbidity (incidence), 2) the level of cure from the morbidity, 3) the level of mortality of persons in morbidity, and/or 4) the level of mortality of persons without morbidity, but under the risk of incidence. By using individual level data in a longitudinal perspective and applying multistage life tables, the four transition rates were allowed to be isolated and quantified. Unfortunately, the data is rare and highly protected in Germany.

To deal with the problem, Nusselder and Looman (2004) introduced a decomposition method which is an extension of the Arriaga method (Arriaga, 1984) and which is suitable for aggregated data without information on incidence and curing. Considering the CFLY and the CLY indicators based on the SLTC census, the method decomposes retrospectively the effect of changes in age-specific prevalence rates (morbidity effect), the effect of changes in survival of the population with care need (mortality effect on CLY, $Mort_{\Delta CLY}$), and the effect of changes in survival of the population without care need (mortality effect on CFLY, $Mort_{\Delta CFLY}$). By definition of a two-state decrement life table like that computed with the Sullivan's method, the morbidity effect on CFLY and on CLY are the same in numbers, but with opposite signs.
In the case of curable morbidity which is not characterised by a high lethality in the short-time perspective after diagnosis – what is generally true for care need – an increase in the prevalence rates of care need is the result of incidence that is higher than the level of the curing rate. It is described in the decomposition method as a positive morbidity effect. Thus, a positive morbidity effect or morbidity component is the lost (gain) in life years without (with) care need due to an increase in the age-specific prevalence in care need.

A reduction in the mortality rates in the population without care need is indicated by a positive value of $Mort_{\Delta CFLY}$, while a reduction in the mortality risk of the population with care need is stated by a positive value of $Mort_{\Delta CLY}$. A positive $Mort_{\Delta CFLY}$ ($Mort_{\Delta CLY}$) is interpreted as a gain in life years without (with) care need due to the reduction of mortality rates. In study 2, the morbidity and mortality components of the changes in $CFLY_{any}$, $CFLY_{severe}$, $CLY_{any}$, and $CLY_{severe}$ in the period 2001/03 ($t_1$) to 2007/09 ($t_2$) were estimated for persons at age 65 and older, separately for both sexes and for the 412 counties of Germany.

The decomposition of the trend in the number of person-years without care need (CFLY) for a particular county, sex, and care level is measured by;

$$\Delta\ {}_iCFLY_x = {}_iMort_{\Delta CFLY,\,x} + {}_iMorb_{\Delta CFLY,\,x} = \left(\frac{(1-{}_i\pi_{x_{t1}})+(1-{}_i\pi_{x_{t2}})}{2}\right)\times\Delta\ {}_iL_x + \left(\frac{{}_iL_{x_{t1}}+{}_iL_{x_{t2}}}{2}\right)\times\Delta(1-{}_i\pi_x)\ , \quad (2)$$

while the trend in number of person-years in care need (CLY) is calculated by;

$$\Delta\ {}_iCLY_x = {}_iMort_{\Delta CLY,\,x} + {}_iMorb_{\Delta CLY,\,x} = \left(\frac{{}_i\pi_{x_{t1}}+{}_i\pi_{x_{t2}}}{2}\right)\times\Delta\ {}_iL_x + \left(\frac{{}_iL_{x_{t1}}+{}_iL_{x_{t2}}}{2}\right)\times\Delta\ {}_i\pi_x\ , \quad (3)$$

where x is the age, i the length of the age interval, ${}_iL_x$ is life table indicator for the number of person-years lived, and ${}_i\pi_x$ the estimated prevalence of care need at age group (x,x+i).

The estimation is computed by a decomposition tool programmed in R by Nusselder and Looman[15].

[15] The decomposition tool and the user guide are available on request (contact: w.nusselder@erasmusmc.nl)

### 2.3. Spatial data analysis: Moran's I and Local Moran's I

Of particular interest in the analysis of spatial patterns is the detection of cluster effects in terms of regional attributes. This clustering is revealed by measures of spatial autocorrelation. Spatial autocorrelation is a measure of dependency or similarity of spatial units by considering the distance in a two-dimensional perspective. An established indicator is Moran's I that is estimated by;

$$I = \frac{N \cdot \sum_i \sum_j W_{ij}(O_i - \bar{O}) \cdot (O_j - \bar{O})}{(\sum_i \sum_j W_{ij}) \cdot \sum_k (O_k - \bar{O})^2} \quad \text{(Anselin, 1995),} \qquad (4)$$

where N is the number of spatial entities, O is the investigated (continuous) outcome, and $\bar{O}$ is the mean of the outcome. W is the prior defined weight matrix that covers the proximity data for each region i with region j. The weight matrix is a Euclidean distance matrix with a threshold of 30 km from the centre of the county. Moran's I is global measures compared to the spatial distribution of a prior selected indicator (like a health outcome) to a random spatial distribution. Values close to -1 indicate a chequered pattern, 0 a totally random pattern and +1 a very high clustering (maybe a bipolarity). The significance is tested by a hypothesis test with the expected value E(I)=-1/(N-1).

To measure region-specific autocorrelation, the Local Moran's I is estimated by;

$$\text{Local } I_i = (O_i - \bar{O}) \cdot \sum_j W_{ij}(O_i - \bar{O}), \qquad (5)$$

with the similar interpretation as the global I. The mean of the all local I is identical to the global I. The Local I values is also tested for significance. Positive autocorrelation can be found for regions with high values surrounded by regions with high values (cluster high-high) or regions with low values surrounded by regions with low values (low-low-cluster). Regions with negative autocorrelation are in the low-high or high-low cluster.

### 2.4. Meta-regression

In study 1, the spatial variance in the HR should be explained by factors of the living context of the populations. For this purpose, a multivariate method was adapted from a different statistical approach. The meta-regression is a statistical method of the meta-analysis. The original application for the meta-analysis is to reveal common causes or consequences in a scientific field based on similar prior studies. The objective is to estimate the effect size by using the results of various studies. One frequently used method in this field is the meta-regression.

The problems of the initial concept are that the results of the converged studies differ by the methods, by the population under study, or by the underlying definitions. Further limitations

include the problem of publication selection (publication bias) and the problem of a low number of comparable studies.

An approach to face these problems is to join the results of various internal estimations by using a common data source. In study 1, the county-specific HR estimates are treated as single studies, where the method of the HR and the uncertainty in the HR is harmonised. Multiple linear meta-regression models with random effects were used. The method allows including selected contextual indicators of the living regions. The method extends the simple ordinary least squares regression by considering the uncertainty in the estimation of county's HR. Thus, it can be analysed whether and how the residual heterogeneity is affected by the inclusion of county-level variables (Harbord & Higgins, 2008). The general formula of a random effects linear meta-regression is;

$$y_i=\alpha+\sum_{k=1}^{K}\beta_k x_{ik}+u_i+\epsilon_i, \text{ where } u_i\sim N(0,\tau^2) \text{ and } \epsilon_i\sim N(0,\sigma_i^2) \text{ (Harbord \& Higgins, 2008), (7)}$$

where $y_i$ is the estimated HR of county i when $x_{ik}$, the value of the context factor, is given. Unlike in the ordinary least squares regressions, there are two error terms: the residuals $\varepsilon_i$ in the HR of a county and the residuals $u_i$ of the HR between the counties. The coefficients β are estimated by the REML (residual/restricted maximum likelihood) method after weighting each observation (county HR) by $1/(\sigma_i^2+\tau^2)$, where σ is the standard error of the estimated spatial HR and $\tau^2$ is the between-county variance (Harbord & Higgins, 2008; Thompson & Sharp, 1999).

The coefficients β can be interpreted as percentage point (PP) changes in HR, since the HR is measured in percentages. A higher HR than in the particular reference counties is indicated by positive values of β and negative values indicate a lower HR. The p-values and 95% confidence intervals display statistical significance.

In study 1, sex-specific and region-specific (East German counties vs. West German counties) models for the HR (65+) were estimated. The results for the age group 65+ were selected and presented. The estimates were performed using STATA 12.1 and the "metareg" routine (Harbord & Higgins, 2008).

### 2.5. Multinomial logistic regression

One of the objectives of study 2 was to investigate the effect size of the morbidity and of the mortality components on the resulting health scenarios. Since the health scenarios were measured by a categorical variable, a multinomial logistic regression was the adequate multivariate method. To prevent problems with a low number of counties in an outcome category, the three general health scenarios (compression, stability, and expansion) were used.

The mean centred morbidity (Morb) and mortality component in CFLY ($Mort_{\Delta CFLY}$) and in CLY ($Mort_{\Delta CLY}$), which were measured in life days, were the explanatory variables of the models.

The counties were weighted by the uncertainty of the $CFLY_{any}$ and $CFLY_{severe}$ estimation - with higher weights for counties with a high estimation precision. The county- and sex-specific precision weights are computed by 1 dividing by the variance of $CFLY_{any}$, respectively $CFLY_{severe}$ at age 65+ (Jagger et al., 2006).

The sex- and care level specific regression models for the persons at age 65+ are defined by;

$$Logit_{i,j}=\log\frac{Pr(Y_i=j)}{Pr(Y_i=j')}=\alpha_j+\beta_{1,j}Morb_i+\beta_{2,j}Mort_{\Delta CFLY,i}+\beta_{3,j}Mort_{\Delta CLY,i}\ , \quad (8)$$

where i indicates the county, j is the category of the health scenario (stability or compression), j' is the reference health scenario (expansion), α is the intercept and the βs are the estimated regression coefficients. For a better interpretation, the coefficients were transformed into relative risk ratios (RRR) on the chance of being a "stability" or a "compression" county versus being an "expansion" county (reference) for both sexes aged 65+ and for any/severe care level by exponentiate the coefficients. All calculations are performed by using the "mlogit" routine in Stata 12.1.

## 2.6. Multilevel logistic and Poisson regression

To reveal the effects of contextual factors, the compositional factors have to be controlled for. Multilevel models are a suitable method to simultaneously analyse the effects of the individual level factors and the effects of the contextual factors. Above the effect size and the significance of the disparities between the individuals and the spatial entities, respectively, multilevel models estimate the two substantial variance components: The within-group variance and the between-group variance. The within-group variance is the variability of the health outcomes of the individuals within a group – in the used definition within a spatial entity. The between-group variance is the variability of the average of the health outcomes of the individuals among all spatial entities.

In study 3, the effects of individual and contextual factors on the individual's health status were estimated by using binary logistic multilevel regression models (Snijders & Bosker, 2004). Since the interest is in the variation of the level of the population health status, random-intercept models were computed. The general formula for a random-intercept regression is;

$$Logit_{i,j}=\log\frac{Pr(Y_i=1)}{Pr(Y_i=0)}=\alpha+\sum_{n=1}^{N}\beta_n x_{nij}+\sum_{k=1}^{K}\beta_k x_{kj}+u_j, \text{ (Snijders \& Bosker, 2004)} \quad (9)$$

where $Y_i$ is the health outcome variable of individual i, j is the living region, N is the number of explanatory individual level factors, K is the number of explanatory contextual level factors, and u is the between-region residual with $u_j=N(0,\sigma^2_u)$. $\sigma^2_u$ is the variance of the residuals at level 2.

The estimations are performed by using the “xtlogit” routine in Stata version 10.1 (Rabe-Hesketh & Skrondal, 2005).

Additional analyses, three-level Poisson regression models with random intercepts and by including the person group exposures are conducted. In contrast to the logistic multilevel models of study 3 where individuals are the units of study at the first level of the analysis, the level of groups of persons are the first level in the Poisson regression models. The general formula of the type of model is;

$$Logit_{i,j,m}=\log(Y_{i,j,m})=\alpha+\sum_{n=1}^{N}\beta_n x_{n,i,j,m}+\sum_{k=1}^{K}\beta_k x_{k,j,m}+\sum_{l=1}^{L}\beta_l x_{l,m}+u_{j,m}+u_m+\ln(exposure_{i,j,m}) \quad (10)$$

where $Y_{i,j,m}$ is the counts of the health outcome variable of person group i, j is the living region, m is the federal state (m=, N is the number of explanatory individual level factors that defines the person groups, K is the number of identifier on small-area level, L is the number of identifier on federal state level, $u_{j,m}$ is the between-region residual with $u_{j,m}=N(0,\sigma^2_{u_{j,m}})$, and $u_m$ is the between-federal state residual with $u_m=N(0,\sigma^2_{u_m})$. The exposures for the person groups - defined by combinations of individual level characteristics - are included by a solely term and the estimated coefficients in the model are constrained to be 1. Since no macro level factors will be included, the formula can be simplified to;

$$Logit_{i,j,m}=\log(Y_{i,j,m})=\alpha+\sum_{n=1}^{N}\beta_n x_{n,i,j,m}+u_{j,m}+u_m+\ln(exposure_{i,j,m}). \quad (11)$$

The estimations are done by the “xtmepoisson” routine in Stata version 14.0.

To quantify the between region variation, the median odds ratio (MOR) is an established method (Larsen & Merlo, 2005). The underlying assumption of the MOR is that two persons with the same combination of covariates but randomly chosen from two different spatial entities. The MOR is calculated as the median odds ratio between the person of a higher propensity and the person of a lower propensity (Larsen & Merlo, 2005). The formula is;

$$MOR=\exp\left(\sqrt{2\cdot\sigma^2_{u_{j,m}}}\cdot\Phi^{-1}(0.75)\right), \quad (12)$$

where $\Phi^{-1}(0.75)$ is the 75th percentile of the cumulative distribution function (about 0.6745) of the normal distribution with mean 0 and variance 1. The MOR ranges from 1 (no regional variability) to very high values (high regional variability).

# V. Results

## 1. Study 1: Small-area care need disparities

### 1.1. Background

In the concept of the dimensions of health by Verbrugge and Jette (1994), care need is the most severe type of morbidity. Care need is associated with a high psychosocial, physical, and financial burden on the disabled persons and the persons who care for them. Due to the long-term ongoing increase in the life expectancy, the population in older ages and with a higher prevalence in care need has grown and will further grow in the future. To face the demographic challenge, the German health care system was reformed to offer support to the persons in need of care and their caregivers. The German health care system is characterised by a decentralisation of the care provider, but with a harmonisation in the legal conditions. Even in the German constitution the policy maxim is established by law to achieve and ensure comparable living conditions (gleichwertige Lebensverhältnisse) independent from the place of residence within Germany.

As found in the literature, the demographic and socioeconomic structures of the populations differ between the regions of Germany. As a result, the past, present, and future challenges in ensuring adequate health care provision are assumed to also differ between the regions. To date, most studies have focussed on the trends in care need in Germany on a national or on the level of the federal states. Small-area disparities were mostly stated for mortality or only in a descriptive perspective for care need. Prior studies have found evidence for linkages of socioeconomic conditions, physical environment, social integration and the access to services and resources with various dimensions of health. However, there are no studies that have investigated the association of the living conditions in the case of care need within a highly developed, established welfare state like Germany. This study intends to fill the gap in this field of research.

### 1.2. Population under study

2,338,252 persons were covered by the German SLTC census in the year 2009. This represents 2.858% of the German population. 1,002,767 persons of those receive care allowance only (43%), 555,198 persons were outpatient cared (24%), 717,419 persons were inpatient cared (31%; mostly permanent care for full-time inpatients: 699,672 persons), and 62,797 persons received semi-residential care and care allowance (3%).

The median age of the SLTC recipients was 76.2 years, and 55% were 75 to 84 years old. 33% of the SLTC receivers were males (median age 70.6) and 67% were females (median age 78.3).

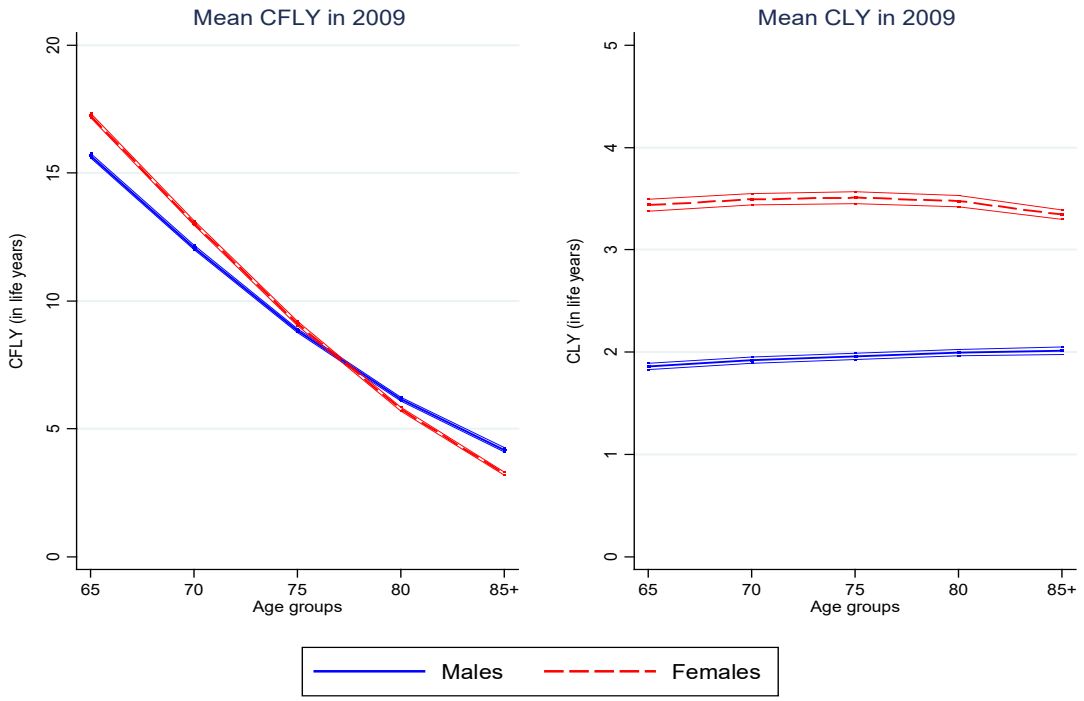
## 1.3. Results

### 1.3.1. Care need-free life expectancy and health ratio on a national level

At the ages with an adequate high prevalence of SLTC, the estimates show specific trends by the age groups and sexes. On average, the CFLY of the counties is decreasing by increasing age of the population (Figure 5). At age 65, the unweighted mean CFLY is 15.68 years for males and 17.25 years for females. The CFLY decreases to 4.18 years for males and 3.24 years for females; indicating higher absolute CFLY values for males compared to females at the highest ages. In the case of CLY, the unweighted means are nearly stable with a mean CLY of 1.85 (males) and of 3.44 life years (females) at age 65 compared to a mean CLY of 2.01 (males) and of 3.34 life years (females) at age 85+.

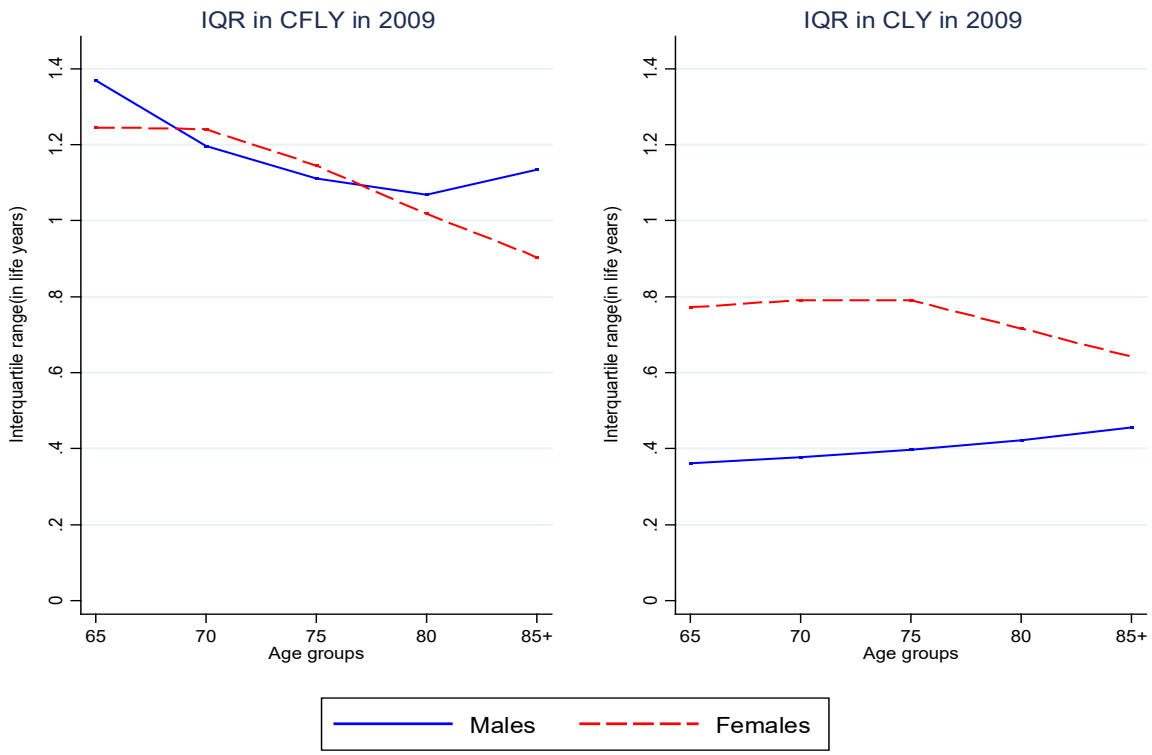
The interquartile range (IQR) of the CFLY indicates a slight decrease in the county-level heterogeneity for males and females over the ages and a mostly higher heterogeneity for males than for females (Figure 6). The absolute variation in terms of CLY is lower; however, there is a marked gender gap with higher dispersion in females than in males. There are only weak age effects.

*Figure 5: Unweighted mean of CLFY and CLY by age and sex, persons at age 65+ in 2009*




(Statistical Offices of the Federation and the Länder, STLC census 2009, own figure)

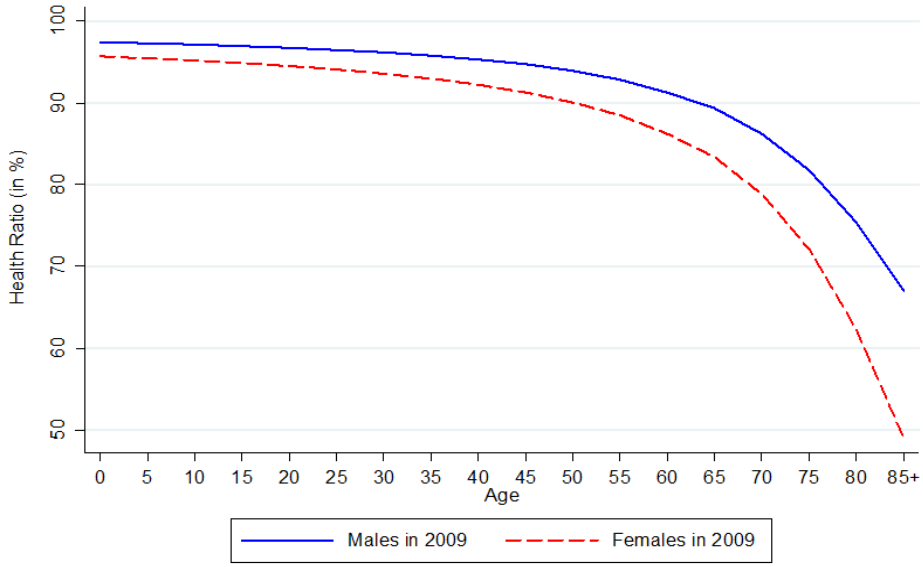
*Figure 6: Interquartile range in CFLY and CLY by age and sex, persons at age 65+ in 2009*




(Statistical Offices of the Federation and the Länder, STLC census 2009 & Regional database 2015, own figure)

At all ages the proportion of CFLY in LE, called the HR, was higher for males than for females (Figure 7). At age 65 it was 89.6% (IQR: 2.34PP) for males and 83.8% (IQR: 3.96PP) for females. Thus, almost 90 percent of the remaining LE of a man at age 65 will be without care need and more than 80 percent of the remaining LE of a woman. The HR decreased with increasing age, and at age 85 the HR was 68.0% (IQR: 9.41PP) for males and 49.4% (IQR: 11.18PP) for females.

*Figure 7: Unweighted mean of health ratio by age and sex in 2009*

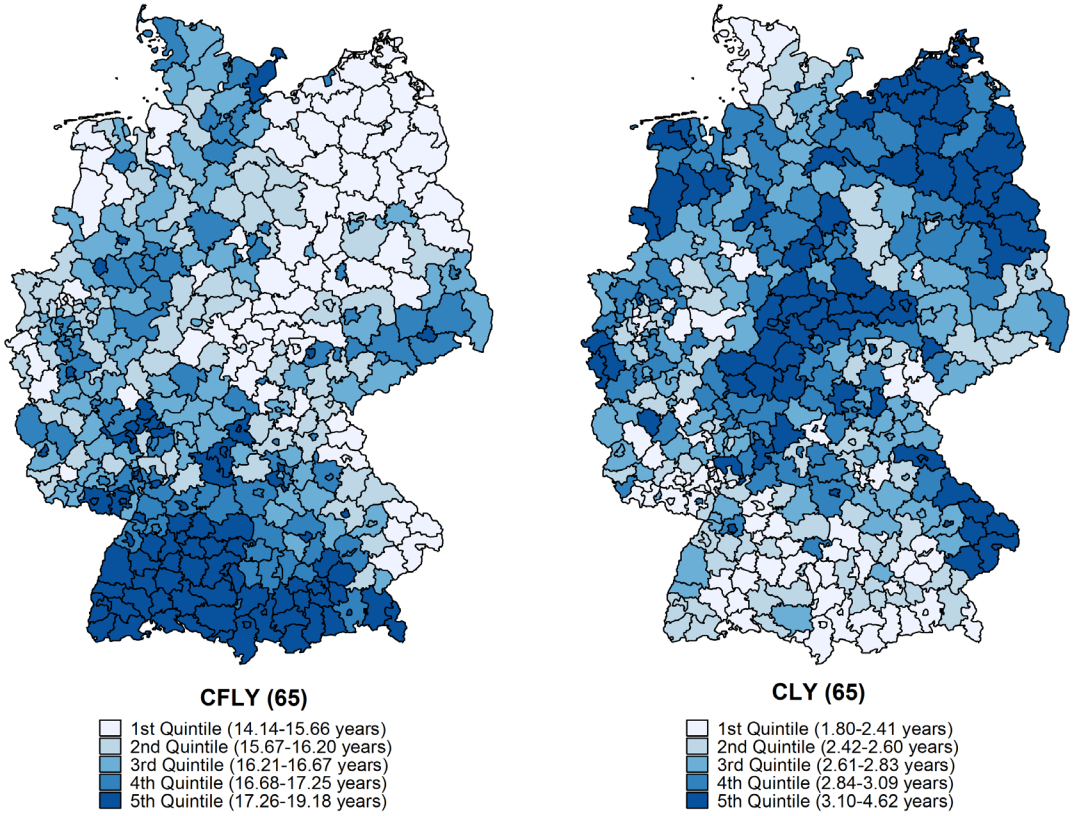



(Statistical Offices of the Federation and the Länder, STLC census 2009 & Regional database 2015, own figure)

### 1.3.2. CFLY, CLY and HR disparities between the counties

To focus the analysis on the population at age 65 and higher, the estimated CFLY and CLY for the counties show clear geographical concentration of county populations with very high values of CFLY and CLY versus populations with very low values in both measures (Figure 8). While an unfavourable situation with low CFLY and high CLY was revealed for counties in the North East, the North West, and the centre of Germany, and also in Western North Rhine-Westphalia and Eastern Bavaria, the opposite – a high CFLY and a low CLY - is true for counties clustered in the North, in the South West, and in the South of Germany. The first impression of the maps leads to the conclusion of an inverse pattern of both indicators, which is not consistent for all counties. For some counties in large parts of Lower Saxony, Saxony, the Rhine region within North Rhine-Westphalia, and in Hesse, Rhineland Palatinate and Berlin, there are – in the cross-county-comparison - high values of both, CFLY and CLY. Low CFLY and CLY are only stated for counties in Saxony-Anhalt.

*Figure 8: Clusters of counties by CFLY and CLY at age 65, 2009*




(Statistical Offices of the Federation and the Länder, STLC census 2009 & Regional database 2015, own figure)

In absolute values, a high LE of a population is linked to higher CFLY and a lower or equal CLY. The linear relationship between LE and CFLY is higher in the 325 West German counties than in the 87 East German counties. In contrast, a weak negative correlation between CLY and LE in the West German counties and no linear relationship in the East German counties is suggested by the correlation analysis.

In a relative perspective, a weaker positive correlation between the HR and the LE is observed in counties in East Germany than in counties in West Germany.

While the clusters of very low HR are concentrated in the North Eastern, North Western, and central counties of Germany, as well as in eastern Bavaria (in the south), the counties of very high HR are clustered in the most North Western part of Germany, and in the Southern and South Western counties. The clusters of the HR are independent of the borders of the federal states and the patterns of HR show only slight differences between males and females.

### 1.3.3. Macro-level factors of health ratio

The multivariate meta-regression models by sex show higher HR levels for counties with higher disposable household income for males and females. For both sexes the long-term unemployment rate has a negative effect on the HR. The effects are consistent and highly significant.

The effects of population density are highly significant with a more favourable HR in urbanised counties than in less densely populated rural areas. The effects were stronger for females than for males. The level of premature mortality was the weakest indicator in the analysis measured in terms of the improvements in model fit.

By the estimation of stratified region-specific regression models, a profound negative correlation between long-term unemployment and the HR was stated for the West German counties. No significant correlation was found for the East German counties. Divergent effects were identified for both German regions in the case of physical and health care conditions.

The most favourable HR was stated for East German counties in the fourth quintile of population density. The most densely populated counties have lower HR in the East. The regression models show a borderline significant effect of high premature mortality for the East German counties, while there is no effect for the West German counties.

The goodness of fit generally increased with the inclusion of the additional macro factors. There exists a lack of improvements of model fit for the long-term unemployment rate. The explained between-county variance is higher for East German counties than for West German counties and higher for males than for females. However, more than 70% of the regional heterogeneity is not explained by the selected indicators.

# 2. Study 2: Trends in care need-free life expectancy and in the health scenarios

## 2.1. Background

The ongoing increase in life expectancy over the last decades has increased the interest in the question, whether the increase in quantity of total life time is also resulting in an increase in the quantity of life time in good health – measured in a prior defined dimension of health. In the literature, a positive scenario (compression), a negative scenario (expansion), and scenario of a stable relation (dynamic equilibrium) are discussed. The health scenarios are classified by investigating the temporal changes of the care-need free life years (CFLY), the life years with care need (CLY), and the relation to each other (the health ratio). The CFLY and the CLY themselves are a result of trends in both mortality or in the prevalence of care need.

## 2.2. Population under study

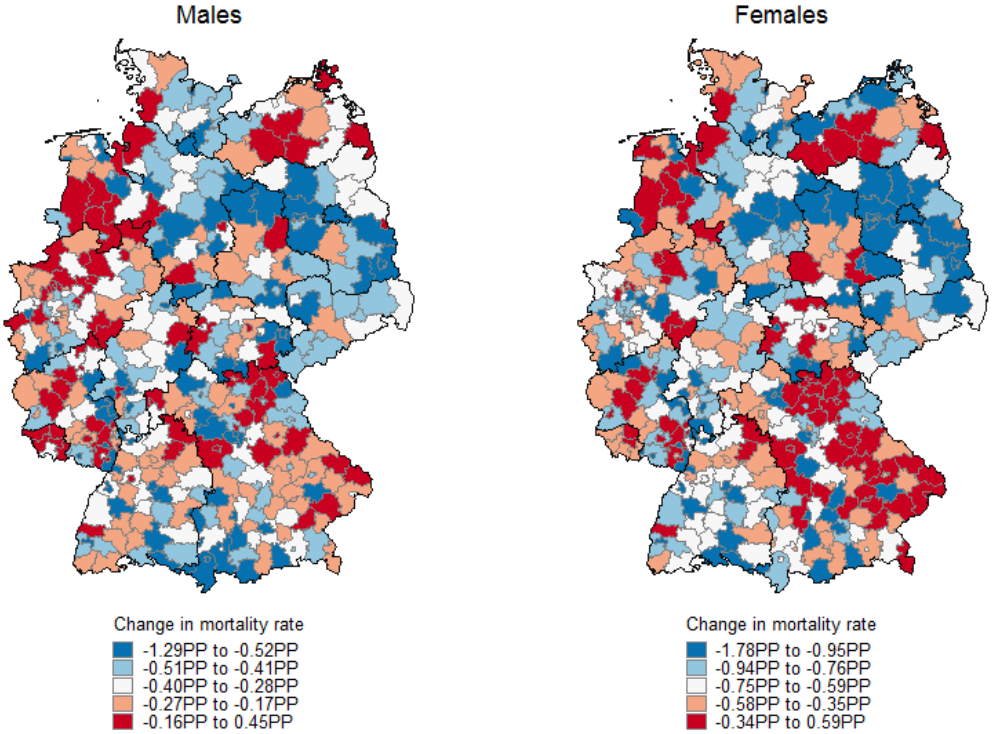
The number of persons in care need has increased from 2.04 to 2.34 million within the period from 2001 to 2009. The raw care need prevalence increased from about 2.5% in 2001 to about 2.9% in 2009. Nearly 50% of the persons in need for care are evaluated as care level 1 (2001: 0.89 million; 2009: 1.25 million persons). The majority are female (2001: 1.40 million; 2009: 1.57 million), but the increase is higher for males (+20%) than for females (+12%) within the observation period. The vast majority of about 81% (2001) respectively 83% (2009) of the persons in need for care are 65 years and older. The absolute gain in the population with care need is solely due to these ages (+18%), while the absolute number of persons younger than 65 is nearly stable (+0.09%) over time.

## 2.3. Results

### 2.3.1. Small-area trends in CFLY and in CLY disparities

***Spatial trends in raw rates:*** The CFLY and the CLY are driven by trends in the mortality rate and the prevalence of care need. The spatial mapping of the trend of the raw mortality rate from 2001 to 2009 shows a very heterogeneous picture of the trends in longevity (Figure 9). The maps for men and women indicate no clear pattern; albeit, a clustering of counties with high or low temporal changes within the federal states, but independently from the state borders. Notable is the fact, that while the great majority of counties experienced a decrease in mortality over the periods, some few counties showed an increase. Since raw rates are used, compositional disparities may lead to bias in terms of these results.

*Figure 9: Absolute change in raw mortality rate, persons by sex at age 65+, 2001-2009*

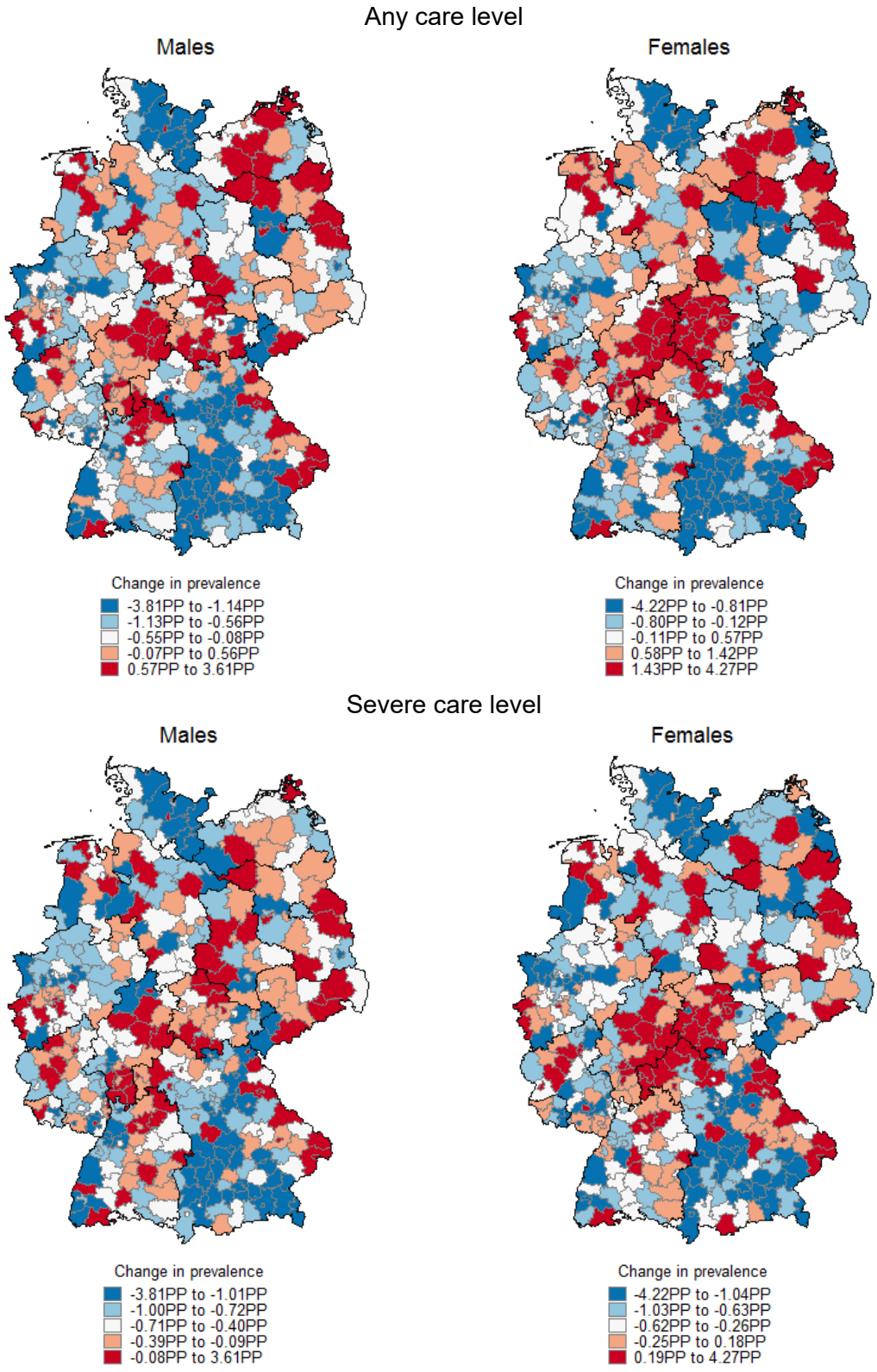



(Statistical Offices of the Federation and the Länder, Regional database 2015, own figure)

***Trends in the indicators on the national level:*** For both sexes, a continuous increase in the remaining LE, $CFLY_{any}$, and $CFLY_{severe}$ can be observed by taking the unweighted mean over all counties. These findings are confirmed by the analysis of the time trends in HR - separated by men and women and by severity of care need. While the proportion of life years free from severe care level ($HR_{severe}$) remained stable or even increased slightly, the proportion of life years free from any care level ($HR_{any}$) decreased.

The gain in mean LE is slightly higher for men than for women. In detail, the male LE at age 65 increased from 15.97 to 17.43 years and mean female LE rose from 19.26 to 20.55 years. The heterogeneity in LE increased for men and decreased for women in the period. $CFLY_{any}$ and $CFLY_{severe}$ show an increase; however, the increase in $CFLY_{severe}$ is higher than in $CFLY_{any}$. Mean $CLY_{any}$ increased from 1.58 to 1.83 years for males and from 3.05 to 3.38 years for females, while male $CLY_{severe}$ stagnated at about 0.85 and female $CLY_{severe}$ at about 1.61 years. By combining the trends in the various indictors into the health scenarios for total Germany, relative expansion can be stated for any care level for both sexes, while there is a stable trend in severe care level of males and a relative compression in severe care level of females.

*Figure 10: Absolute change in raw prevalence, persons by sexes and care level at age 65+, 2001-2009*




(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

***Trends in the indicators on a regional level:*** A high sub-national heterogeneity is revealed by the health scenario classification on the level of counties that is in contrast to the picture of a nationwide consistent trend. The spatial plotting depicts that there is no clear east-west or north-south gap, but a high inequality within the particular federal states.

***Most favourable trends versus most unfavourable trends:*** Further insights can be made by looking at any and severe care level simultaneously (Table 2). An expansion in both care levels (most unfavourable trend) is stated for the majority of counties. 161 out of 412 counties experience an expansion in both care levels in the case of men, while there are 137 out of 412 counties in the case of women. These counties face 93 counties (men) respectively, 108 counties (women) that experience a compression in both levels (most favourable trend). For 154 counties (men) respectively, 161 counties (women), an expansion/stability in any care level combined with a compression/stability in severe care level is revealed. These trends are classified as a dynamic equilibrium which is defined by Manton (1982) as a shift from a large number of persons with more to less severe levels of disability and morbidity.[16]

*Table 2: Classification of counties by combinations of health scenarios by care level*

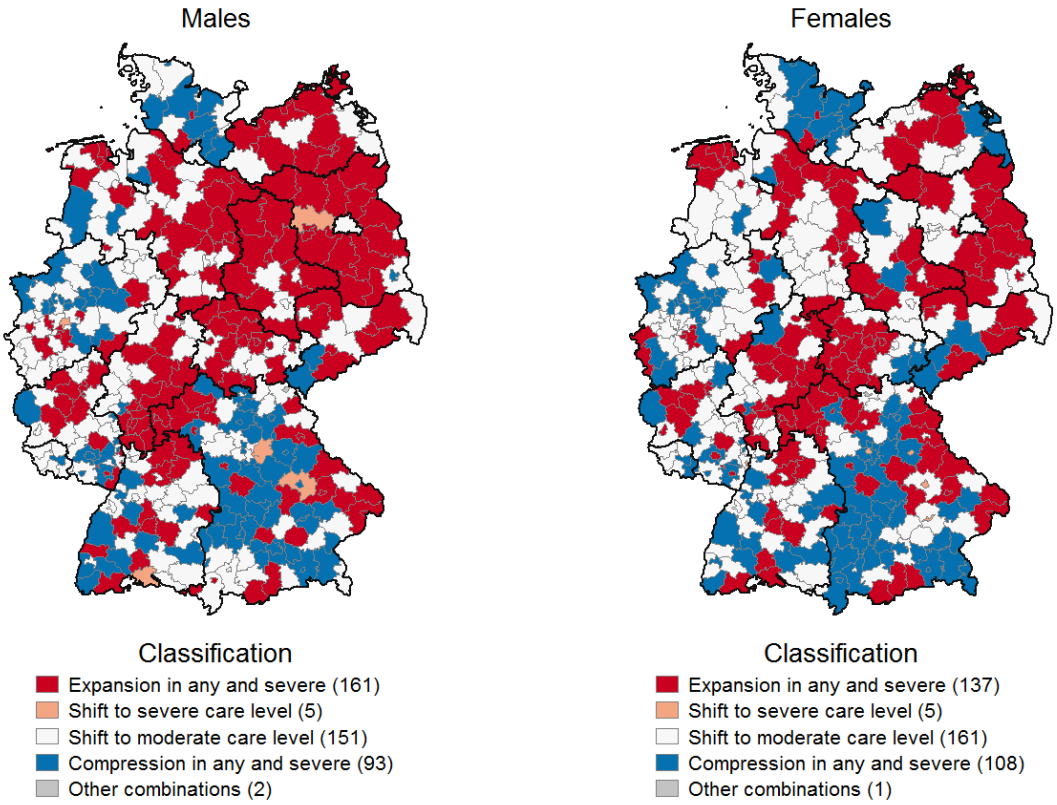
| Sex | Health Scenario | | Severe care level | | |
|---|---|---|---|---|---|
| | | | Expansion | Stability | Compression |
| Men | Any care level | Expansion | **161** | 49 | 74 |
| | | Stability | 0 | 3 | 28 |
| | | Compression | 0 | 2 | **93** |
| Women | | Expansion | **137** | 40 | 111 |
| | | Stability | 0 | 0 | 10 |
| | | Compression | 3 | 2 | **108** |

(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015)

The spatial mapping shows unfavourable trends (expansion in both care levels) in the counties in the North-East – in the case of males - and the Centre of Germany – in the case of both sexes (Figure 11). These regions contrast regions with favourable trends (compression in both care levels) in the very North, the West and the South of Germany.

[16] The remaining counties show inconsistent combinations for both levels or a LE decrease.

*Figure 11: Spatial pattern of counties by combinations of health scenarios by care level, persons at age 65+ by sex, 2001/03 to 2007/09*




(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

### 1.1.1. Decomposition results: Role of morbidity and of mortality

***Driver of the absolute change in CFLY and CLY:*** The highest impacts on absolute CFLY and on absolute CLY can be stated for the changes in mortality. This finding is consistent for both types of care level and for both sexes. Thus, there is a significant proof that the gains in total life expectancy cause an increase in CFLY but also in CLY. Considering the increases in CFLY, on average from 81%, mortality reductions are of higher relative impact on CLY trend than on the trends in CFLY. This is especially the case in the trends in $CLY_{severe}$. Up to 92% is caused by mortality reductions in CFLY, while only 8% to 19% results from morbidity changes. The proportion of $Mort_{\Delta CLY}$ ranges between 135 and 656%.

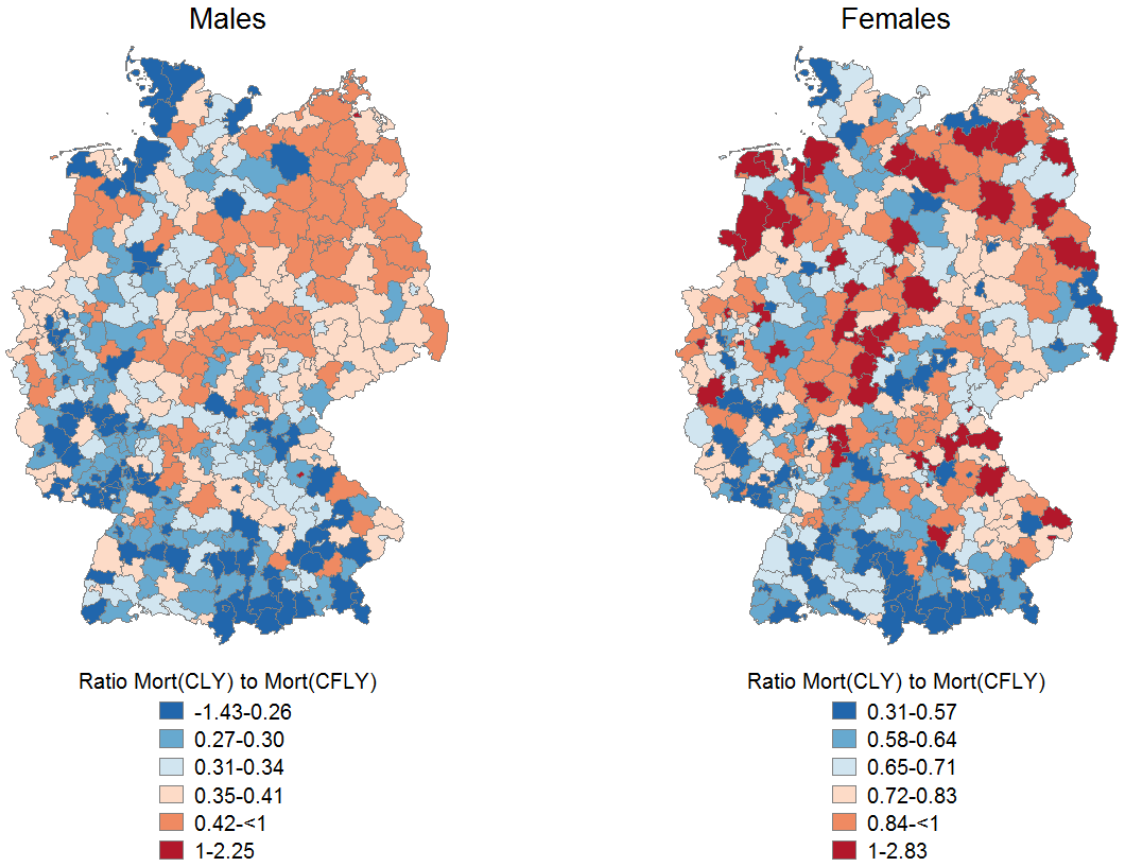
***Impact of mortality reductions on CFLY compared to the impact on CLY:*** Mortality improvements may lead to absolute gains in CFLY (favourable) and in CLY (unfavourable). To quantify the impact of mortality reductions on either the life span living with or without care need, the proportion of absolute CLY gains to the absolute CFLY gains are combined in a ratio. These ratios are computed for both care level, for both sexes, and all counties. Ratios that are higher than one means that there is a higher increase in CLY due to mortality shrinkage compared to the increase in CFLY, which is an unfavourable health trend. Ratios

far below one indicate a favourable situation in which more gained life years are life years without, as opposed to with care need.

In the case of any care level, the results depict that the vast majority of counties show (much) higher gains in CFLY than in CLY, indicated by a ratio far less than one (Figure 12). In general, the north-east and the central German regions show the most unfavourable trends, while the west and the south German counties experienced more positive health improvements due to mortality reductions.[17]

However, there is a disparity between the sexes. In the case of females, the ratios for some counties are much higher than one, which means an unfavourable trend of (partly much) higher CLY gains due to survival improvements compared to CFLY gains. In general, the ratios for the sexes are only weakly correlated which can be interpreted as divergent trends in mortality and care need for men and women. However, the spatial clusters are consistent with the prior results from the heath scenarios.

*Figure 12: Spatial mapping of the ratio of the mortality component in CLY to the mortality component in CFLY at age 65, any care level, 2001/03-2007/09*




(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

[17] For severe care level, the vast majority of the mortality gains cause gains in CFLY with a very low regional diversity (See Figure 19 in the supplementary material)

***Driver of the health scenarios:*** The results of the multinomial regression suggested the highest impact of the morbidity effect on the health scenarios. The value of the coefficients shows that a massively higher chance of being a stability county or a compression county is achieved by even a slight gain in CFLY due to reductions in prevalence. An increase in $Mort_{\Delta CFLY}$ is also linked to a negligibly higher chance of experiencing stability or a compression; however, the influence of $Mort_{\Delta CFLY}$ is statistically significant for males only. A gain in $Mort_{\Delta CLY}$ leads to a significantly lower chance of a county experiencing stability or a compression of care need.

### 1.1.2. Additional results: Spatial data analysis

In the last step, the health trends in a particular county were considered in the context of the neighbouring counties. By using local Moran's I, positive and negative correlations - called spatial autocorrelation - of the health situation in adjacent counties were estimated. The spatial mapping of the values of local Moran's revealed local clusters of counties with high values surrounded by counties with also high values (high-high counties), and clusters of counties with low values surrounded by counties with also low values (low-low counties). Adjacent counties with very different health trends - indicating a negative autocorrelation - were classified as a low-high counties or high-low counties.

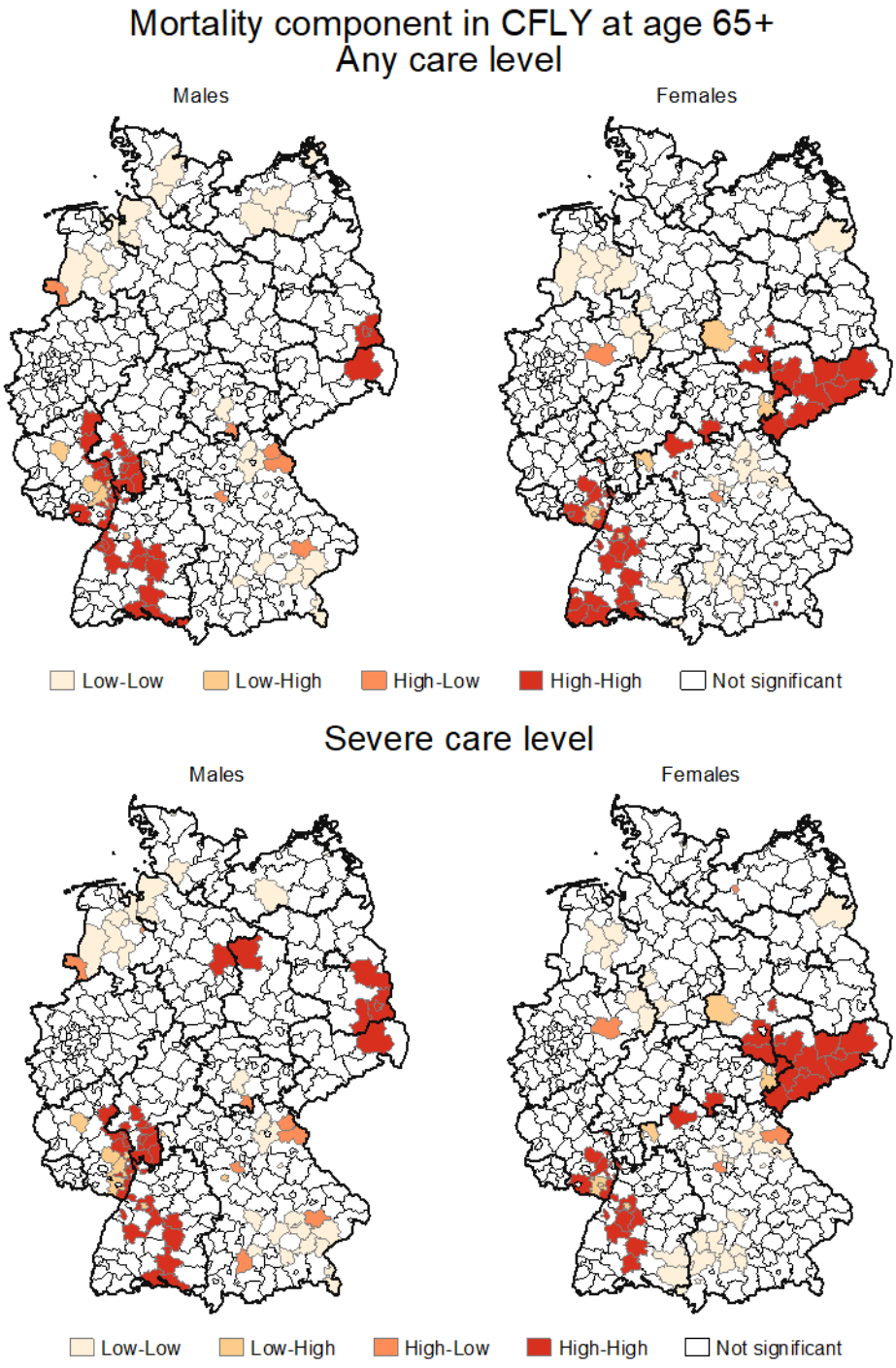
The analysis of the components of CFLY change gives an idea of the geographical concentration of counties with favourable (high-high) or unfavourable (low-low) trends in mortality (mortality component) or in prevalence (morbidity component). Since the CFLY is a measure of good quality of life, the low-low clusters should be interpreted as counties with worse trends. Counties of the high-high clusters show a common positive trend.

***Mortality component in CFLY*** *(Figure 13):* Counties that experience an increase in CFLY due to high mortality reductions are clustered mainly in south western Germany (both sexes and groups of care level) and in Saxony (females). Low increases were observed for clusters in northern and southern Bavaria, western Lower Saxony, and counties in Mecklenburg-Western-Pomerania (males with any care level).[18]

***Mortality component in CLY*** *(Figure 14):* In contrast to the interpretation of the clusters for CFLY trends, the clusters of the CLY components can be classified into favourable and worrying developments. CLY is a measure for low quality of life and, thus, high-high clusters indicate a concentration of counties where the changes in the particular components leads to a worse CLY trend that in the other counties.

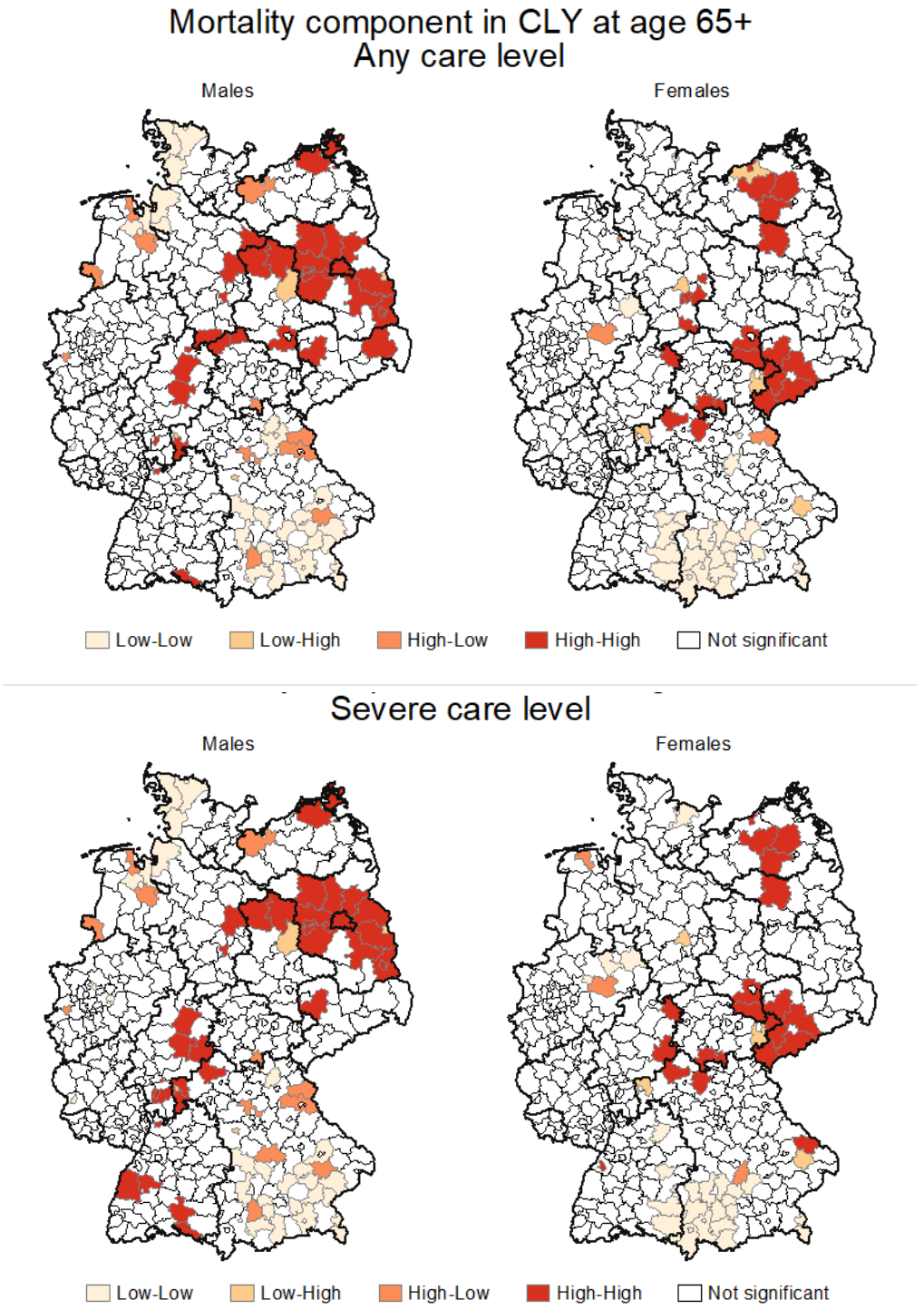
[18] Since the morbidity component of the CFLY is the perfect negative correlate to the morbidity component in CLY, the interpretation will be given below.

*Figure 13: Spatial clusters of mortality component in CFLY at age 65+*



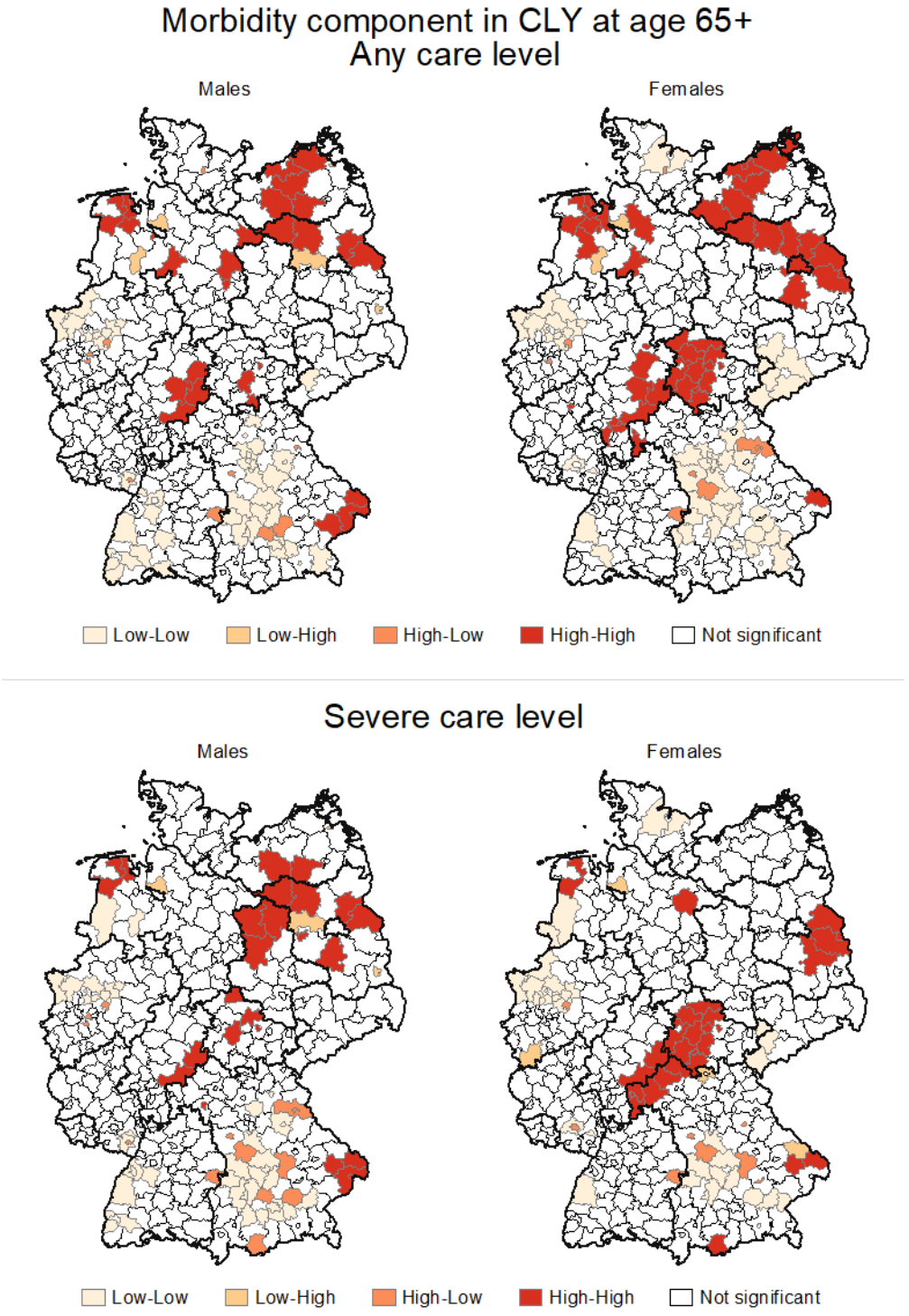

(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

*Figure 14: Spatial clusters of mortality component in CLY at age 65+*




(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

*Figure 15: Spatial clusters of morbidity component in CLY at age 65+*




(Statistical Offices of the Federation and the Länder, STLC censuses 2001-2009, Regional database 2015, own figure)

Clusters of counties that showed a challenging trend in CLY can be found in counties in Mecklenburg-Western Pomerania, in northern Brandenburg and Saxony-Anhalt (both males), Berlin (males), in some counties in Hesse and Thuringia, and in the south of Saxony (females). Positive trends can be suggested for regions in the very North (northern Schleswig-Holstein) and the very South (southern Bavaria).

***Morbidity component in CLY*** *(Figure 15)**:*** For the morbidity component in CLY, there are clusters of a high effect of prevalence fluctuations in Mecklenburg-Western-Pomerania (except for females in severe care level), in (mostly northern) Brandenburg, north east Schleswig-Holstein, and in a large central cluster in Thuringia, Hesse, and northern Bavaria. In contrast, clusters of low morbidity components - can be found in central Bavaria, in the North Rhine and Ruhr region, in northern Schleswig-Holstein (females), in southern Saxony (females) and in western Baden-Württemberg (males).

To conclude, some patterns can be identified from which those of the CLY components are of special interest.

*Table 3: Classification of spatial clusters by positive and negative changes in the morbidity and mortality components of CLY and subgroups*

| | CLY component | Clusters | Sub-Groups |
|---|---|---|---|
| **Positive** | **Mortality** | Southern Bavaria<br>Parts of southern Baden-Württemberg<br>Southern Saxony | All<br>All<br>Females |
| | **Morbidity** | Central Bavaria<br>Ruhr and North Rhine region<br>Southern Saxony | All<br>All<br>Females |
| **Negative** | **Mortality** | Northern Brandenburg<br>Northern Saxony-Anhalt<br>Central and northern Mecklenburg-Western Pomerania<br>Central regions in Thuringia, Hesse, northern Bavaria | All<br>Males<br>All<br><br>Fuzzy clusters |
| | **Morbidity** | Northern Brandenburg<br><br>Northern Saxony-Anhalt<br>North western Lower Saxony<br>Central and northern Mecklenburg-Western Pomerania<br>Central regions in Thuringia, Hesse, northern Bavaria | All, except females with severe care level<br>Males<br>All<br>All, except females with severe care level<br>Fuzzy clusters in males, but marked for females |

The table shows that in particular counties in north eastern Germany show unfavourable trends in mortality and in the prevalence of care need. The clustering effect in these regions is higher for males than for females. The contrary is the case for the counties in the centre of Germany. These regions experience a very unfavourable trend in the prevalence of care need of females. Special cases are the counties in southern Saxony. The CLY of females in these regions has increased due to high reductions in mortality, but the effect of changes in the prevalence rates on the CLY trend was low.

Based on the classification, some counties especially in South Germany show a positive trend in long-term care. On the other side, there are large clusters of counties in central and north Germany with a negative trend in long-term care, due to the changes in the prevalence and the mortality.

# 3. Study 3: Contextual effects on the health of native Germans and Aussiedler

## 3.1. Background

Aussiedler have achieved a high level of social and economic integration in German society (Woellert et al., 2009), in part because integration of these immigrants was intensively promoted by German social policy. The integration of Aussiedler who had a very privileged status among migrants in Germany can be considered as an example of "best practice", which makes them an interesting study population beyond the German context. First, they can be regarded as a sort of benchmark when analysing the effectiveness of integration policies, e.g. in terms of social and public health aspects. This may help to develop future acculturation and naturalisation strategies and to evaluate their consequences. Second, their degree of integration, together with their high levels of education, makes them an attractive population for health research on migrants in general. Considering the well-documented favourable effects of high levels of education on health, the confounding effect of education on health in the Aussiedler population is expected to be smaller than in other migrant groups. Thus, positive or negative effects of living circumstances, life style as well as selection effects such as the "healthy migrant effect" should be better visible because they are less confounded.

## 3.2. Population under study

The analysis covers a total of 11,489 Aussiedler (2.97% of the whole sample) aged 20 years and older. The reference group is made up of 375,762 native Germans aged 20+ (97.03%). By using the information on the year of immigration, the duration of stay in Germany is computed. This information will be used to stratify Aussiedler into four subgroups by length of stay: Aussiedler who have been living in Germany for less than 15 years (in-migration after 1990), for 15 to 30 years (in-migration after 1975) and for more than 30 years (in-migration before 1975). Persons with missing information on the year of immigration are combined in an additional category. The stratification is used to analyse health disparities among different immigration cohorts of Aussiedler.

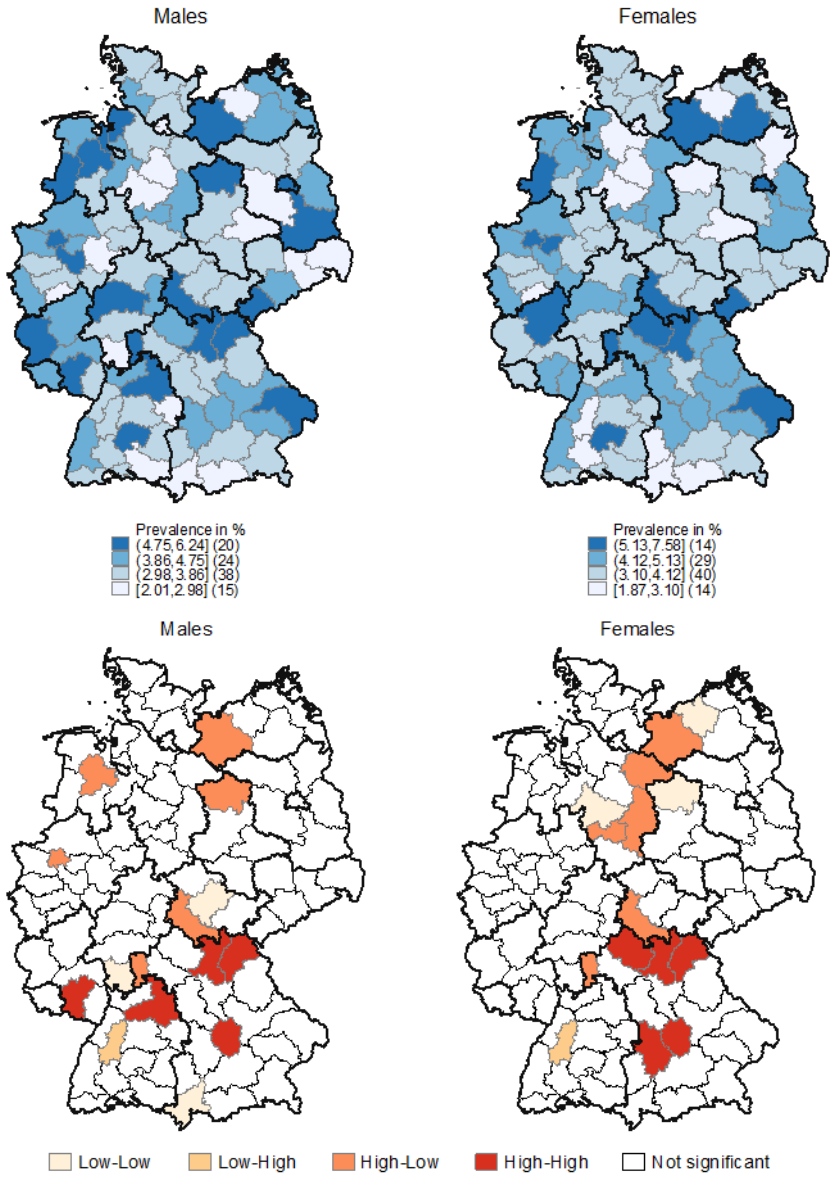
In total, 322,813 native Germans (96.99% of the final sample) and 10,022 Aussiedler (3.01%) remain in the sample under study.

## 3.3. Results

### 3.3.1. Spatial inequalities in the age-adjusted prevalence

The estimated age-adjusted prevalence of longstanding illness by spatial planning regions shows a high variability for both sexes (Figure 16). However, there is no clear pattern. Clusters of regions where there is a population with a high prevalence surrounded by regions where there is a population also with high prevalence can be stated for South Thuringia, and North and central Bavaria. Unsurprisingly, the spatial health situation of the general population is predominantly driven by the health situation of the native Germans. In the further steps, the East German regions are excluded from the analysis.

*Figure 16: Spatial distribution of the prevalence of longstanding illness (first row) and of spatial clusters of the prevalence of longstanding illness (second row) in 2005*




(Statistical Offices of the Federation and the Länder, Microcensus 2005, own figure)

### 3.3.2. Micro-level effects on longstanding illness

The multivariate analysis consists of three nested models. In the first model, the baseline model, the risk of longstanding illness without controlling for any individual characteristic shows that Aussiedler with a duration of stay of less than 30 years have better health than that of native Germans. In contrast, Aussiedler who have been living in Germany for more than 30 years have a higher risk of longstanding illness than Aussiedler with a lower duration of stay. After controlling for the individual-level characteristics and the macro factors, Aussiedler who have been in Germany for less than 15 years have a slight health advantage, compared to Aussiedler living for more than 15 years in Germany and to native Germans.

In general, the effects of the individual factors are the same for Aussiedler and native Germans, but two interesting differences emerge: 1) The effects of education on health differ between native Germans and Aussiedler. While there is no statistically significant educational gradient in the health of Aussiedler, there is an educational degree in native Germans with the greatest health disadvantage in persons with no degree or a low degree. However, a significant social gradient exists for the health effect of income. The health of individuals with low income is worse than those with high income for both native Germans and Aussiedler. For Aussiedler, this effect is significantly more pronounced than for native Germans.

2) There is a different effect of the body mass index between the subgroups. While, individuals who are more overweight have a higher risk of longstanding illness than those with normal weight, there are marked disparities for the health effects of being underweight. Being underweight is linked to a higher risk of longstanding illness in native Germans, while there is no significant health disadvantage for underweight Aussiedler.

Compared to the unadjusted model I, the comparison of the between-region-variance shows an increase of 11% in model II and a decrease of 27% in model III. With a reduction in MOR from 1.22 to 1.19 some unexplained regional variance is still remaining.

### 3.3.3. Macro-level effects on longstanding illness

The highest risk of longstanding illness is stated for native Germans living in highly urbanised regions. High urbanity also has a negative effect on the health of Aussiedler.

A high GDP per capita is associated with a low risk of longstanding illness in native Germans, while those living in economically disadvantaged regions have the worst health. Aussiedler living in regions with low GDP also have worse health than Aussiedler living in economically prosperous regions. Different effects on the health of Aussiedler and native Germans are stated for the proportion of foreigners. However, these effects are not statistically significant for native Germans and for Aussiedler, a high proportion of foreigners has no effect on the health of native Germans and a higher risk of longstanding illness in the case of Aussiedler.

# 4. Study 4: Sub-national cohort inequalities in care need and in longstanding illness

## 4.1. Background

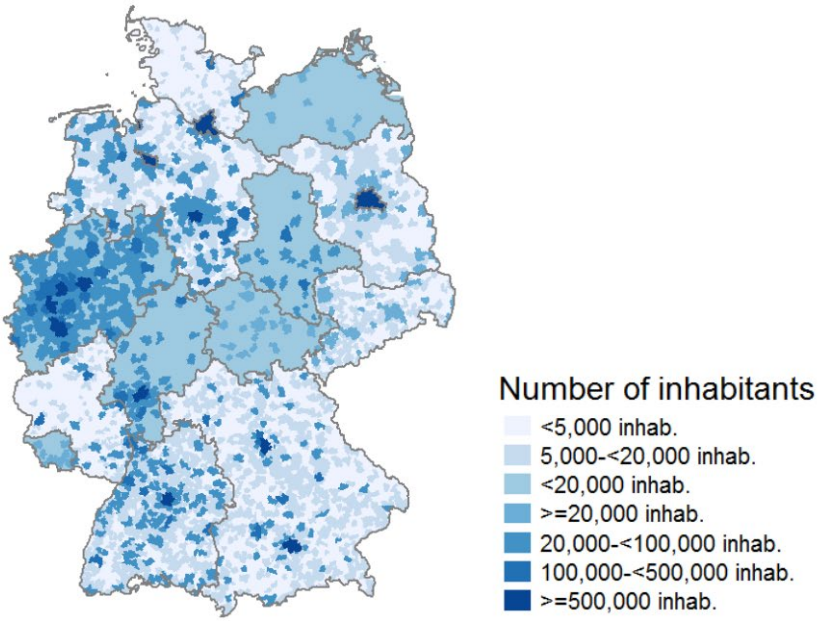
In the literature review it was mentioned that studies investigated various individual behavioural, socioeconomic, family-structural, and cultural attributes, as well as contextual conditions as factors for good or poor health. Although, it is hard to singularise, the aspect of health selection due to mortality and migration that has a direct influence on the composition of a population is not yet investigated on the level of small areas in Germany. In the former studies, the health situation was either considered for an aggregation of persons at age 65 and above or after adjusting for age as an individual determinant. From a biomedical perspective, age is an established indicator for the process of physical and cognitive degeneration (like decelerated cellular renewal and musculoskeletal loss). However, from a medical, demographic, socio-psychological and epidemiological perspective, the health history over the life course is also of interest. Since individual-level longitudinal data over the life course is not available for small-area level in Germany, a proxy must be used. In demographic research, the (birth) cohort is an indicator for similarities in terms of events over the life time. The (standardised) picture of an ideal personal life course with defined sequences of life stages has slowly changed over the last centuries; however, the transition was a long-term process and can be assumed to be more profound between cohorts than within them. Thus, it is expected that persons of the same cohorts experience more similar life courses than persons of other cohorts. Further, it can be assumed that ageing is a general biomedical process that is inherent and ever-present in all human beings, but is influenced by various socio-structural, material, cultural, behavioural, and short-term conditional aspects. By adjusting for these various aspects and neglecting effects of long-term contextual factors, of selective migration and mortality, the health situation of persons of the same cohort is assumed to not differ significantly.

***Data and Methods:*** Since there are only two periods available and the requirements of uniform Lexis triangles are not met, established age-period-cohort models cannot be estimated. Thus, multilevel Poisson regression models were conducted to estimate the risk factors of receiving benefits from the SLTC insurance and of longstanding illness (LSI). The restrictions of the health outcomes are that the care need definition is focussed - but not exclusively -on persons in outpatient informal care since for persons in institutions the benefits are directly given to the care facility. The Multilevel Poisson models are random intercept models with a random coefficient for the birth cohort groups. After the estimation of the final models, the predicted probabilities of the risks of receiving SLTC allowances and of the risk of longstand-

ing illness by the cohort groups are estimated for the particular small-area entities. The probabilities are a combination of the estimated fixed and random components.

The spatial clusters are defined by a combination of administrative boundaries and physical structure (Figure 17): The federal states (Länder) that are area states are differentiated by the number of inhabitants in the municipality (<5000 inhabitants, 5.000-<20.000 inhabitants, 20.000-<100.000 inhabitants, 100.000-<500.000 inhabitants, 500.000 and more inhabitants; exceptions: North Rhine-Westphalia and Saxony-Anhalt: <20.000 inhabitants condensed; Mecklenburg-Western Pomerania: <20.000 inhabitants vs. 20.000 and more inhabitants; Saarland, Brandenburg, Saxony, Thuringia: 20.000 inhabitants and more condensed).

*Figure 17: Classification of municipalities by population size based on the classification available in the Microcensuses (SUF) 2005, 2009*




(Statistical Offices of the Federation and the Länder, own mapping)

The stepwise extended models include the covariates cohort (in 3-year cohort groups from 1910-1945), age (in 5-year age groups from 65 to <95), period (2005, 2009), sex, family status (married, single, divorced, widowed), education (without degree, low degree = Haupt-(Volks-) schulabschluss, moderate degree = Abschluss der allgemeinbildenden Polytechnischen Oberschule of the former GDR/Realschulabschluss or similar, higher degree = Fachhochschulreife, highest degree = Allgemeine oder fachgebundene Hochschulreife, refused to answer), and immigration status (German citizens, German expellees, migrants with German citizenship, migrants with German and additional citizenship, foreigners without German citizenship, unknown). To avoid problems of perfect collinearity, age and cohort are classified into groups.

## 4.2. Population under study

The models for receiving SLTC allowance are based on a dataset of 204,782 persons at age 65 to 94. 5.9% of the total sample are recipients of SLTC allowances. The sample for the longstanding illness covers 178,878 persons of whom 17.0% are classified as having a longstanding illness (LSI). In both samples, the highest absolute numbers of persons are females, married, German citizens, with a low degree, and in the age groups 65 to 69. The sample is higher for the year 2009 than for the year 2005, and the cohort size is highest for the cohorts 1937-1939.

In the bivariate perspective, the trends in the prevalence of SLTC and of LSI are mostly similar, but with exceptions: The trends of SLTC prevalence by age and cohort are more pronounced, while the LSI prevalence is weaker in both, age and cohort. The sex difference in the SLTC prevalence is higher than the sex difference in the LSI prevalence.

The SLTC prevalence shows a stable increase by age – starting with 1.5% at age 65-69 and reaching 35.6% at age 90-94. For the periods, the prevalence is nearly the same level for 2005 and 2009 (5.9% and 5.8%). The cohort prevalence decreases by later cohort from 38.4% in the oldest cohorts (1910-1912) to 1.1% in the youngest cohorts (1943-1945). Females have a higher raw SLTC prevalence (7.2%) than males (4.1%). Widowed persons have the highest prevalence (11.0%), while married persons have the lowest prevalence (3.0%). Further, foreigners have the lowest SLTC prevalence (3.1%), and German citizens and German expellees have the highest prevalence (6.0% and 5.7%). Education shows a clear gradient with the highest prevalence in persons with no degree (10.1%) and the lowest prevalence in persons with higher (2.0%) and highest (2.8%) degrees. Persons with refused answers in the question about education have profound higher SLTC prevalence (41.5%). The lowest SLTC prevalence is stated for urban regions in Rhineland Palatinate (3.9%), the highest prevalence for the former Eastern part of Berlin (9.0%).

In the case of longstanding illness, the prevalence increases by age up to 26.0% at the age 90-94. The prevalence is nearly the same level in 2005 (17.2%) and in 2009 (16.9%), it is increasing by cohort groups up to 21.2% in the cohorts 1916-1918 and nearly continuously decreasing in the younger cohorts, it is higher for females (17.5%) than for males (16.4%), it is highest in widowed (20.2%) and lowest in married (15.3%) persons, it is highest for persons with an unknown citizenship (21.1%), German expellees (18.7%) and migrants with German citizenship (18.9%), and lowest for German citizens (16.7%) and persons with dual citizenships (16.5%), and with a decrease by higher levels of education. Also it is highest for persons with no degree (22.7%) and lowest – except for the persons without information about education - for persons with higher and highest degrees (13.3-13.2%). While Hamburg has the lowest LSI prevalence (10.4%), East Berlin has the highest value of LSI prevalence (24.4%).

*Table 4: Population under study by spatial entity (separated by federal states) and health outcome, persons 65+, 2005, 2009*

| Spatial entities | Receiving SLTC allowance | | | Longstanding illness | | |
|---|---|---|---|---|---|---|
| | persons | cases | | persons | cases | |
| SH (rural) | 2,379 | 148 | 6.2% | 1,998 | 309 | 15.5% |
| SH (semi-rural) | 2,391 | 137 | 5.7% | 1,978 | 280 | 14.2% |
| SH (suburban) | 1,883 | 146 | 7.8% | 1,587 | 253 | 15.9% |
| SH (urban) | 1,142 | 65 | 5.7% | 941 | 157 | 16.7% |
| Hamburg | 4,080 | 165 | 4.0% | 3,164 | 332 | 10.5% |
| LS (rural) | 2,499 | 159 | 6.4% | 2,199 | 375 | 17.1% |
| LS (semi rural) | 5,438 | 312 | 5.7% | 4,681 | 742 | 15.9% |
| LS (suburban) | 6,882 | 370 | 5.4% | 5,804 | 859 | 14.8% |
| LS (urban) | 2,467 | 115 | 4.7% | 2,177 | 437 | 20.1% |
| Hanover | 1,127 | 59 | 5.2% | 967 | 141 | 14.6% |
| Bremen | 1,751 | 105 | 6.0% | 1,339 | 183 | 13.7% |
| NRW (rural) | 5,066 | 272 | 5.4% | 4,461 | 751 | 16.8% |
| NRW (semi rural) | 17,983 | 892 | 5.0% | 15,734 | 2602 | 16.5% |
| NRW (suburban) | 12,685 | 723 | 5.7% | 10,929 | 2088 | 19.1% |
| NRW (urban) | 7,052 | 295 | 4.2% | 6,103 | 1041 | 17.1% |
| HE (rural) | 7,618 | 493 | 6.5% | 6,714 | 1135 | 16.9% |
| HE (semi rural) | 4,530 | 324 | 7.2% | 3,903 | 574 | 14.7% |
| HE (urban) | 1,802 | 132 | 7.3% | 1,565 | 268 | 17.1% |
| Frankfurt/M | 1,362 | 73 | 5.4% | 1,189 | 229 | 19.3% |
| RLP (rural) | 4,570 | 233 | 5.1% | 4,121 | 788 | 19.1% |
| RLP (semi rural) | 2,283 | 168 | 7.4% | 1,973 | 383 | 19.4% |
| RLP(suburban) | 1,988 | 113 | 5.7% | 1,692 | 332 | 19.6% |
| RLP (urban) | 1,291 | 50 | 3.9% | 1,104 | 199 | 18.0% |
| BW (rural) | 3,567 | 144 | 4.0% | 3,208 | 512 | 16.0% |
| BW (semi rural) | 8,938 | 388 | 4.3% | 7,826 | 1269 | 16.2% |
| BW (suburban) | 8,157 | 403 | 4.9% | 7,041 | 1179 | 16.7% |
| BW (urban) | 3,328 | 216 | 6.5% | 2,909 | 558 | 19.2% |
| Stuttgart | 1,441 | 75 | 5.2% | 1,207 | 183 | 15.2% |
| BV (rural) | 8,284 | 463 | 5.6% | 7,293 | 1378 | 18.9% |
| BV (semi rural) | 11,399 | 677 | 5.9% | 9,989 | 1847 | 18.5% |
| BV (suburban) | 5,159 | 324 | 6.3% | 4,385 | 851 | 19.4% |
| BV (urban) | 2,934 | 154 | 5.2% | 2,559 | 467 | 18.2% |
| Munich/Nuremberg | 3,743 | 174 | 4.6% | 3,178 | 402 | 12.6% |
| SL (rural) | 1,434 | 100 | 7.0% | 1,253 | 203 | 16.2% |
| SL (urban) | 1,431 | 71 | 5.0% | 1,192 | 180 | 15.1% |
| B (West) | 4,520 | 312 | 6.9% | 3,905 | 707 | 18.1% |
| B (East) | 3,025 | 272 | 9.0% | 2,633 | 642 | 24.4% |
| BB (rural) | 1,274 | 100 | 7.8% | 1,159 | 226 | 19.5% |
| BB (semi rural)) | 2,540 | 193 | 7.6% | 2,304 | 415 | 18.0% |
| BB (urban) | 2,818 | 205 | 7.3% | 2,573 | 333 | 12.9% |
| MV (rural) | 2,032 | 167 | 8.2% | 1,760 | 240 | 13.6% |
| MV (urban) | 1,964 | 119 | 6.1% | 1,758 | 246 | 14.0% |
| S (rural) | 2,724 | 193 | 7.1% | 2,614 | 424 | 16.2% |
| S (semi rural) | 3,676 | 240 | 6.5% | 3,520 | 636 | 18.1% |
| S (urban) | 6,169 | 388 | 6.3% | 5,761 | 1039 | 18.0% |
| SA (rural) | 3,713 | 259 | 7.0% | 3,440 | 540 | 15.7% |
| SA (semi rural) | 2,224 | 180 | 8.1% | 2,050 | 311 | 15.2% |
| SA (urban) | 1,298 | 90 | 6.9% | 1,205 | 218 | 18.1% |
| TH (rural) | 3,751 | 280 | 7.5% | 3,314 | 559 | 16.9% |
| TH (urban) | 2,970 | 259 | 8.7% | 2,519 | 395 | 15.7% |

(Statistical Offices of the Federation and the Länder, Microcensus 2005 & 2009)

## 4.3. Results

### 4.3.1. Effects of individual-level covariates

The **effects of age** in the regression models are significant in all six models. The risks of SLTC and LSI are generally increasing by increasing age. The effect sizes for the SLTC risk are much higher than the LSI risk at higher ages. In the final models, the highest SLTC risk can be found for the ages 90-94 with a nearly 182% higher risk compared to persons aged between 65-69. For LSI, the highest risk is about 24% higher for persons at age 85-89 compared to persons aged between 65-69. While the effect sizes continuously decreased in the SLTC models by adjusting for additional factors, the age effect in the LSI models are very stable.

The **effect of period** shows in both groups a statistically significant higher risk in later periods; however, the gradient is much steeper for the SLTC risk: 30% higher SLTC risk in the 2005-2009 comparison versus an 8% higher LSI risk. The effects are relatively stable over the inclusion steps.

The **cohort effects** are of central interest in the analysis. The statistically significant gradient of the SLTC risk is much higher than the LSI risk. For example, the SLTC risk of the cohorts 1943-1945 is only 0.11 times the risk of the cohorts 1910-1912. In comparison, the risk ratio is 0.45 in the case of LSI.

The **sex disparities** are weaker than the effects of most of the other covariates. While the risks are slightly higher for females than for males in the SLTC risks and become insignificant by adjusting for other covariates. The risk is significantly about 5% lower for females in the LSI models.

The **effect of the family status** shows the (mostly) significantly lowest risk for married persons, however, the highest risk of SLTC can be stated for singles (99% higher than for the married) and the highest risk of LSI for divorced persons (21% higher). The effects are relatively stable over the inclusion history.

The **immigration status** has different effects on the SLTC risk compared to the LSI risk. While for the SLTC risk, the German citizens have – apart from the persons with unknown nationality - the highest risk ratio, the risk of LSI is significantly higher for German expellees, migrants with German citizenship and foreigners (10%-13% higher than the risk of non-migrated German citizens).

**Education** shows a very steep gradient in both types of models; however, to a higher disparity in the SLTC risk. Persons with no degrees have a significantly 2.81 times higher SLTC risk and a 1.40 times higher LSI risk compared to the risk of persons with moderate degrees. The lowest risks are stated for persons with higher and highest degrees.

*Table 5: Results of the multilevel Poisson regression model for the risk of receiving SLTC allowance, persons at age 65+, 2005, 2009*

| | Risk of receiving SLTC allowance | | | | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Categories** | **Persons** | **Care recipients** | | **RR** | **95% CI** | **RR** | **95% CI** | **RR** | **95% CI** |
| **Age** | **65-69** | 65,848 | 966 | 1.5% | **1** | | **1** | | **1** | |
| | **70-74** | 53,656 | 1,479 | 2.8% | 1.35 | [1.20-1.52] | 1.34 | [1.19-1.51] | 1.34 | [1.19-1.51] |
| | **75-79** | 38,903 | 2,069 | 5.3% | 1.75 | [1.48-2.07] | 1.71 | [1.44-2.02] | 1.71 | [1.45-2.02] |
| | **80-84** | 28,172 | 2,962 | 10.5% | 2.19 | [1.79-2.68] | 2.07 | [1.69-2.54] | 2.08 | [1.70-2.55] |
| | **85-89** | 13,479 | 2,839 | 21.1% | 2.87 | [2.26-3.64] | 2.65 | [2.09-3.37] | 2.60 | [2.05-3.30] |
| | **90-94** | 4,724 | 1,680 | 35.6% | 3.27 | [2.46-4.34] | 3.00 | [2.25-3.98] | 2.82 | [2.12-3.75] |
| **Year** | **2005** | 97,447 | 5,724 | 5.9% | **1** | | **1** | | **1** | |
| | **2009** | 107,335 | 6,271 | 5.8% | 1.33 | [1.26-1.41] | 1.31 | [1.24-1.38] | 1.30 | [1.23-1.38] |
| **Cohorts** | **1910-1912** | 936 | 359 | 38.4% | **1** | | **1** | | **1** | |
| | **1913-1915** | 2,591 | 903 | 34.9% | 0.85 | [0.70-1.03] | 0.87 | [0.72-1.05] | 0.87 | [0.71-1.06] |
| | **1916-1918** | 3,350 | 927 | 27.7% | 0.70 | [0.57-0.86] | 0.72 | [0.59-0.88] | 0.75 | [0.60-0.93] |
| | **1919-1921** | 9,939 | 1,914 | 19.3% | 0.56 | [0.45-0.70] | 0.59 | [0.48-0.73] | 0.62 | [0.49-0.78] |
| | **1922-1924** | 14,076 | 1,921 | 13.6% | 0.44 | [0.35-0.56] | 0.47 | [0.38-0.60] | 0.51 | [0.40-0.65] |
| | **1925-1927** | 18,547 | 1,581 | 8.5% | 0.32 | [0.25-0.41] | 0.36 | [0.28-0.46] | 0.39 | [0.30-0.50] |
| | **1928-1930** | 23,515 | 1,345 | 5.7% | 0.23 | [0.18-0.30] | 0.27 | [0.21-0.35] | 0.29 | [0.22-0.39] |
| | **1931-1933** | 24,301 | 920 | 3.8% | 0.18 | [0.13-0.24] | 0.21 | [0.16-0.29] | 0.23 | [0.17-0.31] |
| | **1934-1936** | 33,980 | 906 | 2.7% | 0.15 | [0.11-0.21] | 0.19 | [0.14-0.26] | 0.20 | [0.15-0.28] |
| | **1937-1939** | 40,155 | 748 | 1.9% | 0.11 | [0.08-0.16] | 0.14 | [0.10-0.20] | 0.16 | [0.11-0.23] |
| | **1940-1942** | 24,353 | 368 | 1.5% | 0.10 | [0.07-0.15] | 0.13 | [0.09-0.18] | 0.14 | [0.10-0.21] |
| | **1943-1945** | 9,039 | 103 | 1.1% | 0.07 | [0.05-0.11] | 0.09 | [0.06-0.14] | 0.11 | [0.07-0.16] |
| **Sex** | **Male** | 86,090 | 3,507 | 4.1% | | | **1** | | **1** | |
| | **Female** | 118,692 | 8,488 | 7.2% | | | 1.03 | [0.99-1.08] | 0.97 | [0.93-1.01] |
| **Family status** | **Married** | 121,656 | 3,608 | 3.0% | | | **1** | | **1** | |
| | **Single** | 10,607 | 1,025 | 9.7% | | | 2.15 | [2.00-2.31] | 1.99 | [1.85-2.14] |
| | **Widowed** | 61,375 | 6,764 | 11.0% | | | 1.67 | [1.59-1.75] | 1.57 | [1.50-1.65] |
| | **Divorced** | 11,144 | 598 | 5.4% | | | 1.69 | [1.54-1.84] | 1.63 | [1.50-1.79] |
| **Immigration status** | **German citizens** | 169,049 | 10,168 | 6.0% | | | | | **1** | |
| | **German expellees** | 21,442 | 1,222 | 5.7% | | | | | 0.94 | [0.88-0.99] |
| | **Migrants with German citizenship** | 8,346 | 319 | 3.8% | | | | | 0.77 | [0.69-0.86] |
| | **Migrants with German & foreign citizenship** | 877 | 41 | 4.7% | | | | | 0.94 | [0.69-1.27] |
| | **Foreigners without German citizenship** | 4,458 | 139 | 3.1% | | | | | 0.77 | [0.65-0.91] |
| | **Unknown nationality** | 610 | 106 | 17.4% | | | | | 1.36 | [1.12-1.65] |
| **Education** | **No degree** | 6,316 | 638 | 10.1% | | | | | 2.81 | [2.53-3.13] |
| | **Lowest degree** | 144,447 | 8,596 | 6.0% | | | | | 1.59 | [1.48-1.70] |
| | **Moderate degree** | 26,861 | 884 | 3.3% | | | | | **1** | |
| | **Higher degree** | 6,074 | 121 | 2.0% | | | | | 0.80 | [0.66-0.96] |
| | **Highest degree** | 18,085 | 512 | 2.8% | | | | | 0.90 | [0.80-1.00] |
| | **Refused to answer** | 2,999 | 1,244 | 41.5% | | | | | 5.93 | [5.42-6.48] |
| **Total sample** | | 204,782 | 11,995 | 5.9% | | | | | | |
| **Constant** | | | | | 0.06 | [0.06-0.07] | 0.12 | [0.09-0.17] | 0.08 | [0.05-0.09] | 0.05 | [0.04-0.07] |
| **Random intercept (SD) - small-area level (cohort)** | | | | | 0.126 | [0.089-0.177] | 0.104 | [0.070-0.150] | 0.102 | [0.067-0.138] | 0.088 | [0.050-0.140] |
| **MOR** | | | | | 1.127 | | 1.105 | (-2.02%) | 1.103 | (-0.17%) | 1.087 | (-1.40%) |
| **Random intercept (SD) - federal state level (cohort)** | | | | | 0.147 | [0.089-0.244] | 0.179 | [0.150-0.220] | 0.172 | [0.140-0.201] | 0.201 | [0.170-0.240] |
| **MOR** | | | | | 1.150 | | 1.186 | (3.08%) | 1.178 | (-0.68%) | 1.211 | (2.83%) |
| **LR Test (ML vs. Poisson), Chi²** | | | | | 290.31 | p<0.001 | 216.360 | p<0.001 | 195.320 | p<0.001 | 265.460 | p<0.001 |

(Statistical Offices of the Federation and the Länder, Microcensus 2005 & 2009, own estimations)

*Table 6: Results of the multilevel Poisson regression model for the risk of longstanding illness, persons at age 65+, 2005, 2009*

| | Risk of longstanding illness (LSI) | | | | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Categories** | **Persons** | **Persons with LSI** | | **RR** | **95% CI** | **RR** | **95% CI** | **RR** | **95% CI** |
| **Age** | **65-69** | 58,399 | 6,851 | 11.7% | **1** | | **1** | | **1** | |
| | **70-74** | 47,576 | 7,568 | 15.9% | 1.14 | [1.08-1.20] | 1.14 | [1.08-1.20] | 1.13 | [1.08-1.19] |
| | **75-79** | 34,313 | 6,808 | 19.8% | 1.18 | [1.08-1.28] | 1.17 | [1.08-1.27] | 1.17 | [1.08-1.27] |
| | **80-84** | 24,216 | 5,504 | 22.7% | 1.21 | [1.09-1.35] | 1.21 | [1.08-1.35] | 1.20 | [1.08-1.34] |
| | **85-89** | 10,877 | 2,778 | 25.5% | 1.26 | [1.09-1.45] | 1.25 | [1.08-1.44] | 1.24 | [1.08-1.43] |
| | **90-94** | 3,497 | 909 | 26.0% | 1.18 | [0.97-1.44] | 1.17 | [0.96-1.43] | 1.16 | [0.95-1.42] |
| **Periods** | **2005** | 86,191 | 14,795 | 17.2% | **1** | | **1** | | **1** | |
| | **2009** | 92,687 | 15,623 | 16.9% | 1.08 | [1.04-1.12] | 1.08 | [1.04-1.11] | 1.08 | [1.04-1.12] |
| **Cohorts** | **1910-1912** | 696 | 179 | 25.7% | **1** | | **1** | | **1** | |
| | **1913-1915** | 1,944 | 499 | 25.7% | 0.98 | [0.81-1.17] | 0.98 | [0.82-1.17] | 0.99 | [0.82-1.18] |
| | **1916-1918** | 2,596 | 711 | 27.4% | 0.99 | [0.82-1.20] | 1.00 | [0.82-1.21] | 1.01 | [0.83-1.23] |
| | **1919-1921** | 8,080 | 1,984 | 24.6% | 0.88 | [0.72-1.08] | 0.89 | [0.72-1.09] | 0.90 | [0.73-1.10] |
| | **1922-1924** | 11,994 | 2,807 | 23.4% | 0.85 | [0.69-1.05] | 0.86 | [0.70-1.07] | 0.87 | [0.71-1.08] |
| | **1925-1927** | 16,165 | 3,587 | 22.2% | 0.82 | [0.66-1.02] | 0.83 | [0.67-1.04] | 0.84 | [0.67-1.05] |
| | **1928-1930** | 20,705 | 4,209 | 20.3% | 0.76 | [0.60-0.95] | 0.77 | [0.62-0.97] | 0.78 | [0.62-0.98] |
| | **1931-1933** | 21,514 | 3,903 | 18.1% | 0.69 | [0.55-0.88] | 0.71 | [0.56-0.90] | 0.71 | [0.56-0.90] |
| | **1934-1936** | 30,274 | 4,748 | 15.7% | 0.63 | [0.49-0.80] | 0.64 | [0.50-0.83] | 0.65 | [0.50-0.83] |
| | **1937-1939** | 35,689 | 4,468 | 12.5% | 0.52 | [0.40-0.67] | 0.53 | [0.41-0.69] | 0.54 | [0.42-0.70] |
| | **1940-1942** | 21,365 | 2,531 | 11.8% | 0.51 | [0.39-0.66] | 0.52 | [0.40-0.68] | 0.53 | [0.40-0.70] |
| | **1943-1945** | 7,856 | 792 | 10.1% | 0.43 | [0.32-0.57] | 0.44 | [0.33-0.59] | 0.45 | [0.34-0.60] |
| **Sex** | **Male** | 76,071 | 12,470 | 16.4% | | | **1** | | **1** | |
| | **Female** | 102,807 | 17,948 | 17.5% | | | 0.97 | [0.95-0.99] | 0.95 | [0.93-0.97] |
| **Family status** | **Married** | 108,262 | 16,588 | 15.3% | | | **1** | | **1** | |
| | **Single** | 8,834 | 1,559 | 17.6% | | | 1.07 | [1.01-1.12] | 1.07 | [1.02-1.13] |
| | **Widowed** | 52,158 | 10,558 | 20.2% | | | 1.09 | [1.06-1.12] | 1.07 | [1.04-1.10] |
| | **Divorced** | 9,624 | 1,713 | 17.8% | | | 1.20 | [1.14-1.26] | 1.21 | [1.15-1.27] |
| **Immigration status** | **German citizens** | 147,649 | 24,617 | 16.7% | | | | | **1** | |
| | **German expellees** | 19,446 | 3,644 | 18.7% | | | | | 1.10 | [1.06-1.14] |
| | **Migrants with German citizenship** | 7,277 | 1,375 | 18.9% | | | | | 1.13 | [1.07-1.20] |
| | **Migrants with German & foreign** | 702 | 116 | 16.5% | | | | | 1.03 | [0.85-1.23] |
| | **Foreigners without German citizenship** | 3,449 | 591 | 17.1% | | | | | 1.11 | [1.02-1.21] |
| | **Unknown nationality** | 355 | 75 | 21.1% | | | | | 1.24 | [0.99-1.56] |
| **Education** | **No degree** | 4,841 | 1,099 | 22.7% | | | | | 1.40 | [1.30-1.50] |
| | **Lowest degree** | 128,026 | 22,775 | 17.8% | | | | | 1.16 | [1.12-1.20] |
| | **Moderate degree** | 23,874 | 3,492 | 14.6% | | | | | **1** | |
| | **Higher degree** | 5,286 | 703 | 13.3% | | | | | 0.95 | [0.87-1.03] |
| | **Highest degree** | 15,955 | 2,107 | 13.2% | | | | | 0.88 | [0.84-0.93] |
| | **Refused to answer** | 896 | 242 | 27.0% | | | | | 1.57 | [1.38-1.79] |
| **Total sample** | | 178,878 | 30,418 | 17.0% | | | | | | |
| **Constant** | | | | | 0.25 | [0.21-0.29] | 0.22 | [0.17-0.28] | 0.21 | [0.16-0.27] | 0.18 | [0.14-0.24] |
| **Random intercept (SD) - small-area level (cohort)** | | | | | 0.121 | [0.076-0.192] | 0.108 | [0.084-0.137] | 0.108 | [0.091-0.128] | 0.105 | [0.081-0.136] |
| **MOR** | | | | | 1.122 | | 1.108 | (-1.24%) | 1.109 | (0.06%) | 1.105 | (-0.33%) |
| **Random intercept (SD) - federal state level (cohort)** | | | | | 0.060 | [0.005-0.726] | 0.013 | [0.000-0.077] | 0.000 | [0.000-0.000] | 0.031 | [0.003-0.300] |
| **MOR** | | | | | 1.058 | | 1.013 | (-4.34%) | 1.000 | (-1.22%) | 1.030 | (3.00%) |
| **LR Test (ML vs. Poisson), Chi²** | | | | | 290.15 | p<0.001 | 84.240 | p<0.001 | 83.460 | p<0.001 | 86.490 | p<0.001 |

(Statistical Offices of the Federation and the Länder, Microcensus 2005 & 2009, own estimations)

The **random components** of the cohort effects on level two (small-area level) and (in most cases) on level three (federal state level) are statistically significantly different from zero, which indicates spatial SLTC and LSI differences between the regions and the federal states. In the final models, the variance of the SLTC prevalence is lower on the level of regions (random intercept=0.088 [0.050-0.140]) in contrast to the level of federal states (random intercept=0.201 [0.170-0.240]). The reverse is true for the risk of LSI, where the variance is much lower on the level of federal states (random intercept=0.031 [0.003-0.300]) than the variance on the level of regions (random intercept=0.105 [0.081-0.136]). The changes in the median odds ratio (MOR) and in the random intercept show, that the explanatory power of the covariates is inconsistent over the models, the spatial level and the health indicator.
These diverse effects of spatial variation of the cohort effects may be explained by the different contextual role of the territorial entities. Since for the SLTC prevalence, the policy directive is part of the administration of the federal states, the disparities between the states may be higher than within the states. In the case of LSI, these policy influences can be neglected.

### 4.3.2. Predicted cohort-specific prevalence on small-area level

After the estimation of the models, the prevalence by the cohorts and the small-area entities are predicted and the confidence intervals computed.
The predicted prevalence can be compared between both of the health indicators, between the small-area entities, and between the cohorts. Considering the hypotheses, the comparison between the indicators should be part of all analyses. Thus, spatial inequalities in the same-cohort prevalence of receiving SLTC allowance and of longstanding illness are compared for all 50 small-area entities.

The results of the same-cohort comparisons of the prevalence by both health outcomes indicate that there are marked differences between the particular small-area entities (Figure 20-37 in the supplementary material).
In the case of the SLTC prevalence, the statistically significantly highest values for the most selected cohorts can be found for regions in North Eastern and central Germany, for example in Mecklenburg-Western Pomerania, Brandenburg, East Berlin and Thuringia. The lowest values are predicted for South Western and Western regions, especially the highly urbanised regions in Baden-Württemberg, Rhineland-Palatinate, Saarland, and North Rhine-Westphalia. The regional patterns significantly differ by the cohort, even if the prevalence rates are multiple adjusted.
In the case of the LSI prevalence, there is a high disparity between the regions as well; however the range is not as high as the range for the SLTC prevalence. The spatial patterns of

the LSI and the SLTC prevalence are inconsistent, since the prevalence pattern of the LSI varies markedly by the cohorts. In contrast to the spatial pattern of SLTC prevalence, the pattern of the LSI prevalence is not characterised by large-scale clusters like clusters of federal states, but by urban-rural-clusters within the state level. However, there is no consistent association between urbanity and LSI prevalence, since for example the city of Hamburg shows mostly the lowest cohort prevalence in contrast to for example the Eastern quarters of the city of Berlin.

# VI. Discussion

## 1. Summary

The aim of this thesis was to obtain deeper insights into the complex interference of the quality of life of the individuals and their multi-faceted conditions of the living areas. To achieve this aim of the thesis in total, the most fruitful and effective approach was to link measures and theories of the research fields of demography, sociology, public health, epidemiology and geography. Although, the general context of the thesis is Germany in the years 2001 to 2009, the intention of studying the health geography of Germany and its changes and determinants was to give basic knowledge about morbidity and health of the populations in the welfare states in general.

In the four studies, diverse sophisticated and established methods and highly adequate datasets and databases were used;

- to prove the existence of spatial inequalities,
- to detect small-and medium-area patterns of a favourable and unfavourable health situation,
- to identify contextual effects on different dimensions of health,
- to reveal the importance of the level of spatial aggregation and its linkage to the choice of the health outcome and of the contextual indicators,
- to study the temporal development of spatial health inequalities and their demographic drivers,
- to bring out the health effect of entering into a different context by inter-cultural in-migration, and
- to quantify the effects of longstanding context exposures and of selection due to mortality and (internal and external) migration.

### 1.1. Reflection of the hypotheses

In the following, the hypotheses of the studies are addressed in the order of the studies.

**Hypothesis 1: Profound regional inequality among the counties exists with consistent patterns to those for mortality.**

In study 1, spatial inequalities are identified for care need by using various measures of population health. In the case of inequalities in absolute values, the spatial mapping of the life years with and without care need shows a clustering of counties with poor and with good health of the population. These patterns indicate a North East versus South West gradient with worse health in the North East. These findings are mostly consistent to the findings

about mortality by Kibele (2012), however there was a much larger cluster of a high prevalence of care need in central Germany than of high mortality. Correlation analysis between total remaining life expectancy and life years without care need substantiate these findings and confirmed the conclusions of Mathers et al. (2001) and Robine et al. (2009). However, the associations of life years with and without care need with life expectancy were weaker or non-existent in East German regions.

The spatial mapping of the health ratio, a relative measure of imbalance between care need and care supply, depicts a pattern that is slightly different from that of the life years with and without care need, but positively correlated with life expectancy. Spatial inequalities were higher among the East in comparison to the West German counties. Marked differences in the patterns can be observed for the Northern most federal state Schleswig-Holstein with a low prevalence of care need causing - since the general level of life expectancy is lower than for the Southern counties - a higher health ratio. These findings indicate a shorter care entry-death span for Schleswig-Holstein than for the comparable regions, something that may be evaluated in future studies.

**Hypothesis 2: The health situation is better in regions with a higher socioeconomic performance, a better socioeconomic composition of the population, and a more favourable health care situation.**

In accordance with the findings in the literature, the spatial health disparities can be partly explained by attributes of the living context. The highest impacts are detected for physical environment measured by population density and for the socioeconomic factors. The health care situation measured by premature mortality showed the weakest effects. A high socioeconomic performance of the region, a low concentration of long-term unemployed persons, a high level of urbanity, and a favourable health (care) structure in a county are significantly linked to a better health situation in terms of care need. The findings vary between the East and the West German counties: For the East German counties, a U-shaped (in the case of disposable household income per capita and urbanity with the best situation in the average disposable household income per capita and average urbanised counties) or a non-existing (in case of long-term unemployment) effect, and a higher impact of premature mortality effect compared to the effects in the West German counties are found. These findings can be explained by the lower spatial variation of the county populations in terms of the selected indicators.

**Hypothesis 3: Urbanity as a measure of physical environment may have positive and negative effects on the health of the individuals.**

Considering the findings about urbanity, the results for population density confirm the findings of Diehl and Schneider (2011) for West Germany; but not for East Germany. The differ-

ent trend of urbanity in the Eastern counties can be explained by differences in the socioeconomic and physical structure. When analysing the county-specific prevalence of premature limiting long-term illness in the southwest of England, Barnett et al. (2001) also stated a U-shaped association of population density with health. The two settings are comparable in terms of socioeconomic conditions and physical structure, since the investigated region is rural and has a lower socioeconomic performance than other regions in England.

**Hypothesis 4: Profound small-area disparities in the health scenarios exist which are unobserved when data for higher spatial entities is used.**

As a result of the literature review, most studies it appears have investigated the health scenarios on the national level, while there are only few results concerning small-area disparities. In study 2, the analysis of the trends in the life years with and without care need and the health ratio found evidence for a high variation of these indicators on a small-area level. Although there is only a relative short observation period, the health trends markedly differ between the counties causing the spatial health inequality that was found in study 1. By combining the particular measures to the health scenarios, the health trends of the counties are evaluated based on an established typology. The patterns of the health scenarios show inconsistencies with the spatial patterns of longevity. This is a further indication for profound disparities between the quantity (life expectancy) and quality (health scenario) of life time of the populations. Furthermore, study 2 suggested that there is a process of divergence among the region, since there were - except for severe care level in female life years without care need and life expectancy - no lower gains in the health indicators in counties with a high level at the beginning of the observation period. This indicates a growing gap between the rear-guard and the vanguard counties.

**Hypothesis 5: The compression or equilibrium scenario is the predominant scenario for most – but not all counties.**

The stratification strategy by the sexes and the care level for the health scenarios reveals that most of the counties in both sexes experienced a relative expansion of any care level. However, there is a type of bipolarisation in relative compression versus relative expansion in the case of severe care level. The aggregation of sub-national trends thus, would lead to false conclusions, especially for severe care level.

However, the hypothesis cannot be rejected completely, since the equilibrium scenario is defined by a combination of trends in the health scenarios. The combination classification showed that the vast majority of counties experienced a very positive (compression in both) or a tendentially positive (shift from severe to any care level) health trend, however faced by a high number of counties with a negative health trend (expansion in both).

**Hypothesis 6: The prevalence of the care need is the main driver of the health scenarios on the small-area level in Germany.**

The most substantial question in the study of the health scenarios is, whether the gains in life years result in an expansion of years in poor health. In the case of care need, the conclusion of study 2 is that the assumption is correct. In terms of absolute gains in (mean) life years with care need, the decomposition analysis suggests that the reductions in mortality (measures by the mortality components) have a much greater magnitude than the changes in the prevalence (measured by the morbidity component). This indicates that the decrease in mortality rates promotes the survival of a person with and without care need.

However, this discrepancy is much higher for any care level than for severe care level, and the absolute gains in the life years without care need due to mortality are higher than the gains in the life years with care need for both sexes and for both types of care level. Thus, the mortality is the decisive driver of the absolute increase in life years with and without care need.

Turning to the relational perspective of the health scenarios, the analyses by using the meta-regression stated that the trends in the prevalence of care need have by far the largest impacts on the classification in terms of the health scenarios. The amounts of model coefficients reveal that the classification is highly sensitive to even slight changes which cause a higher impact than the changes in the mortality components. This conclusion is consistent for both sexes and care levels, albeit even stronger for severe than for any care level. These conclusions confirm the results about health scenarios in France by Cambois et al. (2013).

**Hypothesis 7: Contextual effects of socioeconomic conditions, of physical environment and the regional social capital on longstanding illness exist even after adjusting for individual determinants.**

Due to the design of study 1 and study 2, compositional effects on the spatial health disparities can solely be adjusted by the basic demographic factors of age and sex. In study 3, micro data that is combined with macro data is used to investigate simultaneously the effects of the individual factors and of the contextual factors by diminishing compositional effects. One major conclusion of study 3 is the confirmation of the findings of study 1 and study 2: Even after adjusting for various individual-level factors - including also life style factors that may be assessed as over-control - the contextual effects remain significant. These findings provide evidence for the existence of spatial inequalities in longstanding illness, albeit - as another conclusion of the study - the individual factors have a greater impact on health inequalities than the contextual factors.

**Hypothesis 8: Living context has a universal effect on longstanding illness of native Germans and of Aussiedler.**

The contextual factors show similar effects on the health of the Aussiedler and the native Germans, which confirms the hypothesis. Thus, the macro factors are assumed to have universal effects on the health of the inhabitants. While the regional economic performance measured by the GDP per capita and the physical environment measured by centrality of the population distribution showed to be significantly linked to the health status of the individuals. The social capital or diversity measured by the proportion of foreigners does not explain the spatial disparities. In detail, a high wealth of a living region independent from the individuals' social status is associated with better health of the individuals - a finding that confirms the results of study 1 and of the studies in the literature. Urbanity, in contrast to the findings about care need in study 1, is associated with worse health measured by longstanding illness. These inconsistent effects of the physical environment confirm the contradictory results of prior studies. An explanation for the inconsistencies of the effects of urbanity are the intervening effects of environmental characteristics, supply of services and resources and also the selection effects due to migration. In the case of environmental factors, Voigtländer et al. (2010b), found evidence for the interfering effects on the urban-rural health disparity. Considering the potential pathways of the contextual influences on the different dimensions of morbidity, disparities can be assumed depending on the choice of health problem and their variability due to short- or long-term effects. In the case of care need, long-term positive and negative effects are assumed to have more impact, while for longstanding illness both, long- and short term influences can have an effect. The investigation of these pathways has a high potential for further research.

The regional concentration of foreigners shows no significant effect on the health of both, Aussiedler and native Germans. These findings are consistent with the findings of Karlsen et al. (2002) and contrary to the findings of Lorant et al. (2008). Since Lorant et al. (2008) did not adjust for indicators of urbanity, the results are thus difficult to compare with the results of study 3.

**Hypothesis 9: The healthy migrant effect with better health at the time of the in-migration and deteriorating health by duration of stay does not exist for Aussiedler.**

A major objective of study 3 was to investigate the effect of entering into a new context by in-migration. Of particular interest in this study was to further investigate a particular group of migrants, the Aussiedler. The outstanding policy of integration towards the Aussiedler that allows to get fully naturalised after the recognition of the status is assumed to give further insights into the effects of a policy influenced context. This research question additionally includes the intention to investigate the effects of selection due to migration from context to a new context (in this case into a completely different setting).

The analyses of study 3 show no health inequality of Aussiedler in comparison to the native Germans - even without adjusting for socioeconomic and life style factors. The risk of longstanding illness is reported to be (tendentially, not significantly) lower for the Aussiedler with the shortest duration of stay compared to the native Germans. The missing health disadvantage of the Aussiedler towards the native Germans may be caused by 1) a selection of persons who migrated, 2) a selection bias of mortality in the years before migration, 3) health protective effects of unadjusted imported Aussiedler-specific behaviours or individual attributes, or 4) missing deleterious contextual influences, adapted behaviours and changed individual attributes within the new setting. Since there is no option to differentiate between these causes in a cross-sectional design, the finding is assumed to be a consequence of a combination of these explanations.

The results of the stratified analysis indicate the existence of a deterioration of health in the years after the in-migration. This may be the result of long-term contextual and individual effects such as a climate of discrimination, socioeconomic deprivation and increased stress.

The findings of the individual level factors allow the underlining of these effects of context. Although most of the individual effects are similar for native Germans and Aussiedler, there are profound differences in the health effects of both socioeconomic factors education and income.

In comparison to the native Germans, the educational gradient of health does not exist in Aussiedler. An explanation for this finding is the discrepancy between education and socioeconomic status in migrants, since restrictions in the acceptance of educational degrees, linguistic barriers and (indirect) discrimination at the labour market are assumed to exist. Thus, in contrast to the policy-promoted integration in legal, social and linguistic terms, Aussiedler tend to work in lower positions than they were qualified for in their countries of origin or birth - even if they have high levels of education (Greif, Gediga, & Janikowski, 2003).
In contrast to education, the gradient of income is much steeper than that of the native Germans. This effect is a further indication for a selection effect of the job market that is more distinct than for the native Germans. It can be assumed that the Aussiedler who achieve higher job positions may differ greatly from those in moderate or lower occupational positions (e.g. in terms of job qualifications, language skills, stress tolerance, mobility, motivation, willingness to retrain, flexibility or health).

**Hypothesis 10: Bio-demographic, psychosocial and socioeconomic factors affect the risk of receiving SLTC allowance and the risk of longstanding illness similarly.**

Study 4 aimed to constitute a linkage of the three prior studies to provide further insights into the disparities in care need and longstanding illness within the elderly populations of the German regions. The limitations of the prior studies are that there is an assumed homogenei-

ty of the elderly population among the regions, the spatial variation cannot be compared directly due to different definitions of spatial entities, and the effects of longstanding contextual influences and selection due to migration and mortality cannot be quantified.

One conclusion of study 4 is the finding that the effects of the individual level factors are predominately similar in receiving SLTC allowance and in longstanding illness. However, the effects of age, period, family status, and immigration status differ to some extent between both indicators. Age showed to have an exponential increase in the risk of care need, but showed shrinkage in the risk of longstanding illness above the age of 89. This may be explained by effects of a non-response bias, of a discrepancy between the perception of health and the objective health status, or of problems in the interpretation of the question by the respondents. The period effect shows a much steeper increase in SLTC receivers over the period than in persons with longstanding illness which is assumed to be an effect of underreporting the SLTC allowance in the year 2001. A further disparity was found for the family status. In the case of receiving SLTC allowance, there is profound higher risk disparity of single, widowed and divorced persons compared to married persons than are the estimated inequalities for longstanding illness. These inequalities may be explained better by the role of the partner as the dominating care giver than by the marital status itself. Thus, living in a partnership profoundly lowers the risk of demanding for external financial and personal support. In contrast, the partnership effect on longstanding illness is assumed to be less pronounced since the pathways are more indirect, for example by promoting social capabilities and giving emotional support. One further finding is the disparity in effect of the immigration status, which is to some extent linked to the legal context of the individuals. While the analyses in study 4 stated a significantly lower risk of receiving SLTC allowances by foreigners and migrants with German citizenship compared to the German citizens, the relative risk of longstanding illness is significantly higher for these groups. In the case of the foreigners, the inequality in the risk of SLTC can be explained by legal restrictions to apply for care allowance and potential trends of remigration. Of higher interest is, however, the disparity between the SLTC risk and the risk of longstanding illness of migrants with German citizenship. Assuming that longstanding illness at these ages can be an indication for a later need for care, these discrepancies may be interpreted as a future problem in ensuring an adequate health care for the older former migrants and an adequate support for their families.

**Hypothesis 11: Comparing the level of territorial entities, the spatial health inequalities in both indicators are higher on the level of small regions than on federal states.**

The main findings of study 4 are about the hidden heterogeneity within the elderly population and the differences between these populations among the small-area entities. The first result of the multilevel analysis is the revealing of significant spatial disparities among the entities that vary by level and by health outcome. While the highest variability of the prevalence of

SLTC is stated between the federal states, the highest spatial variance of longstanding illness can be found on the small-area level. These results can be explained by the fact that care need is potentially more affected by the health policy of the federal state than by the health policy of the small-area entities. For longstanding illness, urban-rural and wealth-deprivation disparities – as stated in study 3 – are shown to have a higher impact than large scale policy disparities.

**Hypothesis 12: Comparing the regions, the health of the same birth cohorts significantly differs even when the effects of age, period and other individual factors are adjusted for.**

Marked spatial differences in the cohort-specific prevalence are found for receiving SLTC and for longstanding illness. The spatial mapping of the cohort prevalence of SLTC shows a North East and Centre versus South West gradient – with especially favourable results for the highly urbanised regions - and thus the results partly confirm the findings of study 1. In the case of longstanding illness, the small-area variation of the cohort prevalence within the federal states is very large. Urban-rural disparities in the prevalence of longstanding illness seem to exist, however, there is no consistent tendency. These inconsistencies may be explained by further regional attributes like economic performance – as there was a significant association stated in study 1.

## 1.2. Summary and conclusions: Health and place

The major result of the four studies is the detection of marked spatial inequalities which differ by the level of spatial aggregation, the health indicator, the birth cohort, but only less by sex. The inequalities are revealed by a range of established population health measures that describe disparities in an absolute (prevalence, life years with and without care need), relative (Health ratio, odds ratio, risk ratio), or theory-driven perspective (health scenarios).

The findings about the influence of individual and contextual factors indicate that the health disparities between the individuals is by far higher than the health disparities between the investigated spatial entities, which indicates the efficacy of the health care and social security systems in the welfare states. In particular, the socioeconomic and behavioural individual factors have the highest impact on causing inter-individual inequalities in health. However, stated health disparities of the same birth cohorts - independently from individual attributes - may be an indication for the role of the health influences (on individual and contextual level) in the young or middle ages of the contemporary elderly population. As stated by the analyses, assuming a homogenous population of persons at higher ages ignores a high level of health inequalities of persons within a spatial context but also between different spatial contexts.

The analysis of selected contextual factors stated marked effects of socioeconomic attributes of the regions in terms of context and composition. Living in a wealthier region is linked to better health situation measured by care need or longstanding illness. These findings are consistent for both sexes, native Germans and Aussiedler, and persons in the West German regions. For the persons in the East German regions, the effects of socioeconomic conditions were less clear and pronounced, this can be explained by contradictory after-effects of the health relevant conditions due to the fundamental political, societal, medical and economic changes in the 1990s. The economic transformation leads to general downgrade of the economic performance of the regions with only slight spatial variation. This reorganisation causes insecurity and stress, and promoted unhealthy life styles (high alcohol consumption, smoking, risky road behaviours), which in combination with different paces of the improvements in the health care structure and a high and selective internal out-migration may explain these inconsistencies.

Urbanity measured by two different indicators showed to have a significant, but contrary effect on longstanding illness and care need. Populations of urbanised regions show a lower risk of care need, but a higher risk of longstanding illness. Besides the methodological problems and problems in the operationalisation, these findings can be the consequence of divergent pathways that lead to a confounding of the health effects. For example, higher quality of services in urban regions may delay the risk of care need, but higher environmental hazards may cause longstanding chronic illnesses. Thus, these findings give support to the relevance of future research about health of the urban population in welfare states.

Factors of social diversity as well as factors of the health structure show no contextual effects - except of the findings about the health structure for the East German counties. Due to the historical unique transition and the consequences (e.g. on life style or medicine), the variation of premature mortality is higher in the Eastern part and is further associated with a higher risk of care need.

An indirect conclusion can be stated by the interpretation of the study of the health of Aussiedler - a group of persons, who entered within their life time into a new context in terms of socioeconomic conditions, social and cultural norms, values and tolerance, policy regulations, health infrastructure, health-relevant behaviours and various other dimensions. The study shows a missing health disadvantage of Aussiedler in the years after the in-migration, but Aussiedler with a longer duration of stay have a higher risk of longstanding illness. This result indicates problems with the integration in the labour market, with social participation, and with the access to or the willingness to use the health care system.

## 1.3. Summary and conclusions: Health and time

An essential conclusion of the studies is that the present health situation is a consequence of a complex interplay of influencing factors in the past. In the case of care need, although there is only a weak correlation of the prevalence on starting level (2001/03) with the trend of the prevalence over the period, the spatial patterns of the last observation year (2009) are the results of these trends. The most interesting findings are the high heterogeneity of trends in absolute and relative perspective, the partly inconsistent trends in any and severe care level, and the higher impact of mortality on absolute changes, contrasted by the higher impact of prevalence on relative changes.

By using a stratification strategy, the analyses stated different trends of the counties within Germany, which further vary by the severity of care need. In the case of any care level, the majority of the county populations showed a relative expansion in any care level even in this relatively short observation period. However, there were also counties that experienced stability or compression, but a lower number. These results are consistent in males and females. In the case of severe care level, most of the counties are classified as (absolute and relative) compression counties for both sexes. Like for any care level, there is also a high variation among the counties.

By joining the findings into a typology of counties, a discrepancy becomes obvious: A huge group of counties showed a very negative trend in care need by experiencing an expansion in both, any and severe care level. Another large group of counties showed a gain in care need in general, however, a favourable compression in severe care. This scenario is described in the literature as a dynamic equilibrium. These findings confirm previous findings in the literature (Gärtner & Scholz, 2005; Pattloch, 2010; Unger et al., 2011; Unger & Schulze, 2013).

The most favorable trend can be found for a smaller, but still large group of counties with compression in any and severe care need. Within the federal states, there is a high variability of the health scenarios. The clusters of the combined health scenarios are not consistent to the boundaries of the federal states. Comparing the results of males and females, a cluster of worse trends can be reported for males in North East Germany, while the counties with the unfavourable trends in care need of females are more concentrated in the centre of Germany.

The results of the decomposition analysis show that higher longevity also causes a prolonging of the life span with care need. With the exception of a few counties, the populations of most counties experience profound higher gains in life years without care need than in life years with care need due to the mortality reductions. However, for the majority of counties, the reductions in the prevalence was too low (or non-existing) to compensate the gains due to mortality. The analysis further stated that the prevalence has much higher impacts on the

relative measure of population health: the health scenarios. The classification of the counties shows a high sensitivity to marginal changes in the prevalence. Health policy interventions based on early prevention and efficient treatments may be introduced to influence the future increase in the prevalence.

The disparities in the health scenarios and their components between the regions and the sexes can be explained by a complex interference of etiological and epidemiological processes and present interfering, mediating, and suppressing contextual effects. It can be assumed that the trends are the results of divergent historical and social developments and changes that indirectly affect the behaviour, the psycho-social capacity, and the material situation within the life course of the individuals. These influences are assumed to have different impacts on moderate morbidity than on severe morbidity. Inter-cohort changes in the educational composition, the health awareness and health behaviours may not delay the entry into care need, but the entry into the need for intensive care indicated by a severe care level. Furthermore, continuing processes of selectivity due to mortality and migration may have an effect on the populations' composition of the counties. Since severe care need is concentrated at the highest ages, mortality selection may further lead to a lower increase in severe care level than in any care level.

These explanations for the revealed spatial and temporal health disparities are supported by the findings of the additional investigations in study 4. In study 4, the time trends in health are further investigated concerning the disparities in the cohort-specific prevalence of longstanding illness and care need by using a cohort perspective. Assuming similar trends in aging, there would be an on average very low disparity in the same-cohort prevalence among the regions. However, the analysis stated a high spatial variation in the multiple individual factor adjusted prevalence of same birth cohorts. These findings indicate significant disparities in the health-related composition or experiences of the individuals within the regions. These disparities themselves are the consequence of a complex interplay of differences in the etiological pathways and varying effects of historical and present contextual factors on the individuals' biography. The analysis of longitudinal micro data for a long period that covers validated health measures would be adequate to investigate the causes and changes of the health disparities in greater detail.

## 2. Methodological strengths and limitations

The four studies used various advanced methods to investigate complex social phenomena by using administrative datasets and databases. Both datasets are rarely used for health research, despite the high quality of the data.

**Strengths:** The SLTC is a major data source of this thesis which is used in two studies. It does not suffer from a non-response bias, since all persons who receive care or care allowance are covered by the register. While many surveys exclude persons in institutions, another major strength of the dataset is that these persons are also included. Since persons in private and public insurances are registered in the census, there is also no bias in terms of socioeconomic self-selection. Thus, under-coverage, missing records, or self-selection into or drop-out can be excluded. Due to these advantages in the coverage of the individuals, the SLTC census also has a high adequacy for trend analyses.

In contrast to most other studies, small-area analyses have some special data requirements. There must be a standardised identifier for an established level of spatial entities, a high number and a representative sample of persons within the spatial entities and the legal permission to use the data and combine it with external data such as macro factors. The SLTC includes the standardised identifier of the administrative units of the counties, it is a full sample and thus by definition representative on all spatial levels, and a data agreement was made that permits the merging of external data after aggregating the individual level data into groups by sex, age groups and counties.

Another advantage of the SLTC is the health outcome. Care need is measured by a standardised and harmonised evaluation strategy executed by medical experts of the health insurance plans. Since the German health care system has the same regulations and definitions for all regions, no, or only very small, culture-specific health perceptions may negatively affect the comparability and validity of the findings. Due to care need regulations being binding for each German county, changes in these regulations may affect the level but not the spatial disparities.

Two of the four studies are based on an established population health measure: the healthy life expectancy concept. This indicator combines the information about mortality and morbidity and allows the quantification of the life years with and without morbidity. The calculation of the healthy life years is comprehensible and requires only basic demographic data in a cross-sectional design. A further major advantage of the health measure is that the indicator can be computed for populations independent from the size and age structure; as long as age specific data about the total population, the death counts and the prevalent cases are available. The interpretation of the healthy life expectancy indicator and the health ratio is comprehensible and can be easily joined to a classification typology to identify the theory-driven health scenarios. The health ratio has the further advantage that the health ratio is not as highly correlated with the general level of life expectancy as the healthy life expectancy and thus, the association with the macro level factors is assumed to be not as much overlaid by the effects of the macro factors with mortality than it is the case for the other indicators. Both, the interpretation of the absolute (healthy and unhealthy life years) and the relative

(health ratio) measure, get insights into the health conditions and trends from different perspectives: While the absolute years in and without care need are of greater interest from the individuals perspective, the relative indicators are of higher interest from the policy, societal or public health perspective. Relative measures like the health ratio indirectly indicate the proportion of a number of persons in need for care to a hypothetical number of caregivers or of contributors to the SLTC insurance. The advantage of the health expectancy is further the existence of methods to retrospectively decompose the changes in the indicators to evaluate the complex interplay of trends in mortality and in morbidity

For study 3 and study 4, the German Microcensus is used as the data basis. Similar to the SLTC census, the Microcensus is an administrative dataset with mandatory participation that covers persons in intuitions, as well as even persons at the very highest ages. The self-selection bias is thus assumed to be very marginal. Another advantage is the usage of a standardised identifier of established residential areas, the spatial planning regions. After an evaluation of the research intentions, a data contract was concluded that allows the merging of external data to the micro data. Another clear advantage of the Microcensus is the high number of individual level factors on various dimensions. Besides the dimensions of socio-economic, psychosocial and behavioural factors, one important argument in favour of using the Microcensus is the coverage of basic information about the migration background that allows to identify the group of the Aussiedler. Although, the Microcenus is the largest survey in Europe, data protection law prohibits using lower aggregation levels than spatial planning regions or to analyse migrants in regions with a very low share of migrants. However, the number of persons for the spatial planning regions was sufficient to ensure adequate representation and stability of the estimations. By using the information about the federal state and the type of municipality (urban, suburban, rural), divergent levels of spatial aggregation can be compared on their influence on the health of the individuals.

**Limitations:**

With regards to the general research question, there are some limitations in terms of the interpretation of the results and in terms of the used data and methods that have to be considered. A major limitation within the studies is the choice and the interpretation of the macro factors. As described in the literature review, there is a highly complex interplay of etiological pathways on the individual level which is further altered and mediated by influences on the contextual level. In reverse, the contextual factors may also be affected and interfered by individual level attributes like coping strategies or strategies of enlarging the geographical scope of interaction. The context itself is a construct defined by various overlapping and interfering dimensions. These interplay of context attributes may have contrary effects on the pathways of health, further varying by the used health outcome and the type (aggregation level) of spatial entities. Due to the multifaceted situation within a living context, the choice of

adequate indicators and the interpretation as a proxy for a particular dimension of context attributes is disputable. Most of the pathways, conceptualised in various theoretical frameworks in the literature, are latent and cannot be measured or validated with the used datasets. The indicator of population density, for example, can be interpreted as a proxy for a context characterised by a higher level of (positive and negative) services, environmental hazards, and stress, by a higher acceptance of and opportunities for healthy and unhealthy life styles, by a higher potential for social capital and cohesion or having a higher residential attractiveness considering educational and job opportunities. From a compositional perspective, population density also indicates a higher heterogeneity of the composition of the population and it is itself a result of specific historical, social, political, or economic developments and can - considering the indicator - further alter by changes in the demarcation. Thus, the interpretation of the indicators has to be prudent since a small selection of indicators cannot validly reflect the heterogeneity of a context and the diversity of contexts.

These limitations may explain partly the contrary results, as well as the fact that most of the regional variation in the studies remains unexplained by the models. Further research is needed to detect macro factors that have a higher explanatory power like composite indicators of life style factors and behaviour-related morbidities. As mentioned, the complex interplay of micro and macro level factors is only considered by stratification strategies. To investigate the mediating influences in detail, cross-level interactions may be estimated and compared.

However, there are also some limitations in the datasets, the methods and the interpretations. In the case of the SLTC, only aggregated data was allowed to be merged with macro level data. Thus, an ecological design has to replace a qualitative better multilevel design. Another limitation of the SLTC census is the fact that only basic demographic data (sex and age) are available for controlling the health effects, but no socioeconomic or behavioural factors. Thus, compositional effects cannot be excluded as an intervening bias and the results of the macro level factors should be interpreted rather as a correlation than as a causal interplay. The interpretation of the macro level effects should be with further caution, since the ecological failure should be avoided: all stated associations have to be interpreted on the macro level only and not interpreted in terms of individual level associations. Since there are also no individual level panel data included in the dataset, there is further no option to identify causality, even in the longitudinal perspective of study 2. As a result, the major shortcoming of study 2 is that it is impossible to identify whether the disparities in the health situation and trends are the result of inequalities and unequal changes in the population's between- and within-cohort composition due to 1) (health-related) selective migration and selective mortality or are 2) causally related to the individuals life time accumulation or coping mechanisms on the hazardous conditions within the residential areas.

Another problem can be assumed by the choice of the health outcome: Since only legally recognised care need is investigated, under-coverage could be a problem due to legal restrictions, disparities in health perceptions and health care-seeking behaviours or in the ability to cope with health problems. In contrast, there is also a very slight problem of over-coverage, since until 2008, an unknown number of persons with semi-inpatient care were double-counted. This over-coverage is assumed to be very marginal, since the proportion of persons in semi-inpatient care is on average only 2% of the persons in care need (Statistical offices of the Federation and the Länder, 2012).

Furthermore, there are two problems with vital data. The used population data from the Statistical Offices is based on extrapolation estimations, thus unregistered in- and out-migration causes a bias in the population which is assumed to be higher at older ages (Jdanov, Scholz, & Shkolnikov, 2005). However, post-estimations by using correction weights show only a very marginal effect on the prevalence and on the composite health outcomes.[19] The second problem is the missing stratification of population data beyond the age of 85. This is a particular problem for investigating care need, since these groups show a very high prevalence of care need and also a significant increase in absolute numbers. Thus, for the oldest persons, the inner-group and spatial heterogeneity of care need is underestimated which is confirmed by the analysis of the cohort disparities in study 4.

A methodological problem has to be considered for the used Sullivan method. Since the method based on mortality and morbidity data for the population in total, subgroup-stratified trends of mortality or of incidence, of duration of care need, or of health improvements are overlooked. The estimation of specific transitions from and to health by considering mortality within a multi-state model based on individual-level panel data would solve the problem. Unfortunately these data are not available on small-area level for non-administrative research. However, in the literature, the transition rates are assumed to be very stable (incidence/mortality) or very low (rehabilitation) in the case of care need and thus, the Sullivan method is concluded to be adequate for this application (Pattloch, 2010). Another problem of the Sullivan method is the over simplification of the complex health/morbidity continuum by dichotomisation of care need. A strategy to face the problem is to estimate models that are stratified by severity of care level as done in study 2 and adapted from Pattloch (2010). Thus, the situation and the trends at different stages within the continuum can be compared.

For study 3 and study 4, the German Microcensus is used. One limitation of this dataset is in the definition of health. Health is measured by a few retrospective questions about the expe-

[19] By comparing the extrapolation results and the results of the official population census in 2011, we show that the cumulated overestimation of the population 65+ in 2011 is only about 1.89% in Germany as total and only 1.42% in the unweighted median of all counties. Further, estimated partial CFLY, CLY, HR and LE for the ages 65-84 are highly correlated with those at age 65+ (correlations range from r(LE, females, 2007/09)=0.86 to r(HR, any care, females, 2007/09)=0.97)

riences in the past. The question about "being ill" covers no standardised definition, thus the respondents define being unhealthy according to their own definition. No further specifications about the severity and the type of illness can be made. To indicate the severity of an illness, the duration of the illness is integrated as proxy in the used health outcome. Answering of the questions about health can be refused by the respondent, thus the existence of a non-response bias can be assumed, which is expected to be higher in persons in poor health (Goldberg et al., 2001). Albeit, there is no indication of region-specific non-response, thus the influence on the spatial inequalities is assumed to be low.

The second health indicator used in study 4 is the mandatory question about receiving allowances from the SLTC insurance. Limitations of this indicator are problems in the knowledge about the financial benefits or problems by a conscious denial of these transfers. Further, this health measure is only a limited indicator of care need, since also the care giver may receive financial compensation for their supply for the persons in care need. On the other hand, persons in institutions do not receive the allowance directly, since the institutions receive the allowance. However, like for the indicator of longstanding illness, it can be assumed that the bias in this health outcome has a region-specific variation and may affect the results of the spatial inequalities.

In the analysis of the health of the Aussiedler, further limitations have to be considered. The identification of the Aussiedler is done by a combination of attributes that are particular for Aussiedler. However, a low misclassification bias cannot be fully neglected. Another problem is cross-cultural differences in the perception of being ill between native Germans and Aussiedler. These differences may further vary within the group of Aussiedler, for example by attributes like the duration of stay in Germany, the in-migration cohort or the country of origin. These biasing effects may not have an impact on the spatial inequality but cannot be neglected as a cause for the stated disparities on the individual level.

## 3. Outlook and implications

### 3.1. Implications for health care policy and planning

One of the fundamental objectives of the German constitution is to attain and ensure equal conditions among all regions by national social and health policies. Universal and equitable access to high-quality health care is one of the ways to reach these equal conditions in terms of health, but other dimensions of the natural, social and build environment have further effects on the health conditions. To understand these determinants it is a major step to introduce policy measures to the population in total or to subgroups with a particular high risk of morbidity.

The findings of the four studies indicate a high inequality in longstanding illness and care need. These inequalities in health show an increase over the observation period suggesting either a trend of spatial divergence than a convergence of health. Such convergence further causes a disparity in the level of current and future challenges in public health and in social policy according to financial, economic, infrastructural, socio-humanitarian, and social security aspects.

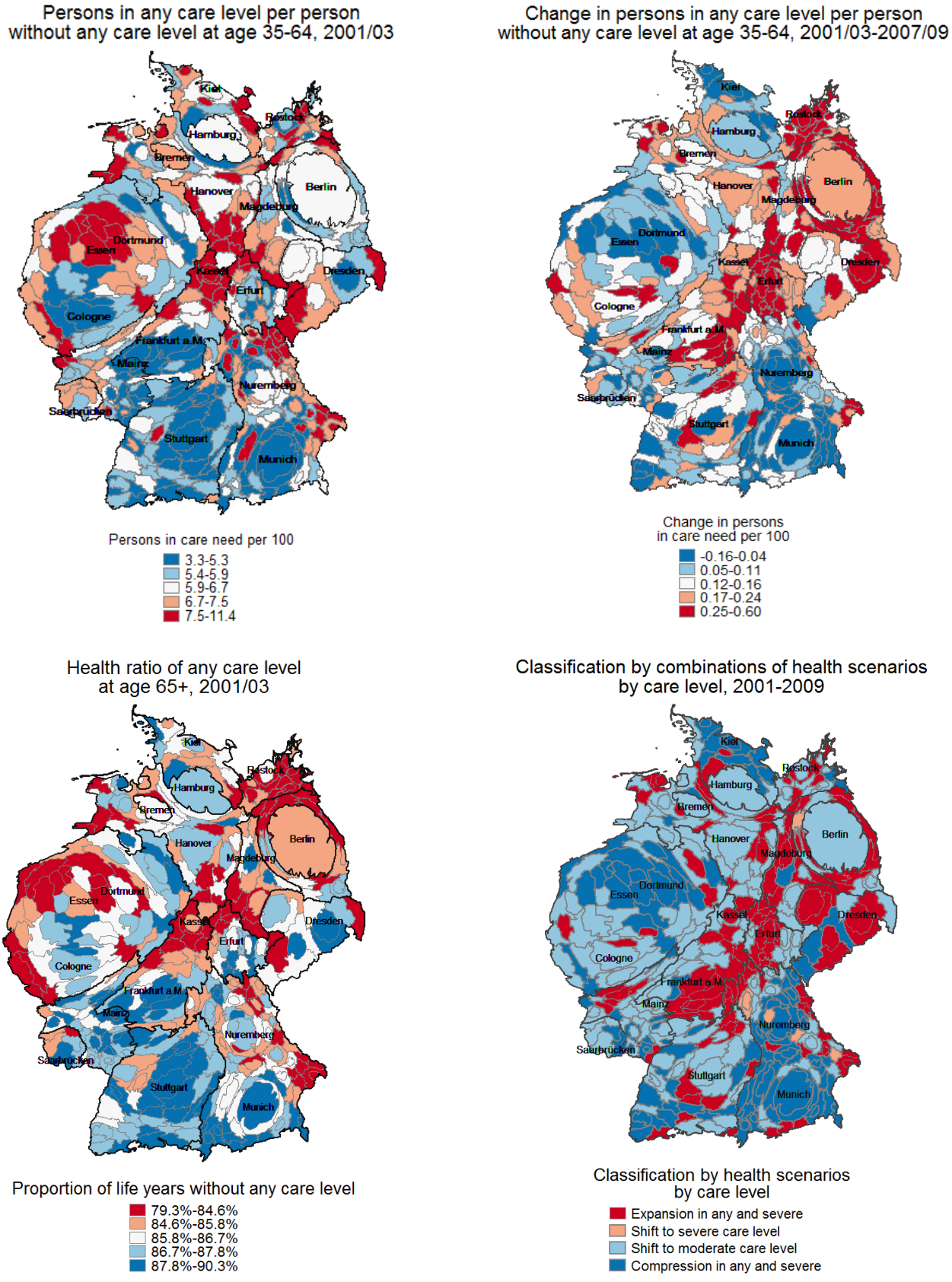
The rear-guard regions with the most unfavourable health situations are those regions with a high prevalence of care need and a high proportion of life years with care need, compared to the life years without care need at the first year of the observation period. The results of the studies indicate that even for these rear-guard regions, there is a trend of further expansion of care need, while there is a compression for some of the vanguard regions. These rear-guard regions will be confronted with a growing proportion of persons in care need living longer with disability and with the need for financial, infrastructural, and professional support. There was no indication of a clear northeast versus southwest gap in both, the health scenarios in the particular indicators. This is in contrast to the findings regarding the spatial pattern of life expectancy (Kibele, 2012) and of the sole indicators of life years with and without care need.

The major focus of the studies in regards to the spatial inequalities was on the comparison of counties assuming that these regions have equal impacts on the national health situation. Considering the variation in the numbers of persons at higher ages, the national trends are mostly determined by the trends in higher populated regions. This perspective depicts the high relevance of the health situation and trends in the cities on the national health state.

For most of the cities (presented by larger entities in Figure 18), a favourable status of care need can be observed than in the less populated rural areas (presented by smaller entities in Figure 18). Interesting exceptions are the densely populated regions in the Ruhr region which shows a very high level and a low health ratio of care need in 2001/03. In contrast, these regions experienced a positive trend over the period, while especially the cities in East and Central Germany show very negative trends over time. The trends of these cities and the high number of rural areas with increases in care need are the drivers for the negative national health trend.

While a large number of counties show an expansion in severe and any care need, another large group of regions show a shift from severe to moderate care need. This shift is a favourable development considering the financial and emotional burden of severe care need for individuals and society.

*Figure 18: Cartograms of spatial inequalities in the status in 2001/03 (left column) and in the trend of care need (right column) between 2001/03 and 2007/09 by using various relative measures of care need, size of counties relative to the size of the population at age 65+*




(Statistical Offices of the Federation and the Länder, SLTC censuses 2001-2009, Regional database 2015)

The analysis of the basic drivers of the trends in morbidity reveals that mortality is the major driver of absolute gains in life years with and without care need, but the trends in the prevalence have a much greater impact on the risk of experiencing a compression or expansion of morbidity. Since promoting the decrease of mortality is already an unalterable objective of the health system, higher efforts are required to reduce the prevalence rates by health (policy) measures and medical intervention programmes. This is of particular importance in counties that already have the highest share of persons in care need, especially those in the North, the East and the Centre of Germany.

One important result of the studies is the detection of determinants of health inequalities. For both health outcomes, longstanding illness and care need, individual level factors appear to be the most influential determinants of health inequalities. Thus, policy interventions promoting healthy life styles, such as, participation in early prevention programmes, regular utilisation of health check-ups, and greater adherence to treatments and medication of persons detected as at-risk groups. These at-risk groups are persons at higher ages, with a low socioeconomic status and risky life styles, being unmarried, and having a migration background.

Of particular interest in this field is the health situation of the aging population of migrants in Germany and the other welfare states. Aiming to develop policy strategies to reduce inequalities in health and to enable migrants to reach old age in good health, knowledge about the determinants of the health of ethnic minorities at the individual and regional levels is needed. The results suggested no disadvantage of Aussiedler in the case of longstanding illness in comparison to the native population, but a deterioration of health of Aussiedler by increasing duration of stay. These results may be an indication of the problems of social and economic integration and of the effects of social deprivation. Additionally, the studies found a higher risk of longstanding illness but a lower risk of receiving SLTC supply for older migrants with German citizenship in general. This result may reveal a discrepancy between a future need for care and the willingness and knowledge to apply for support in giving adequate care. To provide culturally sensitive care and to inform the persons concerned and their relatives about all options of SLTC supply may be a further future challenge to reduce health inequalities.

However, the studies also indicate the effect of the place of residence as a further determinant of health inequality. Living in regions with a low economic performance and an unfavourable socioeconomic composition of the population causes a health disadvantage independent from the individual social standing. These effects are more pronounced in the West German regions than in the East German regions, which is explained by higher disparities among the West German counties. The reverse is true for indicators of the health structure and the medical infrastructure. While the spatial disparities and their effects on health inequalities are low in the West German counties, the indicator is detected to be a determinant

of spatial disparities in health in the East German regions. Urbanity showed to have an inconsistent effect of health disparities – varying by the definition of health and by the choice of the spatial entities. Based on these findings, the major potential for short- and long-term policy interventions can be expected for economic, health and policy measures that directly or indirectly affect the socioeconomic factors or the health (care) structure. Effects of the social capital or the build environment can only be less effective modified by policy; however, specific health promotion interventions targeting persons living regions and neighbourhoods with unfavourable conditions areas should be developed, and their effectiveness should be evaluated.

### 3.2. Implications for health research

In addition to the implications for public health, the studies also showed some implications for future health research. The studies stated a very high impact of individual level factors on health inequalities, while the contextual factors have relatively low effects. One objective for future research could be to use longitudinal administrative micro level data such as health claim data to investigate inter-individual and intra-individual health trends and their linkages to the living context or to changes of the living context by (internal or international) migration. These datasets also allow to compute more advanced multistage life tables that estimate various transitions between the health stages and their linkages with mortality.

A high relevance for the study of health disparities is further to analyse the particular role of selection by mortality and migration on the composition of the population at higher ages. The findings could help to more adequately decompose health inequalities into the effects of composition and into effects of short- and long-term influences of the context. A particular focus should be on the early and mid-life conditions and their influence on the later life health. The results of the thesis suggested spatial disparities between the same-cohorts indicating health effects independently from the effects of ageing.

A major shortcoming of the studies in this thesis was that the complex interplay of micro-macro-level factors was not investigated in detail. Insights into this field of research have the potential to assist in the understanding of the pathways of health inequalities. Including more individual level factors in the analyses would further help to evaluate if the detected spatial disparities are an artefact of under-control, are overestimated or are underestimated.

Another shortcoming of the studies was that the most of the revealed spatial inequality was not explained by the macro level factors. Thus, there is a high potential in detecting adequate indicators that represent the particular health-relevant attributes of a living region. The adequacy is further increased when the effects of these indicators on the individuals' health status are explained by etiological pathways of morbidity causation.

Only as a first step, the studies investigated the influence of the choice of the health outcome and of the choice of the level of spatial aggregation. These investigations may help to understand the grade of spatial inequality and further to evaluate the comparability of the results from different studies. The comparison of specific morbidities may further increase the knowledge about the morbidity patterns and their linkage to the mortality patterns.

Morbidity specific analyses have further relevance in terms of the health scenarios. The results of the thesis prove that the gains in life expectancy are (also) linked to an increase in life years with care need. Since care need is only one particular dimension of health, other morbidities or combinations of morbidities should be analysed to achieve future insights into the disparities and trends in quality of life and well-being, as well as in cause-specific and in avoidable mortality. While higher female total life expectancy at age 65 shows to be associated with lower gains over the observation period, the analyses provides no evidence for reaching an upper level in the case of male total life expectancy and in the case of life expectancy with and without care need. These findings indicate that there is a potential for further improvements but also for further disparities in care need between the regions.

In future research about care need in Germany, it would be important to investigate the trends in care need caused by 1) the expected changes in the composition of future elderly, and 2) the reform of the definition of care need by health policy in 2017. It can be assumed that the future elderly have on average a higher educational level, are less unmarried and less childless, and have lived their whole life in peace times and within a system of material wealth, of (basic) social security and of legally ensured equality in access to health care. However, the proportion of persons within this group that have experienced problems of job security, unintended breaks in the job biography or short- or long-term unemployment. This is of particular interest for persons in the regions of the former German Democratic Republic, but also in the regions with severe structural changes in the economy or of high in-migration that causes an imbalance of demand and supply of employees which can be assumed for cities like Bremen or cities within the Ruhr region. Another challenging change in the composition of the future elderly can be expected for the increase in the ethnic diversity. The trends in and determinants of health and heath disparities within the particular groups of persons that experienced a migration and their descendants should be investigated and policy measures to attenuate health inequalities should be developed and evaluated in future research.

The reform of the SLTC law that was introduced in 2017 is assumed to have further impacts on the conditions of care need. As the definition and evaluation of care need is changed by the law, the comparability with the results of these studies is limited. It can be assumed that the introduction of the new five grades of care need that considers mental and cognitive problems much more than the care levels leads to a high increase in the number of persons

with care need. Additionally, out-patient care is further promoted by various interventions within the reformed law that may affect the composition of the persons with care need. These trends should also be investigated in future research projects.

To sum up, the emerging question is whether the specific living conditions in the counties and their temporal changes are associated with the trends in morbidity, well-being, disability and mortality. The four studies gave new insights into some aspects of this question; however, there are also many new questions that emerge from the findings. Thus, a range of further investigations are needed to uncover the underlying mechanisms of healthy ageing with the substantial objective to understand and to deal with the challenges of increasingly more heterogeneous ageing societies in the welfare states and their regions.

# VII. References

Abraido-Lanza, A. F., Dohrenwend, B. P., Ng-Mak, D. S., & et al. (1999). The Latino mortality paradox: a test of the “salmon bias” and healthy migrant hypotheses. *American Journal of Public Health, 89*, 1543–1548.

Acevedo-Garcia, D., Lochner, K. A., Osypuk, T. L., & Subramanian, S. V. (2003). Future directions in residential segregation and health research: A multilevel approach. *American Journal of Public Health, 93*(2), 215–221.

Albrecht, G., Naplava, T., & Schloosch, A. (1998). Die Krebsmortalität in den alten Ländern der Bundesrepublik Deutschland: Eine medizinökologische Analyse auf Kreisebene. *Soziale Probleme, 9*(2), 182–214.

Albrecht, G. L., & Devlieger, P. J. (1999). The disability paradox: High quality of life against all odds. *Soc Sci Med, 48*(8), 977–988.

Altenstetter, C. (2003). Insights From Health Care in Germany. *American Journal of Public Health, 93*(1), 38–44.

Anselin, L. (1995). Local Indicators of Spatial Association-LISA. *Geographical Analysis, 27*(2), 93–115.

Antonovsky, A. (1979). *Health, stress, and coping.* San Francisco: Jossey-Bass.

Antonovsky, A. (1996). The salutogenic model as a theory to guide health promotion. *Health Promotion International, 11*(1), 11–18.

Aparicio, M., Doring, A., Mielck, A., & Holle, R. L. (2005). Unterschiede zwischen Aussiedlern und der übrigen deutschen Bevölkerung bezüglich Gesundheit, Gesundheitsversorgung und Gesundheitsverhalten: Eine vergleichende Analyse anhand des KORA-Surveys 2000. *Soz Praventivmed, 50*(2), 107–118.

Arntz, M., Sacchetto, R., Spermann, A., Steffes, S., & Widmaier, S. *The German social long-term care insurance: Structure and reform options. Discussion paper series / Forschungsinstitut zur Zukunft der Arbeit: Vol. 2625.* Bonn: IZA.

Arriaga, E. E. (1984). Measuring and explaining the change in life expectancies. *Demography, 21*(1), 83–96, from http://www.jstor.org/stable/2061029.

Balfour, J. L., & Kaplan, G. A. (2002). Neighborhood Environment and Loss of Physical Function in Older Adults: Evidence from the Alameda County Study. *American journal of epidemiology, 155*(6), 507–515.

Barnett, S., Roderick, P., Martin, D., & Diamond, I. (2001). A multilevel analysis of the effects of rurality and social deprivation on premature limiting long term illness. *Journal of Epidemiology & Community Health, 55*, 44–51.

Barr, N. (2004). *Economics of the welfare state.* New York: Oxford University Press.

Bartley, M. (2004). *Health inequality: An introduction to theories, concepts and methods.* Cambridge: Polity Press.

Bazargan, M. (1994). The effects of health, environmental, and socio-psychological variables on fear of crime and its consequences among urban black elderly individuals. *International journal of aging & human development, 38*(2), 99–115.

BBSR (2007). Übersicht und Beschreibung der Indikatoren und Karten zur Raum- und Stadtentwicklung in Deutschland und in Europa des Bundesinstituts für Bau-, Stadt- und Raumplanung, from http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen.

BBSR (2012). *Zentrale Orte,* from http://www.bbsr.bund.de/BBSR/DE/Raumentwicklung/RaumentwicklungDeutschland/Projekte/Archiv/ZentraleOrte/ZentraleOrte.html?nn=411742.

Beard, J. R., Blaney, S., Cerda, M., Frye, V., Lovasi, G. S., Ompad, D., et al. (2009). Neighborhood characteristics and disability in older adults. *The journals of gerontology. Series B, Psychological sciences and social sciences, 64*(2), 252–257.

Becher, H., Razum, O., Kyobutungi, C., Laki, J., Ott, J. J., Ronellenfitsch, U., & Winkler, V. (2007). Mortalität von Aussiedlern aus der ehemaligen Sowjetunion. Ergebnisse einer Kohortenstudie. *Dtsch Arztebl, 104*(23), 1655–1661.

Becker, N., & Wahrendorf, J. (1998). *Krebsatlas der Bundesrepublik Deutschland 1981-1990.* Berlin, Heidelberg, New York: Springer.

Ben-Shlomo, Y., & Kuh, D. (2002). A life course approach to chronic disease epidemology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International journal of epidemiology, 31*, 285–293.

Berger, N., van der Heyden, J., & van Oyen, H. (2015). The global activity limitation indicator and self-rated health: Two complementary predictors of mortality. *Archives of public health Archives belges de sante publique, 73*(1), 25.

Berndt, H., & M. Gregor (1975). Zur Krebsmortalität in der DDR. Regionale Differenzen und zeitlicher Trend der Mortalität an bösartigen Neubildungen des Magens, des Dickdarms und Mastdarms, der Brustdrüse und des Uterus, 1960-1969. *Archiv für Geschwulstforschung, 45*(1), 61–78.

Birg, H. (1982). Regionale Mortalitätsunterschiede in der Bundesrepublik Deutschland: ein Problemaufriss. *IBS-Materialien, 4*, 1–26.

Black, D. (1980). Inequalities in Health: Report of a Research Working Group. DHSS, London.

Blake, B. F., Weigl, K., & Perloff, R. (1975). Perceptions of the ideal community. *Journal of Applied Psychology, 60*(5), 612–615.

Blalock, H. M. (1984). Contextual-Effects Models: Theoretical and Methodological Issues. *Annual Review of Sociology, 10*(1), 353–372.

Bobak, M., Marmot, M. East-West Health Divide and Potential Explanations. In C. Hertzman, S. Kelly, & M. Bobak (Eds.), *East-West Life Expectancy Gap in Europe* (pp. 17–44). Dordrecht, Boston, London: Kluwer Academic Publishers.

Böing, H., Martinez, L., Frentzel-Beyme, R., & Oltersdorf, U. (1985). Regional Nutritional Pattern and Cancer Mortality in the Federal Republic of Germany. *Nutrition and Cancer, 7*(3), 121–130.

Breckenkamp, J., Mielck, A., & Razum, O. (2007). Health inequalities in Germany: Do regional-level variables explain differentials in cardiovascular risk? *BMC public health, 7*(1), 1003.

Brockmann, H., & Klein, T. (2002). Familienbiographie und Mortalität in Ost- und Westdeutschland. *Zeitschrift f□ur Gerontologie und Geriatrie, 35*(5), 430–440.

Brody, E. M. (1979). Service-supported independent living in an urban setting: The Philadelphia Geriatric Center community housing for the elderly. In Byert, T.O. (Ed.), *Environmental Context of Ageing* (pp. 121–128). New York: Garland.

Broom, D. (2000). The Sociology of Health Inequalities. *Health Promotion International, 15*(2), 179–180.

Brüske-Hohlfeld, I., Rosario, A. S., Wolke, G., Heinrich, J., Kreuzer, M., & Kreienbrock, L. (2006). Lung cancer risk among former uranium miners of the Wismut company in Germany. *Health Physics, 90*(3), 208–216.

Brzoska, P., & Razum, O. (2008). Privatverschuldung und Mortalitat: Untersuchung auf Ebene der Kreise und kreisfreien Stadte Deutschlands [Indebtedness and mortality: analysis at county and city levels in Germany]. *Gesundheitswesen (Bundesverband der Arzte des Offentlichen Gesundheitsdienstes (Germany)), 70*(7), 387–392.

Bucher, H., Schlömer, C., & Lackmann, G. (2004). Die Bevölkerungsentwicklung in den Kreisen der Bundesrepublik Deutschland zwischen 1999 und 2020. *Informationen zur Raumentwicklung, Heft 3/4*, 107–126.

Cambois, E., Blachier, A., & Robine, J.-M. (2013). Aging and health in France: An unexpected expansion of disability in mid-adulthood over recent years. *The European Journal of Public Health, 23*(4), 575–581.

Carp, F. M. (1975). Long-range satisfaction with housing. *The Gerontologist, 15*, 68–72.

Carp, F. M., & Carp, A. (1982). The Ideal Residential Area. *Research on Aging, 4*(4), 411–439.

Cassel, J. (1996). The contribution of the social environment to host resistance. The fourth Wade Hampton Frost lecture. *American journal of epidemiology, 104*, 107–123.

Chaturvedi, N., & McKeigue, P. M. (1994). Methods for epidemiological surveys of ethnic minority groups. *Journal of epidemiology and community health, 48*, 107–111.

Chiang, C. L. (1984). *The life table and its applications.* Malabar, Fla.: Krieger.

Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. W. (2009). Ageing populations: The challenges ahead. *The Lancet, 374*(9696), 1196–1208.

Cischinsky, H. (2005). Determinanten regionaler Mortalitätsunterschiede am Beispiel Baden-Württembergs. *Jahrbuch für Regionalwissenschaft, 25*(2), 175–205.

Cockerham, W. C. (1999). *Health and Social Change in Russia and Eastern Europe.* New York, London: Routledge.

Cohen, S., Krantz, D. S., Evans, G. W., & Stokols, D. (1981). Cardiovascular and behavioral effects of community noise. *American scientist, 69*(5), 528–535.

Collatz, J. (1989). Brennpunkte sozialer Ungleichheit bei der medizinischen Versorgung ausländischer Arbeitnehmer und Flüchtlinge in der Bundesrepublik Deutschland. *Zeitschrift für Sozialreform, 35*(11/12), 682–696.

Courbage, Y., & Khlat, M. (1996). Mortality and causes of death of Maroccans in France, 1979-91. *Population, an English selection 8*, 59–94.

Crimmins, E. M., & Beltran-Sanchez, H. (2010). Mortality and Morbidity Trends: Is There Compression of Morbidity? *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66B*(1), 75–86.

Cromm, J., & Scholz, R. (2002). *Regionale Sterblichkeit in Deutschland.* Augsburg, Göttingen: WiSoMed.

Cummins, S., Macintyre, S., Davidson, S., & Ellaway, A. (2005). Measuring neighbourhood social and material context: Generation and interpretation of ecological data from routine and non-routine sources. *Health & place, 11*(3), 249–260.

Curtis, S. (2007). *Health and inequality: Geographical perspectives:* SAGE.

Deckert, A., Winkler, V., Meisinger, C., Heier, M., & Becher, H. (2014). Myocardial infarction incidence and ischemic heart disease mortality: overall and trend results in repatriates, Germany. *The European Journal of Public Health, 24*(1), 127–133.

Deckert, A., Winkler, V., Meisinger, C., Heier, M., & Becher, H. (2015). Suicide and external mortality pattern in a cohort of migrants from the former Soviet Union to Germany. *Journal of psychiatric research, 63*, 36–42.

Diehl, K., & Schneider, S. (2011). How relevant are district characteristics in explaining subjective health in Germany?: – A multilevel analysis. *Social Science & Medicine, 72*(7), 1205–1210.

Dietz, B. (1999). Ethnic German immigration from Eastern Europe and the former Soviet Union to Germany: The effects of migrant networks, from http://hdl.handle.net/10419/20903.

Dietzel-Papakyriakou, M. (1987). *Krankheit und Rückkehr. Frühindividualität ausländischer Arbeitnehmer am Beispiel griechischer Rückkehrer.* Berlin: Edition sigma.

Diez Roux, A. V. (2003). The Examination of Neighborhood Effects on Health: Conceptual and Methodological Issues Related to the Presence of Multiple Levels of Organization. In I. Kawachi & L. F. Berkman (Eds.), *Neighborhoods and Health* (pp. 45–64). Oxford, New York: Oxford University Press.

Diez Roux, A. V., & Mair, C. (2010). Neighborhoods and health. *Annals of the New York Academy of Sciences, 1186*(1), 125–145.

Diez-Roux, A. V. (2000). Multilevel Analysis in Public Health Research. *Annu. Rev. Public. Health, 21*, 171-192.

Dinkel, R. H. (1989). *Bevölkerungsdynamik.* München: Vahlen.

Dinkel, R. H. (1992). Kohortensterbetafeln für die Geburtenjahrgänge ab 1900 bis 1962 in den beiden Teilen Deutschlands. *Zeitschrift f□ur Bevölkerungswissenschaft, 18*(1), 95–116.

Dinkel, R. H. (2000). *Fertilität und Mortalität als Bestimmungsfaktoren der Bevölkerungsentwicklung in Mecklenburg-Vorpommern.* Schwerin: Schweriner Wissenschaftstage 2000, 16-30.

Doblhammer, G., & Kreft, D. (2011). Länger leben, länger leiden? *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 54*(8), 907–914.

Dragano, N., Hoffmann, B., Moebus, S., Mohlenkamp, S., Stang, A., Verde, P. E., et al. (2009a). Traffic exposure and subclinical cardiovascular disease: Is the association modified by socioeconomic characteristics of individuals and neighbourhoods? Results from a multilevel study in an urban region. *Occupational and environmental medicine, 66*(9), 628–635.

Dragano, N., Bobak, M., Wege, N., Peasey, A., Verde, P. E., Kubinova, R., et al. (2007). Neighbourhood socioeconomic status and cardiovascular risk factors: A multilevel analysis of nine cities in the Czech Republic and Germany. *BMC public health, 7*, 255.

Dragano, N., Hoffmann, B., Stang, A., Moebus, S., Verde, P. E., Weyers, S., et al. (2009b). Subclinical coronary atherosclerosis and neighbourhood deprivation in an urban region. *European Journal of Epidemiology, 24*(1), 25–35.

Duncan, L., & Simmons, M. (1996). Health practices among Russian and Ukrainian immigrants. *Journal of community health nursing, 13*(2), 129–137.

Durkheim, E. (1951). *Suicide : a study in sociology:* The Free Press.

Easterbrook, P., Gopalan, R., Berlin, J., & Matthews, D. (1991). Publication bias in clinical research. *The Lancet, 337*(8746), 867–872.

Ecob, R., & Macintyre, S. (2000). Small area variations in health related behaviours; do these depend on the behaviour itself, its measurement, or on personal characteristics? *Health & place, 6*(4), 261–274.

EHLEIS (2016). *Database of the European Health & Life Expectancy Information System,* from http://www.eurohex.eu/ehleis/IS/web/app.php/Ehleis.

Eibich, P., Krekel, C., Demuth, I., & Wagner, G. G. (2016). Associations between Neighborhood Characteristics, Well-Being and Health Vary over the Life Course. *Gerontology, 62*(3), 362–370.

Elkeles, T., & Mielck, A. (1997). Entwicklung eines Modells zur Erklärung gesundheitlicher Ungleichheit. *Gesundheitswesen, 59*, 137–143.

Elstad, J. I. (1998). The Psycho-social Perspective on Social Inequalities in Health. *Sociol Health & Illness, 20*(5), 598–618.

European Communities. *Health statistics. Atlas on mortality in the European Union.* (Vol. 2009). Luxembourg: Oce for Ocial Publications of the European Communities.

Eurostat (2016). *Database: http://ec.europa.eu/eurostat/data/database,* from http://ec.europa.eu/eurostat/data/database.

Fabian, T., Straka, G.A. (1993). Lebenszufriedenheit älterer türkischer Migranten. *Zeitschrift für Gerontologie, 26*, 404–409.

Federal health reporting (2016). *Information System of the Federal Health Monitoring,* from http://www.gbe-bund.de.

Federal Office for Migration and Refugees (2013). *(Spät-)Aussiedler in Deutschland: Eine Analyse aktueller Daten und Forschungsergebnisse:* Forschungsbericht 20.

Federal Office for Migration and Refugees (2016). *Migrationsbericht 2015.* Nürnberg.

Federal statistical office (2007). Fachserie 1 Reihe 2.2 Bevölkerung und Erwerbstätigkeit. Bevölkerung mit Migrationshintergrund. Ergebnisse des Mikrozensus 2005.

Federal statistical office (2011). *Microcensus. Overview and description,* from [http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/press/abisz/Mikrozensus\textunderscore \textunderscore e,templateId=renderPrint.psml, February 2011].

Federal statistical office (2017). *GENESIS Online Database.*

Ferraro, K. F., & Shippee, T. P. (2009). Aging and cumulative inequality: How does inequality get under the skin? *The Gerontologist, 49*(3), 333–343.

Fors, S. (2010). *Blood on the tracks Life-course perspectives on health inequalities in later life.* Cummulative thesis, Department of Social Work, Stockholm University.

Fox, A. J., & Collier, P. F. (1976). Low mortality rates in industrial cohort studies due to selection for work and survival in the industry. *British Journal of Prevention and Social Medicine, 30*, 225–230.

Freedman, V. A., Martin, L. G., & Schoeni, R. F. (2002). Recent Trends in Disability and Functioning Among Older Adults in the United States. A Systematic Review. *Journal of the American Medical Association, 288*, 3137–3146.

Fries, J. F. (1980). Aging, natural death, and the compression of morbidity. *The New England journal of medicine, 303*(3), 130–135.

Fries, J. F. (1989). The Compression of Morbidity: Near or Far? *The Milbank Quarterly, 67*(2), 208–232, from http://www.jstor.org/stable/3350138.

Fries, J. F. (2003). Measuring and Monitoring Success in Compressing Morbidity. *Annals of Internal Medicine, 139*(5_Part_2), 455.

Fries, J. F. (2005). The Compression of Morbidity. *The Milbank Quarterly, 83*(4), 801–823.

Galobardes, B., Lynch, J. W., & Davey Smith, G. (2004). Childhood socioeconomic circumstances and cause-specific mortality in adulthood: Systematic review and interpretation. *Epidemiologic reviews, 26*, 7–21.

Gärtner, K., & Scholz, R. D. (Eds.) (2005). *Schriftenreihe des Bundesinstituts für Bevölkerungsforschung: Band 36. Lebensstile, Lebensphasen, Lebensqualität: Interdisziplinäre Analysen von Gesundheit und Sterblichkeit aus dem Lebenserwartungssurvey des BiB.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Gatrell, A. C., & Elliott, S. J. (2015). *Geographies of health: An introduction* (Third edition). Chichester [England]: Wiley Blackwell.

Gatzweiler, H.-P., & Stiens, G. (1982). Regionale Mortalitätsunterschiede in der Bundesrepublik Deutschland. Daten und Hypothesen. *Jahrbuch für Regionalwissenschaft, 3*, 36–63.

Gaudecker, H.-M. von (2004). *Regionale Mortalitätsunterschiede in Baden-Württemberg. Statistische Analysen:* Eigenverlag, Statistisches Landesamt Baden-Württemberg, Stuttgart.

Gaudecker, H.-M. von, & Scholz, R. D. (2007). Differential mortality by lifetime earnings in Germany. *Demographic Research, 17*, 83–108.

Giersdorf, P., & Lorenz, R. (1986). Zu regionalen Unterschieden der Mortalität in der DDR im Zeitraum 1980/1983. *Zeitschrift für Ärztliche Fortbildung, 80*(22), 947–950.

Gjonca, A., Brockmann, H., & Maier, H. (2000). Old-Age Mortality in Germany prior to and after Reunication. *Demographic research, 3*(1).

Glass, T. A., & Balfour, J. L. (2003). Neighborhoods, Aging, and Functional Limitations. In I. Kawachi & L. F. Berkman (Eds.), *Neighborhoods and Health* (pp. 303–334). Oxford, New York: Oxford University Press.

Goldberg, M., Chastang, J. F., Leclerc, A., Zins, M., Bonenfant, S., Bugel, I., & et al. (2001). Socioeconomic, demographic, occupational, and health factors associated with participation in a long-term epidemiologic survey: A prospective study of the French GAZEL cohort and its target population. *American journal of epidemiology, 154*(4), 373–384.

Graham, P., Blakely, T., Davis, P., Sporle, A., & Pearce, N. (2004). Compression, expansion, or dynamic equilibrium?: The evolution of health expectancy in New Zealand. *Journal of Epidemiology & Community Health, 58*(8), 659–666.

Greenberg, M., & Schneider, D. (1997). Neighborhood Quality, Environmental Hazards, Personality Traits, and Resident Actions. *Risk Analysis, 17*(2), 169–175.

Greif, S., Gediga, G., & Janikowski, A. (2003). Erwerbslosigkeit und beruflicher Abstieg von Aussiedlerinnen und Aussiedlern. In K. Baade & J. Oltmer (Eds.), *Aussiedler. Deutsche Einwanderer aus Osteuropa.* Göttingen: IMIS-Schriften 8. V&R unipress (2nd Edition).

Grobe, T. G., & Schwartz, F. W. (2003). Themenheft 13 "Arbeitslosigkeit und Gesundheit". *Gesundheitsberichterstattung*.

Gröner, G. (1983). Regionale Unterschiede der Sterblichkeit. *Baden-Württemberg in Wort und Zahl, 31*, 38–41.

Gruenberg, E. M. (1977). The failures of success. *The Milbank Memorial Fund Quarterly. Health and Society, 55*(1), 3–24, from http://www.bibliothek.uni-regensburg.de/ezeit/?2235681.

Häcker, J., & Hackmann, T. (2012). Los(t) in Long-term Care: Empirical evidence from German data 2000-2009. *Health Economics, 21*(12), 1427–1443.

Hackmann, T., & Moog, S. (2009). Die Auswirkungen der steigenden Lebenserwartung auf die Prävalenz der Pflegebedürftigkeit in Deutschland. *Zeitschrift für die gesamte Versicherungswissenschaft, 98*(1), 73–89.

Hall, P. A., & Taylor, R. C. (2009). Health, Social Relations, and Public Policy. In A. H. Peter & M. Lamont (Eds.), *Sucessful Socities: How Institutions and Culture affect Health* (pp. 82–103). Cambridge: Cambridge University Press.

Hamil-Luker, J., & O'Rand, A. M. (2007). Gender Differences in the Link Between Childhood Socioeconomic Conditions and Heart Attack Risk in Adulthood. *Demography, 44*(1), 137–158.

Harbord, R. M., & Higgins, J. P. T. (2008). Meta-regression in Stata. *The Stata Journal, 8*(4), 493–519.

Haug, S., & Sauer, L. (2007). *Zuwanderung und Integration von (Spät-)Aussiedlern: Ermittlung und Bewertung der Auswirkungen des Wohnortzuweisungsgesetzes ; Forschungsstudie im Auftrag des Bundesministeriums des Innern ; [Abschlussbericht]. Forschungsbericht / Bundesamt für Migration und Flüchtlinge: Vol. 3.* Nürnberg: Bundesamt für Migration und Flüchtlinge.

Heinrich, J., Hoelscher, B., Wjst, M., Ritz, B., Cyrys, J., & Wichmann, H. (1999). Respiratory diseases and allergies in two polluted areas in East Germany. *Environmental Health Perspectives, 107*(1), 53–62.

Heins, F. (1985). Zur Beobachtung regionaler Unterschiede der Morbidität in der Bundesrepublik Deutschland. *Informationen zur Raumentwicklung, 3-4*, 221–235.

Heins, F. (1991). Regional disparities in mortality: the case of North Rhine-Westphalia and Rhineland-Palatinate. *Espace, Populations, Societe, 1*, 101–111.

Heins, F., & Stiens, G. (1984). Regionale Unterschiede der Sterblichkeit. Untersuchung am Beispiel der Länder Nordrhein-Westfalen und Rheinland-Pfalz. *Bundesforschungsanstalt für Landeskunde und Raumordnung. Seminare, Symposien, Arbeitspapiere. Heft 16*.

Herbert, U. (2003). *Geschichte der Ausländerpolitik in Deutschland. Saisonarbeiter, Zwangsarbeiter, Gastarbeiter, Flüchtlinge.* Bonn: Bundeszentrale für politische Bildung.

Hertzman, C., Power, C., Matthews, S., & Manor, O. (2001). Using an interactive framework of society and lifecourse to explain self-rated health in early adulthood. *Social Science & Medicine, 53*(12), 1575–1585.

Hobcraft, J., Menken, J., & Preston, S. (1982). Age, period, and cohort effects in demography: a review. *Popul Index, 48*(1), 4–43.

Hoffmann, E., & Nachtmann, N. (2010). Old age, the need of long-term care and healthy life expectancy. In G. Doblhammer & R. D. Scholz (Eds.), *Ageing, Care Need and Quality of Life. The Perspectives of Care Givers and People in Need of Care* (pp. 162–176). Wiesbaden: Springer VS Research.

Höhn, C., Mai, R., & Micheel, F. (2007). Demographic Change in Germany. In I. Hamm, H. Seitz, & M. Werding (Eds.), *Demographic change in Germany* (pp. 9–33). New York: Springer.

Howe, G. M. (1986). Does it matter where I live? *Transactions of the Institute of British Geographers, 11*, 387–411.

Huber, M., Knottnerus, J. A., Green, L., van der Horst, H., Jadad, A. R., Kromhout, D., et al. (2011). How should we define health? *BMJ (Clinical research ed.), 343*, d4163.

Ickler, G. (1984). Regionale Unterschiede in der Sterblichkeit. *Statistische Monatshefte Rheinland-Pfalz, 37*(6), 117–125.

Imai, K., & Soneji, S. (2007). On the Estimation of Disability-Free Life Expectancy: Sullivan' Method and Its Extension. *Journal of the American Statistical Association, 102*(480), 1199–1211.

Information for political education (2000). *Aussiedler: Informationen zur politischen Bildung No 267. [Bundeszentrale für politische Bildung, Aussiedler].* Munich: Franzis' print and media GmbH.

Institute for Quality and Efficiency in Health Care (IQWiG) (2015). *Health care in Germany: The German health care system,* from https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0078019/.

Jaehn, P., Holleczek, B., Becher, H., & Winkler, V. (2016). Histologic types of gastric cancer among migrants from the former Soviet Union and the general population in Germany – what kind of prevention do we need? *Eur J Gastroenterol Hepatol, 28*, 863–870.

Jagger, C., Cox, B., Le Roy, S., & EHEMU team (2006). Health Expectancy Calculation by the Sullivan Method: A Practical Guide. 3rd Edition. *EHEMU Technical Report 3rd Edition*.

Jasso, G., Massey, D. S., Rosenzweig, M. R., & et al. (2004). Immigrant Health – Selectivity and Acculturation. *Labor and Demography 0412002. Economics Working Paper*.

Jdanov, D. A., Scholz, R. D., & Shkolnikov, V. (2005). Official population statistics and the Human Mortality Database estimates of populations aged 80+ in Germany and nine other European countries. *Demographic Research, 13*, 335–362.

Jöckel, K.-H. (1989). Cardiovascular Mortality in the Federal Republic of Germany, 1970-79, and the Evaluation of the German Cardiovascular Prevention Study: Results from a Geographic Mortality Study. *Sozial- und Präventivmedizin, 34*(1), 4–9.

Kahn, J. R., & Pearlin, L. I. (2006). Financial Strain over the Life Course and Health among Older Adults. *Journal of Health and Social Behavior, 47*, 17–31.

Kamke, K. (1998). The German health care system and health care reform. *Health Policy, 43*(2), 171–194.

Karlsen, S., Nazroo, J. Y., & Stephenson, R. (2002). Ethnicity, environment and health: putting ethnic inequalities in health in their place. *Social Science & Medicine, 55*(9), 1647–1661.

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of illness in the aged. The index of adl: A standardized measure of biological and psychosocial function. *Journal of the American Medical Association, 185*(12), 914–919.

Kawachi, I., & Berkman, L. F. (Eds.) (2003). *Neighborhoods and Health.* Oxford, New York: Oxford University Press.

Kelly, S., Hertzman, C., & Daniels, M. (1997). Searching For The Biological Pathways Between Stress And Health. *Annu. Rev. Public. Health. (Annual Review of Public Health), 18*(1), 437–462.

Kemptner, D., Wildner, M., Abu-Omar, K., Caselmann, W., Kerscher, G., Reitmeir, P., et al. (2008). Regionale Unterschiede des Gesundheitsverhaltens in Bayern - Mehrebenenana-

lyse einer bevölkerungsrepräsentativen Befragung in Verbindung mit sozioökonomischen Strukturdaten. *Gesundheitswesen, 70*(1), 28–37.

Kentenich, H., Reeg, P., & Wehkamp, K. H. (1984). *Zwischen zwei Kulturen, was macht Ausländer krank?* Berlin: Verlagsgesellschaft Gesundheit mbH.

Kern, K. D., & Braun, W. (1987). Sterblichkeit an ausgewählten Todesursachen im regionalen Vergleich. *Wirtschaft und Statistik, 4*, 319–325.

Kibele, E. (2008). *Explaining small-area mortality variation among pensioners in Germany: The effect of individual characteristics and context. 2nd HMD Symposium, June 13-14, 2008 at the Max Planck Institute for Demographic Research.*

Kibele, E., & Janssen, F. (2013). Distortion of regional old-age mortality due to late-life migration in the Netherlands? *Demographic research, 29*(5), 105–132, from http://www.demographic-research.org/volumes/vol29/5/29-5.pdf.

Kibele, E. U. B., Klusener, S., & Scholz, R. D. (2015). Regional Mortality Disparities in Germany: Long-Term Dynamics and Possible Determinants. *Kolner Zeitschrift fur Soziologie und Sozialpsychologie, 67*(Suppl 1), 241–270.

Kibele, E. U. B. (2012). *Regional Mortality Differences in Germany.* Dordrecht: Springer Science+Business Media.

Kintner, H. J. (1987). The impact of breastfeeding patterns on regional differences in infant mortality in Germany, 1910. *European Journal of Population, 3*, 233–261.

Klein, T., & Unger, R. (2002). Aktive Lebenserwartung in Deutschland und in den USA. *Zeitschrift für Gerontologie und Geriatrie, 35*(6), 528–539.

Kliewer, E. V. (1992). Epidemiology of diseases among migrants. *International Migration*, 141–164.

Klüsener, S., Devos, I., Ekamper, P., Gregory, I. N., Gruber, S., Martí-Henneberg, J., et al. (2014). Spatial inequalities in infant survival at an early stage of the longevity revolution: A pan-European view across 5000+ regions and localities in 1910. *Demographic research, 30*, 1849–1864.

Klüsener, S., & Scholz, R. D. (2013). Regional hot spots of exceptional longevity in Germany. *Vienna Yearbook of Population Research, 11*, 137–163.

Klüsener, S., & Zagheni, E. (2014). The East-West gradient in spatial population development within Germany: Temporary GDR legacy versus longstanding spatial disparities. *Historical Methods, 47*, 167–179.

Kohlhuber, M., Mielck, A., Weiland, S. K., & Bolte, G. (2006). Social inequality in perceived environmental exposures in relation to housing conditions in Germany. *Environmental research, 101*(2), 246–255.

Kohls, M. (2008). Erfassungsfehler, Healthy-Migrant-Effect und andere Schwierigkeiten bei der Analyse der Mortalität von Migranten – Eine Bestandsaufnahme. *Nürnberg: Federal Office for Migration and Refugees.*

Kohls, M. (2010). Selection, Social Status or Data Artefact - What Determines the Mortality of Migrants in Germany? In T. Salzmann, B. Edmonston, & J. Raymer (Eds.), *Demographic Aspects of Migration* (pp. 153–177). Wiesbaden: VS Verlag für Sozialwissenschaften.

Kopetsch, T. (2004). Ärztemangel in Deutschland und Mecklenburg-Vorpommern. *Ärzteblatt Mecklenburg-Vorpommern, 14*(2), 41–44.

Kornischka, J. (1992). *Psychische und soziale Probleme von Spätaussiedlern. Reihe Psychologie: Vol. 27.* Pfaffenweiler: Centaurus-Verl.-Ges.

Kosubek, S. (1998). *Asylbewerber und Aussiedler: Rechte, Leistungen, Hilfen ; Handbuch für Helfer. Beltz Edition Sozial.* Weinheim: Beltz.

Kramer, M. (1980). The rising pandemic of mental disorders and associated chronic diseases and disabilities. *Acta Psychiatrica Scandinavica, 62*(S285), 282–297, from http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0447.1980.tb07714.x/abstract.

Krause, N. (1993). Neighborhood deterioration and social isolation in later life. *International journal of aging & human development, 36*(1), 9–38.

Krieger, N. (2001). Theories for social epidemiology in the 21st century: An ecosocial perspective. *International journal of epidemiology, 30*, 668–677.

Krieger, N. (2008). Proximal, Distal, and the Politics of Causation: What's Level Got to Do With It? *American Journal of Public Health, 98*(2), 221–230.

Kroll, L. E., & Lampert, T. (2012). Regionalisierung von Gesundheitsindikatoren. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 55*(1), 129–140.

Kroll, L. E., Lampert, T., Lange, C., & Ziese, T. (2008). *Entwicklung und Einflussgrößen der gesunden Lebenserwartung. Veröffentlichungsreihe der Forschungsgruppe Public Health: 2008-306.* Berlin: WZB.

Kuhn, J., Zirngibl, A., Wildner, M., Caselmann, W. H., & Kerscher, G. (2006). Regionale Sterblichkeitsunterschiede in Bayern. *Das Gesundheitswesen, 68*(8/9), 551–556.

Kuhrs, E., Winkler, V., & Becher, H. (2012). Risk factors for cardiovascular and cerebrovascular diseases among ethnic Germans from the former Soviet Union: results of a nested case-control study. *BMC public health, 12*, 190.

Kyobutungi, C., Ronellenfitsch, U., Razum, O., & Becher, H. (2006). Mortality from cancer among ethnic German immigrants from the Former Soviet Union, in Germany. *Eur J Cancer, 42*, 2577–2584.

Lämmle, L., Woll, A., Mensink, G. B. M., & Bös, K. (2013). Distal and proximal factors of health behaviors and their associations with health in children and adolescents. *International journal of environmental research and public health, 10*(7), 2944–2978.

Lange, D., Wahrendorf, M., Siegrist, J., Plachta-Danielzik, S., Landsberg, B., & Muller, M. J. (2011). Associations between neighbourhood characteristics, body mass index and health-related behaviours of adolescents in the Kiel Obesity Prevention Study: a multilevel analysis. *European Journal of Clinical Nutrition, 65*(6), 711–719.

Larsen, K., & Merlo, J. (2005). Appropriate assessment of neighborhood effects on individual health: Integrating random and fixed effects in multilevel logistic regression. *American journal of epidemiology*, 81–88.

Latzitis, N., Sundmacher, L., & Busse, R. (2011). Regionale Unterschiede der Lebenserwartung in Deutschland auf Ebene der Kreise und kreisfreien Städte und deren möglichen Determinanten. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)), 73*(4), 217–228.

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist, 9*(3), 179–186.

Lawton, M. P., Kleban, M. H., & Carlson, D. A. (1973). The inner-city resident: To move or not to move. *The Gerontologist, 13*(4), 443–448.

Lawton, M. P., Nahemow, L., & Tsong-Min-Yeh (1980). Neighborhood environment and the wellbeing of older tenants in planned housing. *International journal of aging & human development, 11*(3), 211–227.

Lawton, M. P., Patnaik, B., & Kleban, M. H. (1976). The ecology of adaptation to a new environment. *The International Journal of Aging and Human Development, 7*(1).

Lawton, M. P. (1974). Social ecology and the health of older people. *American Journal of Public Health, 64*(3), 257–260.

Lawton, M. P. (1983). Environment and other determinants of weil-being in older people. *The Gerontologist, 23.4*, 349–357.

Lawton, M. P. (1990). Residential environment and self-directedness among older people. *American Psychologist, 45*(5), 638.

Lawton, M. P., & Nahemow, L. (1973). Ecology and the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), *The psychology of adult development and aging* (pp. 619–674). Washington: American Psychological Association.

Lawton, M. P. (1980). Housing the elderly: Residential quality and residential satisfaction. *Research on Aging, 2.3*, 309–328.

Lawton, P., & Simon, M. A. (1968). The ecology of social relationship in housing for the elderly. *Gerontologist, 8*, 108–115.

Lazarsfeld, P. F., & Menzel, H. (1971). On the relation between individual and collective properties. In A. Etzioni (Ed.), *A sociological reader on complex organizations* (pp. 499–516). New York: Holt, Rinehart, and Winston.

Lechner, I., & Mielck, A. (1998). Die Verkleinerung des Healthy Migrant Effects: Entwicklung der Morbidität von ausländischen und deutschen Befragten im SOEP 1984 bis 1992. *Gesundheitswesen, 60*, 715–720.

Lee, E. S. (1966). A Theory of Migration. *Demography, 3*, 47–57.

Lhachimi, S. K. (2008). *Spatial modeling of all-cause mortality.* Master's thesis, Humboldt-University Berlin; Institute for Statistics and Econometrics, School of Business and Economics.

Lorant, V., van Oyen, H., & Thomas, I. (2008). Contextual factors and immigrants' health status: Double jeopardy. *Health & place, 14*(4), 678–692.

Lukaschek, K., Kruse, J., Emeny, R. T., Lacruz, M. E., Eisenhart Rothe, A. von, & Ladwig, K.-H. (2013). Lifetime traumatic experiences and their impact on PTSD: a general population study. *Social psychiatry and psychiatric epidemiology, 48*(4), 525–532.

Lüschen, G., Niemann, S., & Apelt, P. (1997). The Integration of Two Health Systems: Social Stratication, Work and Health in East and West Germany. *Social Science & Medicine, 44*(6), 883–899.

Luy, M. (2004). Verschiedene Aspekte der Sterblichkeitsentwicklung in Deutschland von 1950-2000. *Zeitschrift für Bevölkerungswissenschaft, 29*(1), 3–62.

Luy, M., & Caselli, G. (2007). The impact of a migration-caused selection effect on regional mortality differences in Italy and Germany. *Genus, 63*(1-2), 33–64.

Lynch, J. W., Smith, G. D., Kaplan, G. A., & House, J. S. (2000). Income inequality and mortality: Importance to health of individual income, psychosocial environment, or material conditions. *BMJ, 320*(7243), 1200–1204.

Lynch, S. M. (2003). Cohort and life-course patterns in the relationship between education and health: A hierarchical approach. *Demography, 40*(2), 309–331.

Macintyre, S., & Ellaway, A. (2003). Neighborhoods and Health: An Overview. In I. Kawachi & L. F. Berkman (Eds.), *Neighborhoods and Health* (pp. 20–42). Oxford, New York: Oxford University Press.

Macintyre, S., Maciver, S., & Sooman, A. (1993). Area, Class and Health: Should we be Focusing on Places or People? *Journal of Social Policy, 22*(02), 213.

Maier, W., Fairburn, J., & Mielck, A. (2012). Regionale Deprivation und Mortalität in Bayern. Entwicklung eines 'Index Multipler Deprivation' auf Gemeindeebene. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)), 74*(7), 416–425.

Manton, K. G. (1982). Changing concepts of morbidity and mortality in the elderly population. *Health and Society, 60*(2), 183–244.

Manton, K. G., Corder, L., & Stallard, E. (1997). Chronic disability trends in elderly United States populations: 1982-1994. *Proceedings of the National Academy of Science, 94*(6), 2593–2598.

Markides, K. S., & Coreil, J. (1986). The health of Hispanics in the southwestern United States: An epidemiologic paradox. *Public Health Reports, 101*(3), 253–265.

Marmot, M., Allen, J., & Goldblatt, P. (2010). A social movement, based on evidence, to reduce inequalities in health. *Social Science & Medicine, 71*, 1254–1258.

Marmot, M., Ryff, C. D., Bumpass, L. L., Shipley, M., & Marks, N. F. (1997). Social inequalities in health: Next questions and converging evidence. *Social Science & Medicine, 44*(6), 901–910.

Marmot, M., & Wilkinson, R. G. (Eds.) (1999). *Social determinants of health.* Oxford: Oxford University Press.

Marmot, M. G. (1994). Social Differentials in Health within and between Populations. *Daedalus, 123*(4), 197–216.

Maslow, A. (1968). *Toward a psychology of being.* New York: Van Nostrand.

Massey, D. S., White, M. J., & Phua, V.-C. (1996). The Dimensions of Segregation Revisited. *Sociological Methods & Research, 25*(2), 172–206.

Mathers, C. D., Sadana, R., Salomon, J. A., Murray, C. J. L., & Lopez, A. D. (2001). Healthy life expectancy in 191 countries, 1999. *The Lancet, 357*(9269), 1685–1691.

McMichael, A. J. (1976). Standardized mortality ratios and the healthy worker effect: scratching beneath the surface. *Journal of Occupational Medicine, 18*, 165–168.

Mielck, A. (2005). *Soziale Ungleichheit und Gesundheit: Einführung in die aktuelle Diskussion.* Bern, Göttingen, Toronto, Seattle: Hans Huber.

Montez, J. K., Hayward, M. D., Brown, D. C., & Hummer, R. A. (2009). Why is the educational gradient of mortality steeper for men? *The journals of gerontology. Series B, Psychological sciences and social sciences, 64*(5), 625–634.

Morgenstern, H. (1995). Ecologic studies in epidemiology: concepts, principles, and methods. *Annu Rev Public Health, 16*, 61–81.

Müller, G., Kluttig, A., Greiser, K. H., Moebus, S., Slomiany, U., Schipf, S., et al. (2013). Regional and neighborhood disparities in the odds of type 2 diabetes: Results from 5 population-based studies in Germany (DIAB-CORE consortium). *American journal of epidemiology, 178*(2), 221–230.

Murray, E. T., Mishra, G. D., Kuh, D., Guralnik, J., Black, S., & Hardy, R. (2011). Life course models of socioeconomic position and cardiovascular risk factors: 1946 birth cohort. *Annals of Epidemiology, 21*(8), 589–597.

Muszyńska, M. M., & Rau, R. (2012). The Old-Age Healthy Dependency Ratio in Europe. *Journal of Population Ageing, 5*(3), 151–162.

Neubauer, G. (1988). Regionale Sterblichkeitsunterschiede in Bayern. Eine empirische Untersuchung der sozioökonomischen und ökologischen Ursachen. *Schriften zur Gesundheits□okonomie, 3*.

Neubauer, G. (1990). Regionale Sterblichkeitsunterschiede und deren mögliche Ursachen. *Bevölkerung und Wirtschaft*, 325–335.

Nolte, E., Koupilova, I., & McKee, M. (2001). Temporal and spatial pattern of infant mortality in Germany after unification. *Soz Praventivmed, 46*(5), 303–310.

Nolte, E., & McKee, M. (2000). Ten years of German unication. *British Medical Journal, 321*(7269), 1094–1095.

Nolte, E., Shkolnikov, V., & McKee, M. (2000). Changing mortality patterns in East and West Germany and Poland. II: Short-term trends during transition and in the 1990s. *Journal of epidemiology and community health, 54*(12), 899–906.

Nowossadek, E. (1994). Sterblichkeitsentwicklung. In K. Freitag, S. Grundmann, E. Nowossadek, S. Mennig, R. Münz, A. Schied, et al. (Eds.), *Regionale Bevölkerungsentwicklung in den neuen Bundesländern. Analysen, Prognosen und Szenarien* (pp. 63–79). Berlin: GSFP.

Noymer, A. (2001). Mortality selection and sample selection: a comment on Beckett. *J Health Soc Behav, 42*(3), 326–327.

Nusselder, W., & Looman, C. W. (2004). Decomposition of differences in health expectancy by cause. *Demography, 41*(2), 315–334.

OECD (2016). *OECD database - Section Health,* from https://data.oecd.org/health.htm.

Omran, A. R. (1971). The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. *The Milbank Memorial Fund Quarterly, 49*(4), 509–538.

Palloni, A., & Arias, E. (2004). Paradox lost: explaining the Hispanic adult mortality advantage. *Demography, 41*, 385–415.

Pattloch, D. (2010). *Pflegebedürftigkeitsfreie Lebenserwartung in Deutschland. Ein Beitrag zur Debatte um die Kompression von Morbidität. Doctor Thesis.* University of Bielefeld.

Peters, A., Skorkovsky, J., Kotesovec, F., Brynda, J., Spix, C., Wichmann, H. E., & Heinrich, J. (2000). Associations between mortality and air pollution in central Europe. *Environmental Health Perspectives, 108*(4), 283–287.

Pfaff, H. (2010). People in Need of Long-term Care: The Present and the Future. In G. Doblhammer & R. D. Scholz (Eds.), *Ageing, Care Need and Quality of Life. The Perspectives of Care Givers and People in Need of Care* (pp. 14–28). Wiesbaden: Springer VS Research.

Pickett, K. E., & Pearl, M. (2001). Multilevel analyses of neighbourhood socioeconomic context and health outcomes: A critical review. *Journal of epidemiology and community health, 55*, 111–122.

Pinheiro, P., & Krämer, A. (2009). Calculation of health expectancies with administrative data for North Rhine-Westphalia, a Federal State of Germany, 1999–2005. *Population health metrics, 7*(1), 509.

Pollack, C. E. (2004). Housing and health in Germany. *Journal of Epidemiology & Community Health, 58*(3), 216–222.

Pollack, C. E., dem Knesebeck, O. von, & Siegrist, J. (2004). Housing and Health in Germany. *Journal of Epidemiology and Community Health (1979-), 58*(3), 216–222.

Pollack, C. E., & dem Knesebeck, O. von (2004). Social capital and health among the aged: Comparisons between the United States and Germany. *Health & place, 10*(4), 383–391.

Porter, M. E., & Guth, C. (2012). *Redefining German Health Care.* Berlin, Heidelberg: Springer Berlin Heidelberg.

Pudrovska, T., & Anikputa, B. (2014). Early-life socioeconomic status and mortality in later life: An integration of four life-course mechanisms. *The journals of gerontology. Series B, Psychological sciences and social sciences, 69*(3), 451–460.

Queste, A. (2007). *Analyse kleinräumiger Mortalitätsraten in Deutschland. Wissenschaftliche Reihe / Lögd: Vol. 22.* Bielefeld: lögd.

Rabe-Hesketh, S., & Skrondal, A. (2005). *Multilevel and longitudinal modeling using Stata.* College Station, Tex.: Stata Press.

Ravenstein, E. G. (1885). The laws of migration. *Journal of the Royal Statistical Society, 48*, 167–227.

Razum, O. (2006). Migration, Mortalität und der Healthy-Migrant-Effekt. In M. Richter & K. Hurrelmann (Eds.), *Gesundheitliche Ungleichheit - Grundlagen, Probleme, Perspektiven* (pp. 255–270). Wiesbaden: VS Verlag für Sozialwissenschaften.

Razum, O., Altenhöner, T., Breckenkamp, J., & Voigtländer, S. (2008). Social epidemiology after the German reunification: East vs. West or poor vs. rich? *International journal of public health, 53*(1), 13–22.

Razum, O., & Rohrmann, S. (2002). Der Healthy-migrant-Effekt: Bedeutung von Auswahlprozessen bei der Migration und Late-entry-bias. *Gesundheitswesen, 64*, 82–88.

Razum, O., & Twardella, D. (2002). Time travel with Oliver Twist – Towards an explanation for a paradoxically low mortality among recent immigrants. *Tropical Medicine and International Health, 7*(1), 4–10.

Razum, O., Zeeb, H., Seval-Akgün, H., & et al. (1998). Low overall mortality of Turkish residents in Germany persists and extends into a second generation: merely a healthy migrant effect. *Tropical Medicine and International Health, 3*(4), 297–303.

Razum, O., Geiger, I., Zeeb, H., & Ronellenfitsch, U. (2004). Gesundheitsversorgung von Migranten. *Dtsch Arztebl, 101*(43), 43.

Razum, O., & Voigtländer, S. (2009). Regionale Ungleichverteilung von Gesundheit und ihre Determinanten. *Sozialer Fortschritt, 58*(2-3), 36–43.

Reiss, K., Spallek, J., & Razum, O. (2010). 'Imported risk' or 'health transition'? Smoking prevalence among ethnic German immigrants from the Former Soviet Union by duration of stay in Germany - analysis of microcensus data. *International journal for equity in health, 9*, 15.

Reiss, K., Berger, U., Winkler, V., Voigtländer, S., Becher, H., & Razum, O. (2013). Assessing the effect of regional deprivation on mortality avoiding compositional bias: A natural experiment. *Journal of Epidemiology & Community Health, 67*(3), 213–218, from http://jech.bmj.com/content/67/3/213.

Reiss, K., Schunck, R., & Razum, O. (2015). Effect of Length of Stay on Smoking among Turkish and Eastern European Immigrants in Germany--Interpretation in the Light of the Smoking Epidemic Model and the Acculturation Theory. *International journal of environmental research and public health, 12*(12), 15925–15936.

Riva, M., Gauvin, L., & Barnett, T. A. (2007). Toward the next generation of research into small area effects on health: A synthesis of multilevel investigations published since July 1998. *Journal of epidemiology and community health, 61*, 853–861.

Robert-Koch-Institut (RKI) (2008). *Schwerpunktbericht: Migration und Gesundheit.* Berlin: Robert- Koch-Institut.

Robine, J.-M., Saito, Y., & Jagger, C. (2009). The relationship between longevity and healthy life expectancy. *Quality in Ageing, 10*(2), 5–14.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, A. S., Lambin, E. F., & et al. (2009). A safe operating space for humanity. *Nature, 461*, 472–475.

Ronellenfitsch, U., Kyobutungi, C., Becher, H., & Razum, O. (2006). All-cause and cardiovascular mortality among ethnic German immigrants from the Former Soviet Union: A cohort study. *BMC public health, 6*, 16.

Ronellenfitsch, U., & Razum, O. (2004). Deteriorating health satisfaction among immigrants from Eastern Europe to Germany. *International journal for equity in health, 3*(4).

Schenk, L. (2002). Migrantenspezifische Teilnahmebarrieren und Zugangsmöglichkeiten im Kinder- und Jugendgesundheitssurvey. *Gesundheitswesen, 64*(S1), 59–68.

Schenk, L. (2007). Migration und Gesundheit-Entwicklung eines Erklärungs- und Analysemodells für epidemiologische Studien. *International journal of public health, 52*(2), 87–96.

Schimany, P. (2003). *Die Alterung der Gesellschaft – Ursachen und Folgen des demographischen Umbruchs.* Frankfurt: Campus.

Schneider, L. (2005). Ost-West-Binnenwanderung: Gravierender Verlust an Humankapital. *Wirtschaft und Wandel, 11*(10), 309–314.

Scholz, R., & Maier, H. (2003). German unication and the plasticity of mortality at older ages. *MPIDR Working Paper WP 2003 031*.

Schwierz, C., & Wübker, A. (2010). Determinants of avoidable deaths from ischemic heart disease in East and West Germany. *Journal of Public Health, 18*(4), 309–317.

Sen, A. (1985). *Commodities and capabilities. Professor Dr. P. Hennipman lectures in economics: Vol. 7.* Amsterdam, New York, New York N.Y. U.S.A.: North-Holland; Sole distributors for the U.S.A. and Canada Elsevier Science Pub. Co.

Sen, A. (1999). *Development as freedom. A Borzoi book.* New York: Knopf.

Settertobulte, W. (2005). Gesundheitliche Lage und Risikoverhalten bei Jugendlichen aus Migrantenfamilien. In P. Marschalck & K. H. Wiedl (Eds.), *Migration und Krankheit* (pp. 171–188). Göttingen: VR unipress.

Siegrist, J. (2000). Place, social exchange and health: Proposed sociological framework. *Soc Sci Med, 51*(9), 1283–1293.

Simon, M. (2005). *Das Gesundheitssystem in Deutschland. Eine Einf□uhrung in Struktur und Funktionsweise.* Bern, Göttingen, Toronto, Seattle: Verlag Hans Huber.

Singh-Manoux, A., Ferrie, J. E., Chandola, T., & Marmot, M. (2004). Socioeconomic trajectories across the life course and health outcomes in midlife: Evidence for the accumulation hypothesis? *International journal of epidemiology, 33*(5), 1072–1079.

Smith, G. D. (1996). Income inequality and mortality: Why are they related? *BMJ, 312*, 987–988.

Snijders, T. A. B., & Bosker, R. J. (2004). *Multilevel analysis: An introduction to basic and advanced multilevel modeling* (Repr). London: SAGE Publications.

Spring, B., Moller, A. C., & Coons, M. J. (2012). Multiple health behaviours: Overview and implications. *Journal of Public Health, 34*(S1), i3-i10.

Statistical offices of the Federation and the Länder (2012). *Pflegestatistik: Pflege im Rahmen der Pflegeversicherung: Kreisvergleich* (Januar 2012). Bonn: Statistisches Bundesamt.

Strohmeier, K. P., Schultz, A., Bardehle, D., Annuss, R., & Lenz, A. (2007). Sozialräumliche Clusteranalyse der Kreise und kreisfreien Städte und Gesundheitsindikatoren in NRW. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)), 69*(1), 26–33.

Subramanian, S. V., Duncan, C., & Jones, K. (2001). Multilevel Perspectives on Modeling Census Data. *Environment and Planning A, 33*(3), 399–417.

Subramanian, S. V., Jones, K., & Duncan, C. (2003). Multilevel Methods for Public Health Research. In I. Kawachi & L. F. Berkman (Eds.), *Neighborhoods and Health* (pp. 65–111). Oxford University Press.

Sullivan, D. F. (1971). A Single Index of Mortality and Morbidity. *HSMHA Health Reports, 86*(4), 347–354.

Sundmacher, L., Scheller-Kreinsen, D., & Busse, R. (2011). The wider determinants of inequalities in health: A decomposition analysis. *International journal for equity in health, 10*, 30.

Swami, B. (2002). The German Health Care System. In. In K. V. Thai, E. T. Wimberley, & S. M. McManus (Eds.), *Handbook of International Health Care Systems* (pp. 333–358). New York, Basel: Marcel Dekker, Inc.

Thompson, S. G., & Sharp, S. J. (1999). Explaining heterogeneity in meta-analysis: A comparison of methods. *Statistics in Medicine, 18*(20), 2693–2708.

Tong, S. (2000). Migration bias in ecologic studies. *European Journal of Epidemiology, 16*(4), 365–369.

Trachte, F., Sperlich, S., & Geyer, S. (2015). Kompression oder Expansion der Morbidität? *Zeitschrift für Gerontologie und Geriatrie, 48*(3), 255–262.

Turra, C. M., Elo, I. T., Kestenbaum, B., & et al. (2005). Is there a salmon bias effect? Mortality differentials by place of residence among primary social security beneficiaries in the United States. *Working Paper*.

Unger, R., Müller, R., & Rothgang, H. (2011). Lebenserwartung in und ohne Pflegebedürftigkeit. Ausmaß und Entwicklungstendenzen in Deutschland. *Gesundheitswesen, 73*(05), 292–297.

Unger, R., & Schulze, A. (2013). Können wir (alle) überhaupt länger arbeiten? Trends in der gesunden Lebenserwartung nach Sozialschicht in Deutschland. *Zeitschrift für Bevölkerungswissenschaft, 38*, 545–564.

Unger, R. (2006). Trends in active life expectancy in Germany between 1984 and 2003—a cohort analysis with different health indicators. *Journal of Public Health, 14*(3), 155–163.

Unger, R. (2010). Cohort trends in disability and future care need in Germany. *Ageing, care need and quality of life*, 82–93.

Vaupel, J. W., Carey, J. R., & Christensen, K. (2003). It's Never Too Late. *Science, 301*(5640), 1679–1680.

Verbrugge, L., & Jette, A. M. (1994). The disablement process. *Social Science & Medicine, 38*(1), 1–14.

Vogt, T. C., & Kluge, F. A. (2015). Can public spending reduce mortality disparities? Findings from East Germany after reunification. *The Journal of the Economics of Ageing, 5*, 7–13.

Vogt, T. C., & Vaupel, J. W. (2015). The importance of regional availability of health care for old age survival - Findings from German reunification. *Population health metrics, 13*, 26.

Voigtländer, S., Berger, U., & Razum, O. (2010a). Zunehmende regionale Unterschiede bei den Lebensverhältnissen in Deutschland und ihre Bedeutung für die Erklärung gesundheitlicher Ungleichheit. *Gesundheitswesen, 72*(05), 301–308.

Voigtländer, S., Berger, U., & Razum, O. (2010b). The impact of regional and neighbourhood deprivation on physical health in Germany: A multilevel study. *BMC public health, 10*(1), 111.

Voigtländer, S., Berg-Beckhoff, G., & Razum, O. (2008). *Gesundheitliche Ungleichheit: Der Beitrag kontextueller Merkmale. Challenges in public health: Vol. 55.* Frankfurt am Main: Lang.

Wamala, S. P. (2001). Women's exposure to early and later life socioeconomic disadvantage and coronary heart disease risk: The Stockholm Female Coronary Risk Study. *International journal of epidemiology, 30*(2), 275–284.

Ware, J. E. (1987). Standards for validating health measures: Definition and content. *Journal of Chronic Diseases, 40*(6), 473–480.

Watson, P. (1995). Explaining rising mortality among men in Eastern Europe. *Social Science & Medicine, 41*(7), 923–934.

Weber, I., Abel, M., Altenhofen, L., & et al. (1990). Zur gesundheitlichen Lage der ausländischen Bevölkerung in der Bundesrepublik Deutschland: Erste Erkenntnisse. In Projektgruppe Prioritäre Gesundheitsziele (Ed.), *Dringliche Gesundheitsprobleme der Bevölkerung in der Bundesrepublik Deutschland* (pp. 577–601). Baden-Baden: Nomos.

Wellman, B., & Leighton, B. (1979). Networks, Neighborhoods, and Communities: Approaches to the Study of the Community Question. *Urban Affairs Review, 14*(3), 363–390.

White, K. (2002). *An introduction to the sociology of health and illness* (Online-Ausg). London: SAGE.

Whitehead, M., & Dahlgren, G. (2006). *Levelling up, Part 1: Concepts and principles for tackling social inequalities in health.* Copenhagen: World Health Organisation.

WHO (1946). WHO definition of Health, Preamble to the Constitution of the World Health Organization.

WHO/Europe health statistics (2016). *Europe health statistics,* from http://www.euro.who.int/en/data-and-evidence/databases.

Wilkinson, R. G. (1992). Income distribution and life expectancy. *BMJ : British Medical Journal, 304*(6820), 165–168.

Wilkinson, R. G. (1998). *Unhealthy Societies: The Afflictions of Inequality.* London: Routledge.

Williams, R. (1993). Health and length of residence among South Asians in Glasgow: a study controlling for age. *Journal of Public Health Medicine, 15*, 52–60.

Wilson, W. J. (1996). When Work Disappears. *Political Science Quarterly, 111*(4), 567.

Winkler, V. (2008). *Specific aspects of the health profile of German migrants from the Former Soviet Union.* PhD Thesis, Institute of Public Health, University of Heidelberg.

Winkler, V., Holleczek, B., Stegmaier, C., & Becher, H. (2012). Prostate cancer in Germany among migrants from the Former Soviet Union. *Global health action, 5*, 9135.

Winkler, V., Holleczek, B., Stegmaier, C., & Becher, H. (2014). Cancer incidence in ethnic German migrants from the Former Soviet Union in comparison to the host population. *Cancer epidemiology, 38*(1), 22–27.

Wittig, U., Merbach, M., Siefen, R., & Brähler, E. (2004). Beschwerden und Inanspruchnahme des Gesundheitswesens von Spätaussiedlern bei Einreise nach Deutschland. *Gesundheitswesen, 66*(2), 85–92.

Wolf, C. (2004). Wohnquartier und Gesundheit: Eine Mehrebenenanalyse. In R. Kecskes, M. Wagner, & C. Wolf (Eds.), *Angewandte Soziologie* (pp. 103–126). Wiesbaden: VS Verlag für Sozialwissenschaften.

Woods, R. (2003). Urban-rural mortality differentials: An unresolved debate. *Population and Development Review, 29*, 29–46.

Yen, I. H., & Kaplan, G. A. (1999). Neighborhood Social Environment and Risk of Death: Multilevel Evidence from the Alameda County Study. *American journal of epidemiology, 149*, 898–907.

Yen, I. H., Michael, Y. L., & Perdue, L. (2009). Neighborhood environment in studies of health of older adults: A systematic review. *American journal of preventive medicine, 37*(5), 455–463.

Young, F. W. (2001). An explanation of the persistent doctor-mortality association. *Journal of Epidemiology & Community Health, 55*(2), 80–84, from http://jech.bmj.com/content/55/2/80.

Zajacova, A., & Burgard, S. A. (2013). Healthier, Wealthier, and Wiser: A Demonstration of Compositional Changes in Aging Cohorts Due to Selective Mortality. *Population research and policy review, 32*(3), 311–324.

Zeeb, H., Baune, B. T., Vollmer, W., Cremer, D., & Krämer, A. (2004). Gesundheitliche Lage und Gesundheitsversorgung von erwachsenen Migranten – ein Survey bei der Schuleingangsuntersuchung. *Gesundheitswesen, 66*, 76–84.

Zeeb, H., Razum, O., Blettner, M., & et al. (2002). Transition in cancer patterns among Turks residing in Germany. *European Journal of Cancer, 38*, 705–711.

Ziegler, U., & Doblhammer, G. (2008). Cohort Changes in the Incidence of Care Need in West Germany Between 1986 and 2005. *European Journal of Population / Revue européenne de Démographie, 24*(4), 347–362.

# VIII. Original publications

## 1. Study 1

# Spatial patterns in German long-term care and their relationship with socioeconomic factors

*Daniel Kreft*

## Abstract

The ongoing rise in life expectancy implies larger numbers of dependent elderly, with an increased demand for long-term assistance and care services. The severity of the limitations for the individuals, the psychosocial and financial burdens for their families, and the mounting structural and financial challenges for the welfare system suggest an urgent need to identify the risk factors of long-term care.

This study explores spatial disparities in long-term care in Germany using the health ratio which is the proportion of disability-free life years to total remaining life years. Disability is defined as receiving benefits from the German statutory long-term care insurance system. Data from the official census of all beneficiaries, the German Statutory Long-Term Care (SLTC) Census 2009, are combined with county-level life table estimates and socioeconomic indicators from the regional database of the German National Statistical Office.

The health ratios reveal pronounced spatial clusters which extended beyond the borders of federal states and are linked to the socioeconomic conditions in the respective counties. The cross-sectional perspective suggests that high life expectancy in a county goes together with a high number and large proportion of healthy years spent without disability. The positive correlations are stronger in the West German counties than in the East German counties. Results from meta-regression suggest a significant relationship between a county's health ratio and the county's socioeconomic performance, socioeconomic composition, level of urbanization, and health care structure. A high household income per capita, a low long-term unemployment rate, a high population density, and a low level of premature mortality in a county are significantly linked to a high health ratio.

This is the first study that shows the existence of spatial differentials in care need and the resulting health ratio for Germany. Even more important, the study shows that these differentials are linked to the socioeconomic structure and performance of the county, which should provide guidance in designing appropriate policy interventions.

## 1 Introduction

Healthy aging has become one of the main challenges in aging societies. The long-term decrease in mortality, which was initiated by various behavioral changes, medical improvements, and enhancements in socioeconomic conditions, has resulted in a continuous rise in the number of people who reach old and oldest ages (Christensen et al. 2009). Degenerative disorders and diseases, such as sensory disorders, neoplasms, and mental and behavioral disorders, as well as diseases of the circulatory system, the

musculoskeletal system and the nervous system, are highly concentrated in these highest age groups. Thus, the share of the aging population who are in poor health is likely to expand (Olshansky and Ault 1986). Although an increase in morbidity prevalence can be seen in all highly developed countries, the pace and extent of the changes differ between (Muszyńska and Rau 2012) and within countries (Porell and Miltiades 2002).

Because of its position as one of the forerunners of population aging (Muszyńska and Rau 2012) and because it has an extensive social welfare system (Barr 2004), Germany is an interesting context in which to investigate trends in healthy aging. Recent studies have shown that there are marked socioeconomic, demographic, and health disparities in Germany (Breckenkamp et al. 2007; Voigtländer et al. 2008; Voigtländer et al. 2010a; Voigtländer et al. 2010b; Diehl and Schneider 2011; Kroll and Lampert 2012).

This study focused on spatial patterns in disability in Germany, with disability defined as receiving benefits from the German system of Statutory Long-Term Care (SLTC) insurance (SGB 1995). The data came from the SLTC Census of the year 2009 which contained basic anonymized information on the more than two million beneficiaries in Germany in 2009. The county-specific health ratio (HR) was used as the main health outcome. The county-specific HR was defined as the proportion of the county-specific disability-free life expectancy (DFLE) to the county-specific life expectancy (LE). Thus, the relative measure HR combined two well-established measures of mortality and health with the advantage that it was independent from the absolute level of the LE.

This study had three aims. First, the spatial patterns of long-term care in Germany were identified. Second, the question was explored whether higher life expectancy was associated with improved health or with increased disability. Third, the study tried to identify the macro-level determinants of the spatial health disparities measured by the health ratio.

## 2 Background

Numerous studies have examined country-specific trends and cross-country differences based on the concept of the disability-free life expectancy, which is more generally referred to as healthy life years (Bickel 2001; Robine et al. 2003; Lievre et al. 2007; Jagger et al. 2008; Hoffmann and Nachtmann 2010; Jagger et al. 2011). One fundamental objective in health research is to investigate the association of life expectancy with disability-free life expectancy, and the association of life expectancy with disabled life years (DLY). Mathers et al. (2001) estimated the disability-free life expectancy of 191 countries based on global data from 1999. The cross-sectional study revealed a close positive correlation between the disability-free life expectancy and the corresponding life expectancy and a negative relationship of the disabled life years with life expectancy. In the case of European countries, Robine et al. (2009) also found a positive, but weaker correlation between values of the life expectancy and values of the disability-free life expectancy for the year 2006.

One obstacle with using country-specific data is that researchers are confronted with problems related to variations in health policy systems and cultural differences in defining and reporting health (Jagger et al. 2011). Using small-area data for the evaluation of the relationship between county-level life expectancy and the disability-free life expectancy within a country has substantial advantages compared to cross-country evaluations. The

problem of regional cultural differences in health perception and the intervening effects of differences in health policies and health care systems can be assumed to be small.

Despite these advantages, only a few studies have used spatial disability-free life expectancy estimates. However, these studies revealed profound sub-national health disparities, albeit with varying health definitions, in France (Robine et al. 1998), Spain (Gutiérrez-Fisac et al. 2000), Denmark (Brønnum-Hansen et al. 2003), the Netherlands (Groenewegen et al. 2003), Japan (Fukuda et al. 2005; Seko et al. 2012), China (Liu et al. 2010), Italy (Burgio et al. 2009), Belgium (van Oyen et al. 1996; Karakaya 2009), Scotland (Wood et al. 2006), England (Smith et al. 2011), and the German federal state of North Rhine-Westphalia (Pinheiro and Krämer 2009). Until now no study has examined small-area disparities in the disability-free life expectancy or in the health ratio in Germany in total.

As interest in the investigation of the effects of the living context – abbreviated as contextual effects – on health has grown in recent years, the number of empirical studies using an ecological design (Gutiérrez-Fisac et al. 2000; Groenewegen et al. 2003; Fukuda et al. 2005; van Lenthe 2006; Fantini et al. 2012) or using a multilevel design (Pickett and Pearl 2001; Kawachi and Berkman 2003; Riva et al. 2007; Yen et al. 2009) has increased rapidly. It is a long-standing practice in the study of contextual effects on health to establish a comprehensive conceptual (Diez-Roux 2003) and theoretical framework (Lawton and Nahemow 1973) to define the causal pathways between macro-level characteristics and micro-level outcomes (e.g. individual health status or aggregated health measures).

One of these frameworks is the causal model of neighborhood effects on aging by Glass and Balfour (2003). They differentiated between four factors of the living environment: "socioeconomic conditions," "social integration," "physical aspects of place," and "services and resources." These factors are directly and indirectly linked with health and functioning. In this model, socioeconomic conditions are the most influential determinants affecting, confounding, and mediating the three other dimensions. The relationship between neighborhood deprivation and poor health is well-studied (Gutiérrez-Fisac et al. 2000; Pickett and Pearl 2001; Glass and Balfour 2003; Groenewegen et al. 2003; Fukuda et al. 2005; Riva et al. 2007; Yen et al. 2009; Voigtländer et al. 2010a; Gordon 2003). Two pathways that explain the relationship of area deprivation and population's health status are discussed: On the one hand, community health is related to the socioeconomic composition of the region's population, which in turn is influenced by selective migration (Kibele and Janssen 2013). A high prevalence of morbidity in a region may be the result of a high concentration of persons with attributes related to a high risk of ill-health, e.g. higher age, lower socioeconomic status, or riskier lifestyle behaviors. On the other hand, the general context of the region's wealth and social climate affects the health situation of the individuals – and by aggregation of the regions (van Lenthe 2006).

In addition to the direct compositional and contextual effects of socioeconomic conditions, Glass and Balfour (2003) highlighted the role of built environment and (health care) services on health status. Diez-Roux and Mair (2010) gave an overview of the importance of the physical environment for various dimensions on health (e.g., physical activity, social integration, depression, and hypertension), but reported varying results for the particular health outcomes. Fukuda et al. (2005) found a negative impact of population density on health in municipalities in Japan. The greater environmental hazards and psychosocial stress in highly urbanized regions, which could have a negative impact on health, may explain these findings (Voigtländer et al. 2010a).

In contrast, Diehl and Schneider (2011) concluded that rurality is positively linked with ill health. Glass and Balfour (2003) attributed the positive effect of urbanity on health to the dimension of services and resources. Following Glass and Balfour (2003), the expectation is that rural, peripheral areas with low economic performance are at high risk of having comprehensive structural problems, e.g., in terms of the quality of the health care services and the infrastructure. In the literature, amendable mortality is a reliable indicator for measuring regional disparities in the quality of health care services, and it has a highly negative association with disability-free life expectancy (Fantini et al. 2012).

There is no prior research on the relationship of regional disability and life expectancy in terms of county-specific LE and DFLE, LE and DLY, LE and HR, and LE and the age standardized prevalence (ASP) of care need. However, based on studies on the country level, a positive correlation between LE and DFLE and a negative correlation between LE and DLY is assumed. No specific hypotheses were formulated concerning the association of the LE and the HR, or the association of the LE and the ASP.

Hypotheses about the effects of the living context were formulated based on the above literature: First, counties with good socioeconomic conditions and compositions, and those with favorable health care situations in terms of premature mortality should reveal a higher health ratio. Second, the physical environment and the urbanity may have both negative and positive effects on the health ratio, as has been demonstrated by the inconsistent results of earlier studies.

## 3 Data

This study used the most recent data from the German SLTC Census ("*Pflegestatistik*") of 2009. The SLTC Census is conducted every two years, and it is an official mandatory census of all care facilities, all mobile nursing services, and all individuals in Germany who are legally attested to be severely limited in their activities of daily living (Pfaff 2010; Hoffmann and Nachtmann 2010). For a detailed overview of the German SLTC insurance, see Grigorieva in this issue.

Over 2 million beneficiaries were extracted, who were then classified by county of residence (NUTS 3 level), sex, and age group (65-69, 70-74, 75-79, 80-84, 85+). The last interval was defined as 85+ in order to avoid having groups with too few cases, and to prevent privacy violations.

In order to calculate the age- and sex-specific prevalence of disability, information about the population at risk stratified by county of residence, sex, and age groups was required. The population at risk was defined as the average of the total population at the end of the year 2008 and at the end of the year 2009. Moreover, data on the death counts were used to make life table estimations. The information on the death counts and the population at risk, stratified by age, county, and sex, were taken from the regional database of the German National Statistical Office.

In addition, the analysis included information indicating particular dimensions of the attributes of the counties: the economic performance, the social composition, the grade of urbanization, and the health care condition. The decision to use these dimensions was inspired by the "causal model of neighborhood effects on aging" (Glass and Balfour 2003).

To measure these dimensions, four indicators were chosen:

1) the disposable income of the private households (indicating the socioeconomic conditions),
2) the long-term unemployment rate (indicating the social composition and the degree of social cohesion),
3) the population density (indicating the physical aspects of the place), and
4) the level of premature mortality at ages 1-44 (indicating the health and medical care conditions).

Table 1: Overview of computation of county-level indicators

| Group of indicator | Indicator | Year | Computation |
|---|---|---|---|
| Socioeconomic conditions and composition | Disposable income of private households per capita | 2009 | No computation needed (official indicator in the regional statistics database) |
| | Long-term unemployment rate | 2009* | Persons in unemployment lasting one year or longer divided by all persons at age 15-65 |
| Physical and health care conditions | Population density | 2009 | Total population divided by area of the county |
| | Level of premature mortality | 2009 | Number of deaths in the life table population between age 1 and 45 per 100,000 persons |

Note: * Because there are no available data for 2009 on the long-term unemployed in the city of Wiesbaden, data for 2010 are used.

The first and third macro factors are official indicators of the National Statistical Office, while the second and fourth factors are composite variables. To calculate the level of premature mortality, infant mortality was excluded and the total number of deaths (of the overall life table population) at all ages up to Germany's population mean age of about 44 years was covered.

The four covariates were categorized into quintiles, with the first category (lowest disposable income, lowest long-term unemployment rate, lowest population density, and lowest premature mortality level) used as the reference group.

## 4 Methods

First, the abridged county-, age-, and sex-specific life tables (Chiang 1984) were computed, along with the county-, age-, and sex-specific prevalence of disability.

Second, based on the Sullivan (1971) method, the prevalence and the life tables by counties were used to calculate the DFLE and the DLY at the NUTS-3 level. Additionally, age standardized prevalence (ASP) was computed for age 65+ using the county-, age-, and sex-specific prevalence and the old European standard population as the population at risk.

Third, the DFLE and the LE were used to calculate the county-, age-, and sex-specific HR, the proportion of DFLE to LE. Higher values of the HR indicate a better health situation of a population. The resulting HR was the health outcome used in the regression models shown below.

The aim of the multivariate analysis in the main part of this study was to explain the spatial variance in the health outcome HR by factors of living context. Multiple linear meta-regression models were estimated that included selected proxies for specific health-relevant characteristics of a county. A linear random effects meta-regression model is an extension of the simple OLS regression. The advantage is the option of including uncertainty in the estimation of county's HR, and of including county-level variables and analyzing residual heterogeneity (Harbord and Higgins 2008). The general formula of a random effects linear meta-regression is

$$y_i=x_i\beta+u_i+\epsilon_i, \text{ where } u_i\sim N(0,\tau^2) \text{ and } \epsilon_i\sim N\left(0,\sigma_i^2\right) \text{ (Harbord and Higgins 2008),}$$

where $y_i$ is the estimated HR of county i when $x_i$, the county-level attribute, is given. Unlike in the OLS regressions, there are two error terms ($u_i$ and $\varepsilon_i$), and the coefficients $\beta$ are estimated by the REML (residual/restricted maximum likelihood) method after weighting each observation by $1/\left(\sigma_i^2+\tau^2\right)$, where $\sigma$ is the standard error of the estimated spatial HR and $\tau^2$ is the between-county variance (Thompson and Sharp 1999; Harbord and Higgins 2008).

The standard errors $\sigma$ of the HR are calculated based on the assumption that the DLFE is a random variable (Jagger et al. 2007), and that the LE is a scalar variable.[1] To meet this assumption and to lessen the impact of short-term random fluctuations in the LE, small-area life expectancies were calculated by using pooled data on the death counts and the population at risk from the last five available years (2006-2010).

Sex-specific and region-specific (East German counties vs. West German counties) models for the HR (65+) were estimated and results for the age group 65+ were presented. All of the estimates were performed using STATA 12.1 and the "metareg" routine (Harbord and Higgins 2008).

## 5 Results

In 2009, 2,338,252 persons received benefits from SLTC insurance in Germany. The median age of the recipients was 76.2 years, and 55% were 75 to 84 years old. One-third were males (median age 70.6) and 67% were females (median age 78.3).

[1] $\sigma(HR_x)=\sqrt{1/LE_x^2\cdot Var(DFLE_x)}$

Table 2: Median life expectancy (LE), median disability-free life expectancy (DFLE), median health ratio (HR), and selected statistical measures of dispersion of the HR for males and females in 2009 based on 412 counties (not weighted by population size)

| Age | Median LE (years) | Median DFLE (years) | Median HR (%) | Q1(HR) (%) | Q3(HR) (%) | Min (HR) (%) | Max (HR) (%) | N |
|---|---|---|---|---|---|---|---|---|
| Males | | | | | | | | |
| 65+ | 17.47 | 15.69 | 89.58 | 88.40 | 90.74 | 81.83 | 93.64 | 412 |
| 75+ | 10.78 | 8.86 | 82.14 | 79.86 | 84.38 | 67.77 | 88.70 | 412 |
| 85+ | 6.16 | 4.16 | 67.98 | 62.70 | 72.11 | 40.68 | 80.81 | 412 |
| Females | | | | | | | | |
| 65+ | 20.66 | 17.20 | 83.77 | 81.57 | 85.53 | 72.19 | 89.72 | 412 |
| 75+ | 12.56 | 9.09 | 72.73 | 69.18 | 75.82 | 53.52 | 82.71 | 412 |
| 85+ | 6.50 | 3.23 | 49.42 | 43.66 | 54.84 | 24.81 | 66.25 | 412 |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; author's calculations

Table 2 shows the sex-specific age profiles in the unweighted[2] median HR for the 412 counties and for selected ages. At all ages the HR was lower for females than for males. At age 65 it was 83.8% (IQR: 3.96PP) for females and 89.6% (IQR: 2.34PP) for males, which implies that slightly more than 80 percent of the remaining LE of a woman and almost 90 percent of a man will be without disability. The HR decreased with increasing age, and at age 85 the HR was 49.4% (IQR: 11.18PP) for females and 68.0% (IQR: 9.41PP) for males.[3]

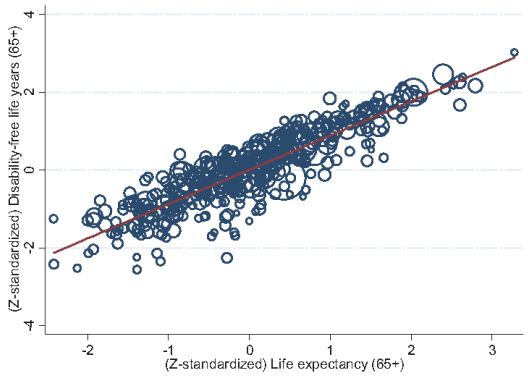
### *5.1 The county-level relationship between life expectancy and disability*

In absolute terms, the elderly in counties with high life expectancy had a higher number of years without disability (DFLE) and lived fewer or an equal number of years with disability (DLY). There was a significant and positive linear relationship between LE and DFLE ($\beta$[4]=0.88, $p<0.001$) which was higher in the 325 West German counties ($\beta$=0.89, $p<0.001$) than in the 87 East German counties ($\beta$=0.77, $p<0.001$) (Figure 1a). In contrast, there was a weak negative correlation between DLY and LE in the West German counties ($\beta$=-0.24, $p<0.001$), and there was no linear relationship between the two indicators in the East German counties ($\beta$=0.02, $p=0.849$) (Figure 1b). Both the weak correlation in the West and the missing correlation in the East were the results of the high number of counties with an average LE but a high DLY (circles in the top center).

2 The median HR is not weighted by the county's population size, which is why it slightly differs from the total HR of Germany (females at age 65: 83.6%; males at age 65: 89.6%).
3 IQR = Interquartile range (third quartile Q3 minus first quartile Q1).
4 $\beta$ = Coefficient in the meta-regression

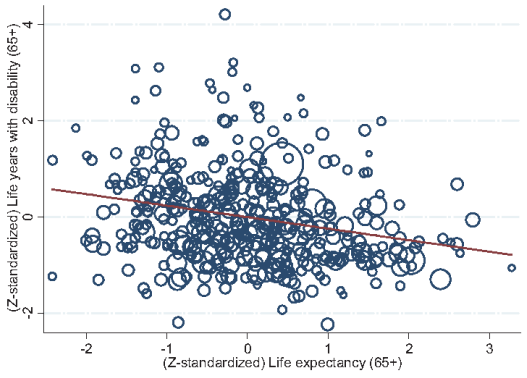
Figure 1: Life expectancy at age 65+ compared with disability-free life expectancy (65+), life years with disability (65+), age-standardized prevalence rate (65+) and health ratio (65+) for German counties in 2009 (z-standardized values, (larger) size of the single marker/circle indicates the (higher) particular precision of estimation)

Figure 1a: Disability-free life expectancy and life expectancy



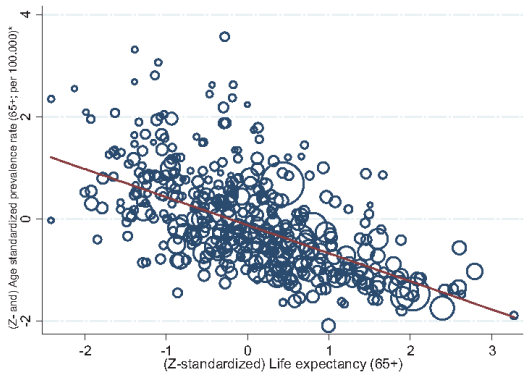

β=0.88 (p<0.001)
West: β=0.89 (p<0.001)
East: β=0.77 (p<0.001)

Figure 1b: Life years with disability and life expectancy




β=-0.24 (p<0.001)
West: β=-0.20 (p<0.001)
East: β=-0.02 (p=0.849)

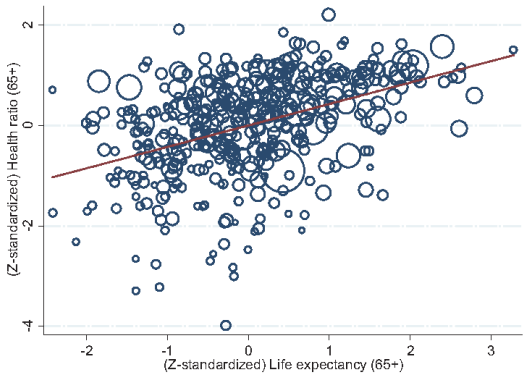
Figure 1c: Age-standardized prevalence rate* and life expectancy




Note: * Old European standard population

β=-0.60 (p<0.001)
West: β=-0.59 (p<0.001)
East: β=-0.41 (p<0.001)

Figure 1d: Health ratio and life expectancy




β=0.43 (p<0.001)
West: β=0.40 (p<0.001)
East: β=0.20 (p=0.060)

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; author's calculations and plotting

In relative terms, the proportion of years without disability (HR) was slightly higher in counties with high life expectancy as the latter was combined with a lower prevalence of disability (ASP). The correlation between the LE and the ASP was linear and significantly negative ($\beta$=-0.58, $p<0.001$), although the strength of the correlation differed in the East and the West (Figure 1c). In West Germany, there was a higher negative correlation of LE with the ASP ($\beta$=-0.57, $p<0.001$) than in East Germany ($\beta$=-0.39, $p<0.001$). There was a weaker (positive) correlation between the HR and the LE in East Germany ($\beta$=0.20, $p=0.060$) than in West Germany ($\beta$=0.40, $p<0.001$) (Figure 1d). Both findings can be explained by the large number of counties with very low LE but high ASP, resulting in a low HR. The table in the appendix displays the values of the LE, the DFLE, the DLY, the HR and the ASP for the 40 counties with the highest overall HR and the 40 counties with lowest overall HR.

## *5.2 Living context as a factor of spatial disability patterns*

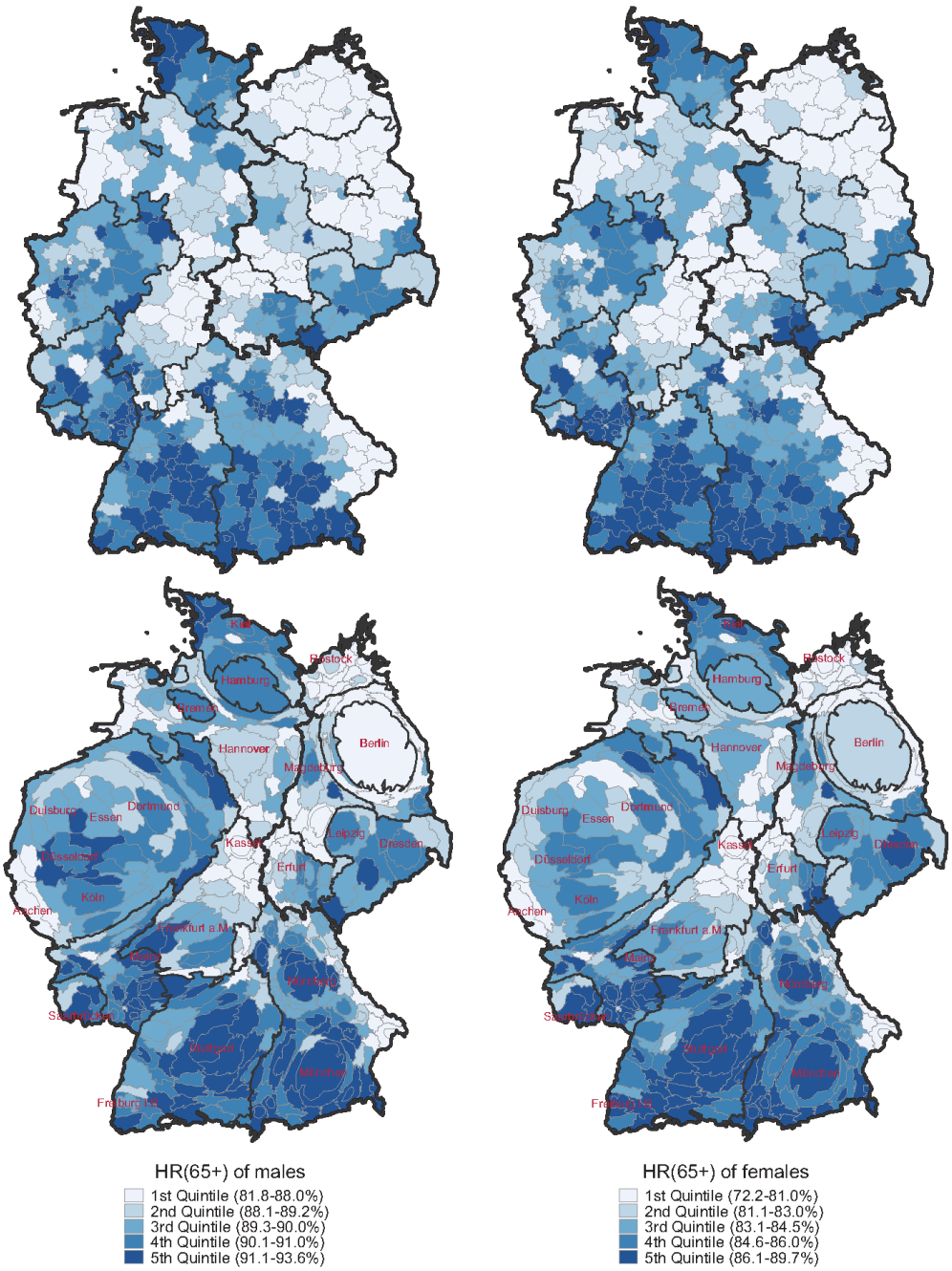
The spatial mapping of HR (see Figure 2) showed clear geographical patterns of high (dark blue) and low (light blue) HR for males and females at age 65+. The first row of Figure 2 displays the HR by using two administrative maps denoting the political boundaries, while the second row shows two isodemographic maps[5] that have been weighted and resized by the male and female populations at age 65+.

The clusters of very low HR were in the northeastern, northwestern, and central counties of Germany, as well as in eastern Bavaria (in the south). The clusters of very high HR were concentrated in the most northwestern part of Germany, and in the southern and southwestern counties. The clusters were independent of the borders of the federal states. The male and female patterns of HR showed only slight differences.

The isodemographic maps showed that the largest population with the lowest HR in Germany was concentrated in Berlin, in the Northern Ruhr region, in Aachen and Kassel and the surrounding areas.

5 Isodemographic maps are useful for highlighting the absolute concentration of persons by specific characteristics.

Figure 2: Spatial mapping of the health ratio (HR) at ages 65+ of males (left) and females (right) in 2009; categorized in quintiles




Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; author's calculations and plotting. Base map: Bundesamt für Kartographie und Geodäsie

Note: First row: unweighted, second row: weighted by population at age 65+; shape of East and West Germany in bold black lines and shapes of the federal states in thin black lines. This figure in high quality: http://www.budrich-academic.de/de/bevoelkerungswissenschaft/

The unweighted mean disposable income of the private households per capita in the 412 German counties was 18,590 Euros, with a standard deviation (SD) of 2,390 Euros, which indicates a relatively low degree of county-level heterogeneity (Table 3). The mean long-term unemployment rate was 19.75 per 10,000 persons, and had a relatively high standard deviation of 16.71 persons. The mean and the standard deviations of the population density (519.55 inhabitants per km²; SD: 672.80 inhabitants per km²) indicated that most counties are sparsely populated, while a few counties (e.g., Munich, Berlin, and Herne, with more than 3,000 inhabitants/km²) showed a very high level of urbanization. For the synthetic indicator of the level of premature mortality, the life table showed a mean value of about 1,445 (or 1.4%) deaths per 100,000 persons, with a standard deviation of 388 deaths (or 0.39PP), which was moderate compared to the standard deviations of the last two indicators.

Table 3: Descriptive overview of the covariates (SD=standard deviation)

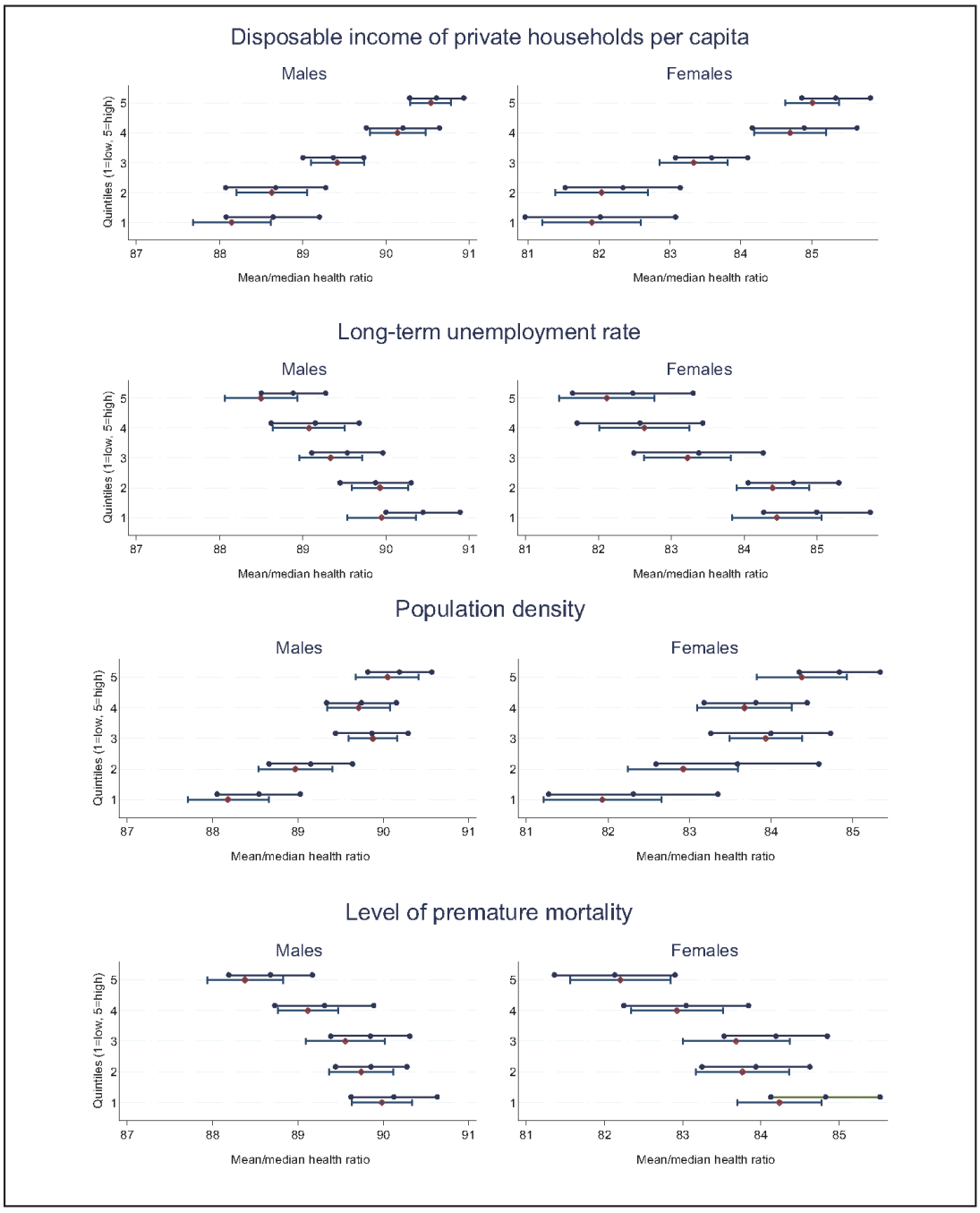
| Covariates | Mean (SD) | Median | Minimum | Maximum | N |
|---|---|---|---|---|---|
| Disposable income of the private households per capita (in 1,000 Euro) | 18.59 (2.39) | 18.44 | 13.90 | 31.02 | 412 |
| Population density (in inhabitants per km²) | 519.55 (672.80) | 198.64 | 37.59 | 4,282.21 | 412 |
| Unemployment rate (in %) | 7.92 (3.57) | 7.00 | 2.20 | 18.30 | 412 |
| Level of premature mortality (in deaths in age 1 - <45 per 100,000) | 1,445.99 (388.80) | 1,412.43 | 168.92 | 2,741.47 | 412 |

Source: Statistische Ämter des Bundes und der Länder; Regional database 2013

To identify potential problems of colinearity, the correlation matrices of the indicators were examined. Generally, the correlations (not shown here) were found to be weak (0.31 and lower); only for long-term unemployment rate and population density was a moderate correlation of 0.49 shown.

For both sexes, there was a significant correlation between the covariates and the HR, although the quintile groups of counties were shown to be more homogeneous in terms of health conditions for males than for females. Wealthier counties measured by “disposable income of the private households per capita” generally showed higher mean and median HR than did poorer counties (Figure 3). A higher concentration of long-term unemployed people was generally correlated with lower average HR. The mean and median HR were significantly lower in counties with a lower population density and in counties with a higher level of premature mortality.

Figure 3: Mean health ratios (95% confidence intervals; red squares) and median health ratios (95% confidence intervals; blue circles) by quintiles of the macro factors in 2009 (not weighted by population size)




Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; Regional database 2013; author's calculations and plotting

To analyze the effects of the four indicators simultaneously, multivariate meta-regression models by sex were estimated. These models (Table 4) showed higher HR levels for counties with higher disposable household income. These differences were significant for males and females. Those living in the wealthiest counties had a 1.27PP (men) and a 1.28PP (women) higher HR than their counterparts in the most deprived counties. For both sexes the effects of the long-term unemployment rate were consistent and highly significant. Females in the counties with the highest long-term unemployment rate had a 2.24PP lower HR than did females in the counties with the lowest rate. For males the effect was negative 1.08PP.

Table 4: Meta-regression models of the health ratio for males (left) and females (right) at ages 65+ in 2009

| | | Males (65+) | | | Females (65+) | | |
|---|---|---|---|---|---|---|---|
| Covariates | | Coefficient | 95% CI | p-value | Coefficient | 95% CI | p-value |
| Constant | | 88.81 | (88.10 - 89.52) | <0.001 | 83.51 | (82.43 - 82.43) | <0.001 |
| Disposable income of private households per capita (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | 0.10 | (-0.44 - 0.64) | 0.722 | -0.62 | (-1.45 - 0.20) | 0.139 |
| | 3rd | 0.71 | (0.09 - 1.32) | 0.024 | 0.33 | (-0.61 - 1.27) | 0.488 |
| | 4th | 1.07 | (0.41 - 1.73) | 0.002 | 1.20 | (0.19 - 2.21) | 0.020 |
| | 5th - highest | 1.27 | (0.61 - 1.93) | <0.001 | 1.28 | (0.28 - 2.29) | 0.013 |
| Long-term unemployment rate (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | -0.29 | (-0.81 - 0.23) | 0.278 | -0.38 | (-1.17 - 0.41) | 0.349 |
| | 3rd | -0.81 | (-1.34 - -0.28) | 0.003 | -1.47 | (-2.28 - -0.67) | <0.001 |
| | 4th | -0.68 | (-1.25 - -0.10) | 0.021 | -1.65 | (-2.52 - -0.78) | <0.001 |
| | 5th - highest | -1.08 | (-1.75 - -0.41) | 0.002 | -2.24 | (-3.26 - -1.22) | <0.001 |
| Population density (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | 0.36 | (-0.15 - 0.87) | 0.167 | 0.37 | (-0.40 - 1.15) | 0.345 |
| | 3rd | 0.78 | (0.22 - 1.34) | 0.007 | 0.66 | (-0.19 - 1.51) | 0.129 |
| | 4th | 0.96 | (0.40 - 1.51) | <0.001 | 1.04 | (0.19 - 1.89) | 0.016 |
| | 5th - highest | 1.53 | (0.95 - 2.11) | <0.001 | 2.19 | (1.31 - 3.08) | <0.001 |
| Level of premature mortality (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | -0.19 | (-0.69 - 0.31) | 0.461 | -0.38 | (-1.14 - 0.39) | 0.331 |
| | 3rd | 0.09 | (-0.42 - 0.60) | 0.726 | 0.28 | (-0.50 - 1.06) | 0.479 |
| | 4th | -0.31 | (-0.82 - 0.20) | 0.231 | -0.46 | (-1.24 - 0.31) | 0.242 |
| | 5th - highest | -0.72 | (-1.25 - -0.20) | 0.007 | -0.80 | (-1.60 - 0.00) | 0.051 |
| Adjusted $R^2$ | | | 28.46% | | | 26.74% | |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; Regional database 2013; author's calculations

The effects of population density were also highly significant in that both men and women in highly urbanized counties were found to have a more favorable HR than those in less densely populated rural areas. The effects were stronger for females (2.19PP) than for males (1.53PP). Measured in terms of the improvements in model fit, the level of premature

mortality was the weakest indicator in the analysis. The HR in counties with the highest degree of premature mortality was 0.72PP lower for men and 0.80PP lower for women than in counties with the most favorable level of premature mortality.

In recognition of the fact that there were still marked societal and economic differences between the counties in the former German Democratic Republic[6] and the counties in West Germany, separate region-specific regression models were additionally estimated for both regions (Table 5).

Table 5: Meta-regression models of the health ratio of the West German counties (left, n=325) and of the East German counties (right, n=87) at ages 65+ in 2009

| | | West Germany | | | East Germany | | |
|---|---|---|---|---|---|---|---|
| Covariates | | Coefficient | 95% CI | p-value | Coefficient | 95% CI | p-value |
| Constant | | 85.53 | (84.67 - 86.40) | <0.001 | 81.40 | (79.53 - 79.53) | <0.001 |
| Disposable income of private households per capita (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | -0.05 | (-0.73 - 0.62) | 0.874 | 1.73 | (-0.03 - 3.48) | 0.053 |
| | 3rd | 0.81 | (0.11 - 1.50) | 0.023 | 3.09 | (1.32 - 4.86) | <0.001 |
| | 4th | 1.57 | (0.83 - 2.31) | <0.001 | 2.96 | (1.13 - 4.78) | 0.002 |
| | 5th - highest | 1.57 | (0.61 - 1.93) | <0.001 | 1.40 | (-0.45 - 3.25) | 0.137 |
| Long-term unemployment rate (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | -0.09 | (-0.77 - 0.59) | 0.790 | 0.37 | (-1.25 - 2.00) | 0.648 |
| | 3rd | -0.68 | (-1.37 - 0.02) | 0.057 | -0.17 | (-1.80 - 1.45) | 0.832 |
| | 4th | -0.90 | (-1.61 - -0.19) | 0.014 | -0.61 | (-2.28 - 1.06) | 0.470 |
| | 5th - highest | -1.45 | (-2.28 - -0.61) | <0.001 | -0.31 | (-1.39 - 2.02) | 0.714 |
| Population density (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | 0.06 | (-0.63 - 0.75) | 0.865 | 1.29 | (-0.52 - 3.11) | 0.159 |
| | 3rd | 0.12 | (-0.62 - 0.86) | 0.747 | 1.36 | (-0.27 - 2.99) | 0.101 |
| | 4th | 0.56 | (-0.19 - 1.30) | 0.143 | 3.03 | (1.18 - 4.88) | 0.002 |
| | 5th - highest | 1.48 | (0.68 - 2.29) | <0.001 | 1.50 | (-0.26 - 3.26) | 0.093 |
| Level of premature mortality (quintiles) | 1st - lowest | Ref | | | Ref | | |
| | 2nd | -0.31 | (-0.97 - 0.36) | 0.366 | -0.93 | (-2.58 - 0.72) | 0.264 |
| | 3rd | 0.24 | (-0.43 - 0.92) | 0.479 | -0.87 | (-2.49 - 0.76) | 0.292 |
| | 4th | -0.10 | (-0.78 - 0.58) | 0.774 | -1.14 | (-2.78 - 0.50) | 0.170 |
| | 5th - highest | -0.49 | (-1.19 - 0.22) | 0.177 | -1.65 | (-3.44 - 0.15) | 0.071 |
| Adjusted $R^2$ | | | 23.41% | | | 27.37% | |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; Regional database 2013; author's calculations

Given the imbalance in the number of counties in the East (87) and in the West (325), it was apparent that most of the effects of the covariates in the West German counties were similar to the effects in the overall sex-specific models. The correlation between socioeconomic

6 Including the city of Berlin.

wealth and the health of the population seemed to be log-linear in the West, while it was a U-shaped relationship in the East. The counties with the highest HR were the counties of the two highest income quintiles in the West and the average-income counties in the East.

A profound negative correlation between long-term unemployment and the HR was found in the West German counties, but no significant correlation was found in East German counties. For the indicators of physical and health care conditions, divergent effects were identified for both German regions. In the East, the most favorable health ratios were found for counties in the fourth quintile of population density. Compared to this group, the most densely populated counties in the East had lower HR. The regression models showed a borderline significant effect of premature mortality for the most disadvantaged East German counties, but no effect for the West German counties.

The results of region-specific regression models by sex (not shown here) were consistent with the findings of the models separated by sex and region.

Table 6: Goodness of fit (adjusted $R^2$ and $tau^2$) by type of model and sex

| | Between county-variance $tau^2$ (relative change) | | | | Adjusted $R^2$ | |
|---|---|---|---|---|---|---|
| | Males | | Females | | Males | Females |
| | | % | | % | % | % |
| Modell 0 | 3.64 | | 8.24 | | | |
| Modell I | 2.84 | -28 | 6.59 | -25 | 21.78 | 19.96 |
| Modell II | 2.85 | 0 | 6.50 | -1 | 21.61 | 21.10 |
| Modell III | 2.65 | -8 | 6.11 | -6 | 27.08 | 25.81 |
| Modell IV | 2.60 | -2 | 6.04 | -1 | 28.46 | 26.74 |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; Regional database 2013; author's calculations

Note: model 0 = Baseline model without covariates; model I = model 0 + disposable income; model II = model I + long-term unemployment rate; model III = model II + population density; model IV = model III + premature mortality

Table 7: Goodness of fit (adjusted $R^2$ and $tau^2$) by type of model and region

| | Between county-variance $tau^2$ (relative change) | | | | Adjusted $R^2$ | |
|---|---|---|---|---|---|---|
| | West Germany | | East Germany | | West Germany | East Germany |
| | | % | | % | % | % |
| Modell 0 | 4.60 | | 7.50 | | | |
| Modell I | 3.71 | -24 | 5.73 | -31 | 19.38 | 23.59 |
| Modell II | 3.71 | 0 | 5.97 | 4 | 19.33 | 20.36 |
| Modell III | 3.54 | -5 | 5.43 | -10 | 23.09 | 27.61 |
| Modell IV | 3.52 | 0 | 5.45 | 0 | 23.41 | 27.37 |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; Regional database 2013; author's calculations

Note: model 0 = Baseline model without covariates; model I = model 0 + disposable income; model II = model I + long-term unemployment rate; model III = model II + population density; model IV = model III + premature mortality

The goodness of fit, measured by the adjusted $R^2$, generally increased with the inclusion of the additional macro factors, whereas the between-county variance decreased in both the sex-specific (Table 6) and the region-specific models (Table 7). A lack of improvements of model fit existed for the indicator of the long-term unemployment rate. The adjusted $R^2$ of the final model (model IV) differed slightly between the subgroups. The explained between-county variance was higher for males than for females, and it was higher for East German counties than for West German counties. The adjusted $R^2$ implied, however, that more than 70% of the regional heterogeneity was not explained by these indicators.

## 6 Discussion

This is the first study that combines census data and advanced healthy-aging measures to investigate spatial patterns in disability in Germany, and to explore their relationship to life expectancy and to socioeconomic factors. The results show a high positive correlation between the life expectancy and the disability-free life expectancy at age 65 in East and West Germany. The population of a county with a high life expectancy tends to have a higher disability-free life expectancy as well. This was also found to be true for the health ratio: A higher life expectancy is associated with a higher health ratio. The strength of the correlation differs between East and West German counties, with a stronger correlation in the West than in the East. By contrast, the findings show a weak positive correlation between life expectancy and disabled life years in the West German counties, and no relationship in the East German counties.

The relationships of the four measures of long-term care with the life expectancy can be interpreted in two ways: from the individual perspective and from a societal or public health perspective. From the individual's point of view, the absolute measures of the disability-free life expectancy and the disabled life years are of higher interest than the relative measures. This study confirmed the conclusions of Mathers et al. (2001) and Robine et al. (2009) to also be true on the level of counties. Thus, a person who lives in a county with a high life expectancy can also expect to live absolutely more years without disability and absolutely fewer disabled years in the lifetime. From the societal or public health perspective, the relative measures of the health ratio and the age standardized prevalence are of interest. Both measures indirectly indicate the proportion of a number of disabled persons to a hypothetical number of caregivers or to a hypothetical number of contributors to the SLTC insurance. The results showed a favorable higher proportion and a higher prevalence of persons without disability in counties with a higher life expectancy, however, there were also inconsistent findings in absolute and relative terms. A comparison of the four counties Rügen, Passau, Kaiserslautern, and Stuttgart shows the inconsistency: The elder population of Rügen, a county in the northeast of Mecklenburg-Western Pomerania, shows nearly the same health ratio as the elderly of Passau, a city county in Eastern Bavaria (about 79.4% to 79.8%; see Table in the appendix). However, the elderly in Passau were expected to live a total of about 1.5 years (19.2 years) longer than persons at age 65+ residing in the county of Rügen (17.8 years). In comparison, e.g. the elderly living in the city of Kaiserslautern in Rhineland-Palatinate had a significantly higher health ratio (90.2%) than did those in the county of Rügen (79.8%), Passau (79.4%) and the city of Stuttgart (89.4%). However, the elderly in Kaiserslautern had fewer years to live (18.6

years) than their counterparts in Passau (19.2 years) and in Stuttgart (20.9 years). Thus, the correct interpretation depends on the adequate choice of the measure.

There are three potential explanations for the disparities found in the East and West German counties. First, the political reunification led to various societal and economical changes in the East German counties that in return had significant contradictory effects on diverse health relevant conditions. For example, there were enormous improvements in the medical infrastructure and the health care provision, and these resulted in rapid gains in life expectancy. In contrast, the reorganization of the economic system and labor market caused large-scale unemployment and a short-term lack of perspectives. These trends were often indirectly linked to unfavorable changes in lifestyle behavior such as alcohol consumption, physical inactivity, and smoking, all of which are potential determinants of the risk of long-term care in later life. Second, there was a different pace in the process of reorganization of the health care infrastructure and the job market in the East German counties that, furthermore, resulted in a different pace in the catch-up process of the life expectancy and of the disability-free life expectancy. The counties in Saxony were the forerunners hereof, while counties in Mecklenburg Western-Pomerania, Brandenburg, and Thuringia did not keep pace. Third, selective migration of healthy, younger elderly and their relatives in the years after reunification may have caused a divergent composition of population in the East German counties. Because most counties in the East are sparsely populated, migration has a generally higher effect on the composition of a population than it does on those of populous counties. Further research is needed to evaluate the effects of health selection in migration.

There is one outstanding conclusion of the spatial mapping, in that that disparities in the health ratio within East (IQR: 4.5PP) and West Germany (IQR: 3.1PP) were higher than the disparities between the two regions (median difference: 2.2PP). By further considering the absolute number of each county's population, the study confirmed that the highest number of persons with low HR was not in the cluster of counties in the northeast of Germany but rather in Berlin, in the Northern Ruhr region, in Aachen and Kassel and the surrounding areas.

This study stated that spatial health differentials in Germany were associated with the level of urbanization, the socioeconomic performance and composition, and, to a small extent, the regional health structure. The most pronounced gradients on health existed for population density and socioeconomic factors. While the short term policy intervention options are limited for the first factor, the socioeconomic factors are affected directly and indirectly by economic and policy measures. However, even if population density cannot be changed in the short term, health policies targeted differently at urban and rural areas should be developed, and their effectiveness should be evaluated.

The study detected different associations between the macro factors and health in both German regions. The relationship between disposable income and health in the West German counties resembles the relationship between gross domestic product and life expectancy reported by Preston (1975), who found large differences in life expectancy between countries with low gross domestic product levels and small differences between the wealthiest countries. The relationship found in this study in the West German counties was similar to such a function, which is also known as the Preston curve. In East Germany, by contrast, disposable incomes are shown to have a U-shaped relationship with health, with the best health situations found in counties with an average disposable income.

Long-term unemployment as an indicator for an unfavorable socioeconomic composition and a weak social cohesion (Berger-Schmitt 2002) is closely linked with poorer health in the

West German counties. However, it has no effect on health in East Germany. Further investigations are needed to explain the latter finding.

The study shows a positive correlation between population density and health in the West German counties. Counties with a high concentration of population have better health than sparsely populated counties. In contrast, the multivariate regression analysis reveals a U-shaped relationship with urbanity in the East German counties. Thus, the results for population density confirm the findings of Diehl and Schneider (2011) for West Germany; but not for East Germany. The U-shaped association of population density with health was also found by Barnett et al. (2001) when analyzing the county-specific prevalence of premature limiting long-term illness in the southwest of England. Because the region is rural and is among the most deprived in England, the two settings are comparable in terms of socioeconomic conditions and physical structure.

The relationship of premature mortality and the health ratio was pronounced in East Germany, whereas no relationship was found in West Germany. One possible explanation for this finding is the low spatial variability in premature mortality. As a result, only the extremes differ significantly. Because these disparities of premature mortality are slightly larger in East (IQR: 605.2 deaths) than in West Germany (IQR: 465.3 deaths), the relationship is stronger in the East than in the West. In the case of East Germany, the findings confirm those of Fantini et al. (2012), who concluded that a high level of premature mortality is linked with low disability-free life expectancy.

This study has four major strengths. The first is the use of census data with the large number of beneficiaries permitting the analysis of counties. All STLC beneficiaries, regardless of whether they are a member of a private or public health plan, are part of the census, which means there is no bias due to undercoverage, missing records, or self-selection into or drop-out from the study.

The second strength is the use of an objective health measure. Disability is diagnosed by experts employed through the health insurance plans and disability status is based on a nationally standardized evaluation.

The third strength is the regional homogeneity of the German health care system in terms of long-term care regulations. There are no, or only very small, culture-specific health definitions that may negatively affect the comparability of the findings. In contrast to cross-country surveys, the SLTC Census is a highly harmonized data source. Because care need regulations are binding for each German county, even changes in these regulations do not bias the spatial disparities.

The fourth strength is the selected health outcome. The HR is a synthetic, composite measure combining two synthetic, composite measures, the DFLE and the LE. Both measures are based on a hypothetical cohort with constant sex- and age-specific mortality rates (as in 2006-2010) and morbidity rates (as in 2009). The calculation method of the cohort, respectively the LE and the DFLE, is simple, as only basic cross-sectional data is required. Both the DFLE and the LE are independent of the size and age structure of the population, as is the resulting HR. Furthermore, the interpretation of the HR is easy to understand. In addition, the HR is independent of the absolute level of the LE. This standardization makes it possible to compare counties even if they are at different levels in terms of the absolute measures. The correlation of the DFLE with the LE depends on the overall level of the disability prevalence. The lower the prevalence, the higher the correlation between the DFLE and the LE because all differences between the counties are driven by differential life expectancy. In terms of the multivariate analysis, the use of the

HR implies that the relationship of the macro factors with the HR is not overlaid by the relationship between the macro factors and LE. Thus, the HR is particularly suited for comparisons of small-area health conditions and their relationship to the macro factors.

However, the study also has some limitations, most of which stem from the ecological design of the study. The units under study are counties, not individuals. The health outcome HR is a synthetic aggregate measure of health at the individual level. Because only basic demographic data (sex and age) are available in the census and there is no other socioeconomic or demographic information on the individuals, there is also no direct information about the social composition of the population in the counties. Hence it is impossible to separate the effects of composition and context (van Lenthe 2006). Thus, while it is feasible to detect correlations, it is not possible to identify causality.

In addition, in the interpretation of the effects, ecological failures must be avoided; all relationships have to be interpreted as relationships at the level of counties only, and not at the individual level. Moreover, only one dimension of health, severe disability, is considered in this study. The findings of previous studies have varied according to the health indicators used. Severe disability in this study may be influenced by problems with legal eligibility for long-term care allowances, health care-seeking behaviors, or the ability to cope with health problems.

Further, the choice of the macro indicators must also be viewed with caution. Each indicator selected was treated as a single proxy of a particular broad dimension of the living context in this analysis. Because the causal effects of the contextual dimensions on heath outcome are complex and mediated by various latent factors, the interpretation has to be prudent. Population density, for example, was used as an indicator of physical environment in this study, but this is a simplification. Population density can be interpreted in various ways, e.g. in terms of access to services and resources, residential attractiveness, lifestyle, stress, or social networks. Furthermore, the population density – as well as other macro-level characteristics – of a county is directly influenced by the historically, politically, or economically established demarcation of the county. Thus, the heterogeneity of living contexts within a county cannot be validly reflected by a single indicator. The problem of overlaid heterogeneity is more urgent for larger counties in terms of surface area.

In this study, most of the variability in the health ratio between the counties is not explained by the selected indicators. Further analyses that include additional macro factors are needed in order to explain the residual regional variance, e.g. indirect indicators of health behavior such as cause-specific mortality data. Interaction effects between the indicators may also be considered in order to investigate mediating influences. Including geographical distances between the counties by using spatial regression models that control for spatial autocorrelation might further improve the analysis.

All of these ideas may help to improve the understanding of the determinants of healthy aging, and may help ensure universal and equitable access to high-quality health care and the attainment of equal living conditions. According to the German constitution, such equal conditions are among the fundamental objectives of the national social and health policies in Germany.

## References

Barnett, S.; Roderick, P.; Martin, D.; Diamond, I. (2001): A multilevel analysis of the effects of rurality and social deprivation on premature limiting long term illness. In: *Journal of Epidemiology & Community Health* 55, pp. 44-51.

Barr, N. (2004): Economics of the welfare state. New York: Oxford University Press.

Berger-Schmitt, R. (2002): Considering Social Cohesion in Quality of Life Assessments: Concept and Measurement. In: *Social Indicators Research* 58, pp. 403-428.

Bickel, H. (2001): Lebenserwartung und Pflegebedürftigkeit in Deutschland. In: *Das Gesundheitswesen* 63 (1), pp. 9-14.

Breckenkamp, J.; Mielck, A.; Razum, O. (2007): Health inequalities in Germany: do regional-level variables explain differentials in cardiovascular risk? *BMC Public Health* 7, p. 132.

Brønnum-Hansen, H.; Davidsen, M.; Kjølle, M. (2003): Tresårige danskeres forventede levetid uden funktionsindskraenkning. In: *Ugeskr Laeger* 165 (23), pp. 2395-2398.

Burgio, A.; Murianni, L.; Folino-Gallo, P. (2009): Differences in Life Expectancy and Disability Free Life Expectancy in Italy. A Challenge to Health Systems. In: *Social Indicators Research* 92 (1), pp. 1-11. [DOI: 10.1007/s11205-008-9283-y]

Chiang, C. L. (1984): The life table and its applications. Malabar, Florida: Robert E. Krieger.

Christensen, K.; Doblhammer, G.; Rau, R.; Vaupel, J. W. (2009): Ageing populations: the challenges ahead. In: *The Lancet* 374, pp. 1196-1208.

Diehl, K.; Schneider, S. (2011): How relevant are district characteristics in explaining subjective health in Germany? – A multilevel analysis. In: *Social Science & Medicine* 72 (7), pp. 1205-1210. [DOI: 10.1016/j.socscimed.2011.02.013]

Diez-Roux, A. V. (2003): The Examination of Neighborhood Effects on Health: Conceptual and Methodological Issues Related to the Presence of Multiple Levels of Organization. In: Kawachi, Ichiro; Berkman, L. F. (Eds.): *Neighborhoods and Health*. New York: Oxford University Press, pp. 45-61.

Diez-Roux, A. V.; Mair, C. (2010): Neighborhoods and health. In: *Annals of the New York Academy of Sciences* 1186 (1), pp. 125-145. [DOI: 10.1111/j.1749-6632.2009.05333.x]

Fantini, M. P.; Lenzi, J.; Franchino, G.; Rainieri, C.; Burgio, A.; Frova, L. et al. (2012): Amenable mortality as a performance indicator of Italian health-care services. In: *BMC Health Services Research* 12 (1), p. 310. [DOI: 10.1186/1472-6963-12-310]

Fukuda, Y.; Nakamura, K.; Takano, T. (2005): Municipal health expectancy in Japan: decreased healthy longevity of older people in socioeconomically disadvantaged areas Municipal health expectancy in Japan: decreased healthy l of older people in socioeconomically disadvantaged areas. In: *BMC Public Health* 5 (1), p. 65. [DOI: 10.1186/1471-2458-5-65]

Glass, T. A.; Balfour, J. L. (2003): Neighborhoods, Aging, and Functional Limitations. In: Kawachi, Ichiro; Berkman, L. F. (Eds.): *Neighborhoods and Health*. New York: Oxford University Press, pp. 303-334.

Gordon, D. (2003): Area based deprivation measures: A UK Perspective. In: Kawachi, I.; Berkman, L. (Eds.): Neighborhoods and Health, Oxford University Press, pp. 179-207.

Groenewegen, P. P.; Westert, G. P.; Boshuizen, H. C. (2003): Regional differences in healthy life expectancy in the Netherlands. In: *Public Health* 117 (6), pp. 424-429.

Gutiérrez-Fisac, J. L.; Gispert, R.; Solà, J. (2000): Factors explaining the geographical differences in Disability Free Life Expectancy in Spain. In: *Journal of Epidemiology & Community Health* 54, pp. 451-455.

Harbord, R. M.; Higgins, J. P. T. (2008): Meta-regression in Stata. In: *The Stata Journal* 8 (4), pp. 493-519.

Hoffmann, E.; Nachtmann, N. (2010): Old age, the need of long-term care and healthy life expectancy. In: Doblhammer, G.; Scholz, R. (Eds.): Ageing, Care Need and Quality of Life. The Perspectives of Care Givers and People in Need of Care. Wiesbaden: Springer VS Research, pp. 162-176.

Jagger, C.; Cox, B.; Le Roy, S. et al. (2007): Health Expectancy Calculation by the Sullivan Method: A Practical Guide. European health expectancy monitoring unit (EHEMU), Technical Report 3 (2006)

Jagger, C.; Gillies, C.; Moscone, F.; Cambois, E.; van Oyen, H.; Nusselder, W. et al. (2008): Inequalities in healthy life years in the 25 countries of the European Union in 2005: a cross-national meta-regression analysis. In: *The Lancet* 372 (9656), pp. 2124-2131.

Jagger, C.; Weston, C.; Cambois, E.; van Oyen, H.; Nusselder, W.; Doblhammer, G.; et al. (2011): Inequalities in health expectancies at older ages in the European Union: findings from the Survey of Health and Retirement in Europe (SHARE). In: *Journal of Epidemiology and Community Health* 65 (11), pp. 1030-1035.

Karakaya, G. (2009): Long-term care: Regional disparities in Belgium. In: *Journal of Applied Economic Sciences* 4 (1(7)), pp. 58-79.

Kawachi, Ichiro; Berkman, L. F. (Eds.) (2003): Neighborhoods and Health. New York: Oxford University Press.

Kibele, E.; Janssen, F. (2013): Distortion of regional old-age mortality due to late-life migration in the Netherlands. In: *Demographic Research* 29 (5), pp. 105-132.

Kroll, L. E.; Lampert, T. (2012): Regionalisierung von Gesundheitsindikatoren Ergebnisse aus der GEDA-Studie 2009. Bundesgesundheitsblatt 55, pp. 129-140. [DOI 10.1007/s00103-011-1403-1]

Lawton, M. P.; Nahemow, L. (1973): Ecology and the aging process. In: Eisdorfer, C.; Lawton, M. P. (Eds.): *The psychology of adult development and aging*. Washington, DC: American Psychological Association, pp. 619-674.

Lievre, A.; Jusot, F.; Barnay, T.; Sermet, C.; Brouard, N.; Robine, J.-M. et al. (2007): Healthy working life expectancies at age 50 in Europe: a new indicator. In: *Journal of Nutrition, Health & Aging* 11 (6), pp. 508-514.

Liu, J.; Chen, G.; Chi, I.; Wu, J.; Pei, L.; Song, X. et al. (2010): Regional variations in and correlates of disability-free life expectancy among older adults in China. In: *BMC Public Health* 10, p. 446. [DOI: 10.1186/1471-2458-10-446.

Mathers, C. D.; Sadana, R.; Salomon, J. A.; Murray, C. J. L.; Lopez, A. D. (2001): Healthy life expectancy in 191 countries, 1999. In: *The Lancet* 357 (9269), pp. 1685-1691. [DOI: 10.1016/S0140-6736(00)04824-8]

Muszyńska, M. M.; Rau, R. (2012): The Old-Age Healthy Dependency Ratio in Europe. In: *Journal of Population Ageing* 5 (3), pp. 151-162. [DOI: 10.1007/s12062-012-9068-6]

Olshansky, S. J.; Ault, A. B. (1986): The Fourth Stage of the Epidemiologic Transition: The Age of Delayed Degenerative Diseases. In: *The Milbank Quarterly* 64 (3), pp. 355-391.

Pfaff, H. (2010): People in Need of Long-term Care: The Present and the Future. In: Doblhammer, G.; Scholz, R. (Eds.): *Ageing, Care Need and Quality of Life*. The Perspectives of Care Givers and People in Need of Care. Wiesbaden: Springer VS Research, pp. 14-28.

Pickett, K. E.; Pearl, M. (2001): Multilevel analyses of neighbourhood socioeconomic context and health out Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review socioeconomic critical review. In: *Journal of Epidemiology & Community Health* 55, pp. 111-122.

Pinheiro, P.; Krämer, A. (2009): Calculation of health expectancies with administrative data for North Rhine-Westphalia, a Federal State of Germany, 1999-2005. In: *Population Health Metrics* 7, p. 4. [DOI: 10.1186/1478-7954-7-4]

Porell, F. W.; Miltiades, H. B. (2002): Regional differences in functional status among the aged. In: *Social Science & Medicine* 54, pp. 1181-1198.

Preston, S. H. (1975): The Changing Relation between Mortality and level of Economic Development (29).

Riva, M.; Gauvin, L.; Barnett, T. A. (2007): Toward the next generation of research into small area effects on health: a synthesis of multilevel investigations published since July 1998. In: *Journal of Epidemiology & Community Health* 61 (10), pp. 853-861. [DOI: 10.1136/jech.2006.050740]

Robine, J.-M.; Cambois, E.; Romieu, I.; Mormiche, P. (1998): Variations régionales de l'espérance de vie sans incapacités entre 1982 et 1990. *Note au haut Comité de Santé Publique*, pp. 99-140.

Robine, J.-M.; Saito, Y.; Jagger, C. (2009): The relationship between longevity and healthy life expectancy. In: *Quality in Ageing* 10 (2), pp. 5-14.

Robine, Jean-Marie; Jagger, C.; Mathers, C.; Crimmins, E.; Suzman, R. (Eds.) (2003): Determining health expectancies. Chichester, Hoboken, NJ: J. Wiley.

Seko, R.; Hashimoto, S.; Kawado, M.; Murakami, Y.; Hayashi, M.; Kato, M. et al. (2012): Trends in Life Expectancy With Care Needs Based on Long-term Care Insurance Data in Japan. In: *Journal of Epidemiology*. [DOI: 10.2188/jea.JE20110069]

SGB (1995): Elftes Buch Sozialgesetzbuch - Soziale Pflegeversicherung. SGB XI.

Smith, M. P.; Olatunde, O.; White Chris (2011): Disability-free life expectancy: comparison of sources and small area estimates in England, 2006-2008. In: *Health Statistics Quarterly* 50, pp. 40-78.

Sullivan, D. F. (1971): A Single Index of Mortality and Morbidity. In: *HSMHA Health Reports* 86 (4), pp. 347-354.

Thompson, S. G.; Sharp, S. J. (1999): Explaining heterogeneity in meta-analysis: a comparison of methods. In: *Statistics in Medicine* 18 (20), pp. 2693-2708. [DOI: 10.1002/(SICI)1097-0258(19991030)18:20<2693::AID-SIM235>3.0.CO;2-V]

van Lenthe, F. (2006): Aggregate deprivation and effects on health. In: Siegrist, J.; Marmot, M. (Eds.): *Social inequalities in health*. New evidence and policy implications. New York: Oxford University Press, pp. 167-192.

van Oyen, H.; Tofforeau, J.; Roelands, M. (1996): Regional Inequities in Health Expectancy in Belgium. In: *Social Science & Medicine* 43 (11), pp. 1673-1678. [DOI: 10.1016/S0277-9536(96)00080-9]

Voigtländer, S., Berg-Beckhoff, G.; Razum, O. (2008): Gesundheitliche Ungleichheit. Der Beitrag kontextueller Merkmale. Frankfurt am Main, Berlin, Bern, Bruxelles, New York, Oxford, Wien. Challenges in Public Health 55.

Voigtländer, S., Berger, U.; Razum, O. (2010a): The impact of regional and neighbourhood deprivation on physical health in Germany: a multilevel study. *BMC Public Health* 10(1): 403.

Voigtländer, S, Berger, U.; Razum, O. (2010b): Increasing regional disparities in living conditions in Germany and their role in the explanation of health inequalities. In: *Gesundheitswesen* 72(5), pp. 301-308. [DOI: 10.1055/s-0029-1233487]

Wood, R.; Sutton, M.; Clark, D.; McKeon, A.; Bain, M. (2006): Measuring inequalities in health: the case for healthy life expectancy. In: *Journal of Epidemiology & Community Health* 60 (12), pp. 1089-1092. [DOI: 10.1136/jech.2005.044941]

Yen, I. H.; Michael, Y. L.; Perdue, L. (2009): Neighborhood Environment in Studies of Health of Older Adults. A Systematic Review. In: *American Journal of Preventive Medicine* 37 (5), pp. 455-463. [DOI: 10.1016/j.amepre.2009.06.022]

# Appendix

Overview of the overall values of the LE, the DFLE, the DLY, the HR, and the ASP at age 65+ for 40 counties with the lowest (first part) and the highest HR (second part) in 2009 (sorted by LE)

| County | Federal state | LE (65+) years | DFLE (65+) years | DLY (65+) years | HR (65+) (%) | ASP (65+) (per 100k) |
|---|---|---|---|---|---|---|
| Kyffhäuserkreis | Thüringen | 17.56 | 14.26 | 3.29 | 81.23 | 14.80 |
| Rügen, Kreis | Mecklenburg-Vorpommern | 17.76 | 14.17 | 3.59 | 79.80 | 15.21 |
| Uecker-Randow, Kreis | Mecklenburg-Vorpommern | 17.85 | 14.52 | 3.33 | 81.32 | 14.29 |
| Unstrut-Hainich-Kreis | Thüringen | 17.90 | 14.60 | 3.29 | 81.60 | 14.02 |
| Cloppenburg, Landkreis | Niedersachsen | 18.10 | 14.74 | 3.36 | 81.45 | 14.26 |
| Kronach, Landkreis | Bayern | 18.27 | 14.98 | 3.28 | 82.03 | 13.39 |
| Stralsund, Kreisfreie Stadt | Mecklenburg-Vorpommern | 18.27 | 14.43 | 3.84 | 78.97 | 15.48 |
| Freyung-Grafenau, Landkreis | Bayern | 18.27 | 14.14 | 4.13 | 77.40 | 16.75 |
| Nordhausen, Kreis | Thüringen | 18.30 | 14.93 | 3.37 | 81.57 | 13.91 |
| Aurich, Landkreis | Niedersachsen | 18.36 | 15.00 | 3.36 | 81.69 | 13.43 |
| Uckermark, Landkreis | Brandenburg | 18.44 | 14.51 | 3.93 | 78.71 | 15.73 |
| Oberhavel, Landkreis | Brandenburg | 18.46 | 15.01 | 3.45 | 81.32 | 13.98 |
| Nordvorpommern, Kreis | Mecklenburg-Vorpommern | 18.47 | 14.33 | 4.14 | 77.58 | 16.24 |
| Werra-Meißner-Kreis | Hessen | 18.48 | 14.95 | 3.53 | 80.89 | 14.11 |
| Heinsberg, Kreis | Nordrhein-Westfalen | 18.50 | 15.16 | 3.33 | 81.97 | 13.41 |
| Prignitz, Landkreis | Brandenburg | 18.52 | 14.88 | 3.64 | 80.37 | 14.19 |
| Deggendorf, Landkreis | Bayern | 18.52 | 15.19 | 3.33 | 82.03 | 13.28 |
| Emsland, Landkreis | Niedersachsen | 18.58 | 15.04 | 3.54 | 80.94 | 14.03 |
| Regen, Landkreis | Bayern | 18.79 | 15.33 | 3.47 | 81.56 | 13.32 |
| Demmin, Kreis | Mecklenburg-Vorpommern | 18.84 | 15.36 | 3.48 | 81.53 | 13.09 |
| Nordwestmecklenburg, Kreis | Mecklenburg-Vorpommern | 18.85 | 15.39 | 3.47 | 81.61 | 13.11 |
| Güstrow, Kreis | Mecklenburg-Vorpommern | 18.90 | 14.91 | 4.00 | 78.86 | 15.00 |
| Müritz, Kreis | Mecklenburg-Vorpommern | 18.93 | 14.99 | 3.93 | 79.21 | 15.36 |
| Märkisch-Oderland, Landkreis | Brandenburg | 19.02 | 15.16 | 3.86 | 79.70 | 14.47 |
| Oder-Spree, Landkreis | Brandenburg | 19.03 | 15.37 | 3.66 | 80.76 | 13.85 |
| Barnim, Landkreis | Brandenburg | 19.03 | 14.41 | 4.62 | 75.71 | 17.25 |
| Schwalm-Eder-Kreis | Hessen | 19.04 | 15.40 | 3.64 | 80.87 | 13.87 |
| Ostprignitz-Ruppin, Landkreis | Brandenburg | 19.10 | 15.00 | 4.10 | 78.55 | 14.86 |
| Eichsfeld, Kreis | Thüringen | 19.11 | 14.92 | 4.18 | 78.11 | 15.37 |
| Greifswald, Kreisfreie Stadt | Mecklenburg-Vorpommern | 19.12 | 15.44 | 3.68 | 80.77 | 12.80 |
| Osterode am Harz, Landkreis | Niedersachsen | 19.15 | 15.66 | 3.48 | 81.81 | 12.80 |
| Passau | Bayern | 19.23 | 15.27 | 3.96 | 79.42 | 14.58 |
| Weimar, krsfr. Stadt | Thüringen | 19.28 | 15.49 | 3.79 | 80.32 | 13.59 |
| Passau, Landkreis | Bayern | 19.32 | 15.55 | 3.77 | 80.48 | 13.67 |
| Rottal-Inn, Landkreis | Bayern | 19.33 | 15.65 | 3.68 | 80.96 | 13.23 |
| Dahme-Spreewald, Landkreis | Brandenburg | 19.45 | 15.89 | 3.56 | 81.71 | 12.37 |
| Delmenhorst, Kreisfreie Stadt | Niedersachsen | 19.57 | 15.89 | 3.68 | 81.18 | 12.51 |
| Wittmund, Landkreis | Niedersachsen | 19.68 | 15.82 | 3.86 | 80.37 | 12.55 |
| Schwerin, Kreisfreie Stadt | Mecklenburg-Vorpommern | 19.71 | 15.99 | 3.72 | 81.12 | 13.00 |
| Vogelsbergkreis | Hessen | 20.38 | 16.73 | 3.65 | 82.09 | 11.83 |

| County | Federal state | LE (65+) years | DFLE (65+) years | DLY (65+) years | HR (65+) (%) | ASP (65+) (per 100k) |
|---|---|---|---|---|---|---|
| Fürth | Bayern | 18.34 | 16.21 | 2.13 | 88.39 | 8.38 |
| Worms, Kreisfreie Stadt | Rheinland-Pfalz | 18.36 | 16.28 | 2.08 | 88.67 | 8.41 |
| Kaiserslautern, Kreisfreie Stadt | Rheinland-Pfalz | 18.63 | 16.82 | 1.82 | 90.24 | 7.21 |
| Bad Dürkheim, Landkreis | Rheinland-Pfalz | 18.86 | 16.75 | 2.11 | 88.81 | 7.89 |
| Donau-Ries, Landkreis | Bayern | 19.04 | 16.91 | 2.13 | 88.81 | 7.58 |
| Rhein-Pfalz-Kreis | Rheinland-Pfalz | 19.09 | 16.87 | 2.22 | 88.36 | 8.00 |
| Günzburg, Landkreis | Bayern | 19.21 | 16.99 | 2.22 | 88.42 | 8.11 |
| Memmingen | Bayern | 19.29 | 17.07 | 2.22 | 88.50 | 8.14 |
| Lippe, Kreis | Nordrhein-Westfalen | 19.31 | 17.06 | 2.25 | 88.35 | 8.01 |
| Kaufbeuren | Bayern | 19.31 | 17.15 | 2.16 | 88.82 | 7.71 |
| Herford, Kreis | Nordrhein-Westfalen | 19.38 | 17.12 | 2.26 | 88.35 | 7.91 |
| Dessau-Roßlau, Kreisfreie Stadt | Sachsen-Anhalt | 19.49 | 17.23 | 2.26 | 88.40 | 7.83 |
| Nordfriesland, Landkreis | Schleswig-Holstein | 19.49 | 17.25 | 2.24 | 88.49 | 7.70 |
| Kempten (Allgäu) | Bayern | 19.53 | 17.59 | 1.93 | 90.10 | 6.83 |
| Alb-Donau-Kreis | Baden-Württemberg | 19.54 | 17.33 | 2.21 | 88.71 | 7.77 |
| Trier, Kreisfreie Stadt | Rheinland-Pfalz | 19.58 | 17.31 | 2.27 | 88.41 | 7.52 |
| Göppingen, Landkreis | Baden-Württemberg | 19.59 | 17.38 | 2.21 | 88.73 | 7.68 |
| Südliche Weinstraße, Landkreis | Rheinland-Pfalz | 19.59 | 17.32 | 2.28 | 88.38 | 7.71 |
| Neu-Ulm, Landkreis | Bayern | 19.63 | 17.58 | 2.05 | 89.57 | 6.89 |
| Unterallgäu, Landkreis | Bayern | 19.63 | 17.46 | 2.17 | 88.94 | 7.44 |
| Ostallgäu, Landkreis | Bayern | 19.67 | 17.61 | 2.06 | 89.52 | 7.01 |
| Schweinfurt, Landkreis | Bayern | 19.69 | 17.40 | 2.29 | 88.38 | 8.04 |
| Ludwigshafen am Rhein, Kreisfreie Stadt | Rheinland-Pfalz | 19.78 | 17.68 | 2.10 | 89.36 | 7.06 |
| Freising, Landkreis | Bayern | 19.82 | 17.53 | 2.29 | 88.45 | 7.66 |
| Erding, Landkreis | Bayern | 19.85 | 17.61 | 2.24 | 88.71 | 7.34 |
| Heilbronn, Kreisfreie Stadt | Baden-Württemberg | 19.89 | 17.69 | 2.20 | 88.93 | 7.35 |
| Oberallgäu, Landkreis | Bayern | 19.91 | 18.12 | 1.80 | 90.96 | 5.92 |
| Rosenheim | Bayern | 20.03 | 17.92 | 2.11 | 89.48 | 6.87 |
| Frankenthal (Pfalz), Kreisfreie Stadt | Rheinland-Pfalz | 20.05 | 17.98 | 2.07 | 89.68 | 6.77 |
| Garmisch-Partenkirchen, Landkreis | Bayern | 20.20 | 17.85 | 2.35 | 88.35 | 7.71 |
| Heidelberg, Kreisfreie Stadt | Baden-Württemberg | 20.28 | 17.94 | 2.35 | 88.43 | 7.31 |
| Miesbach, Landkreis | Bayern | 20.30 | 18.02 | 2.28 | 88.77 | 6.95 |
| Berchtesgadener Land, Landkreis | Bayern | 20.33 | 18.16 | 2.17 | 89.31 | 6.92 |
| Erlangen | Bayern | 20.54 | 18.39 | 2.15 | 89.53 | 6.51 |
| Ludwigsburg, Landkreis | Baden-Württemberg | 20.54 | 18.22 | 2.32 | 88.71 | 7.00 |
| München, Landeshauptstadt | Bayern | 20.63 | 18.25 | 2.38 | 88.46 | 7.16 |
| Bad Tölz-Wolfratshausen, Landkreis | Bayern | 20.64 | 18.31 | 2.33 | 88.72 | 7.09 |
| Stuttgart, Kreisfreie Stadt | Baden-Württemberg | 20.88 | 18.67 | 2.21 | 89.41 | 6.60 |
| Baden-Baden, Kreisfreie Stadt | Baden-Württemberg | 21.05 | 18.60 | 2.45 | 88.36 | 7.15 |
| Neustadt a.d. Weinstraße, Kreisfreie Stadt | Rheinland-Pfalz | 21.49 | 19.18 | 2.31 | 89.24 | 6.32 |

Source: Statistische Ämter des Bundes und der Länder; SLTC Census 2009; author's calculations

## 2. Study 2

Kreft and Doblhammer *Population Health Metrics* (2016) 14:24
DOI 10.1186/s12963-016-0093-1

Population Health Metrics

RESEARCH Open Access

# Expansion or compression of long-term care in Germany between 2001 and 2009? A small-area decomposition study based on administrative health data

Daniel Kreft[1*] and Gabriele Doblhammer[2]

**Abstract**

**Background:** Studies state profound cross-country differences in healthy life years and its time trends, suggesting either the health scenario of expansion or compression of morbidity. A much-discussed question in public health research is whether the health scenarios are heterogeneous or homogeneous on the subnational level as well. Furthermore, the question arises whether the morbidity trends or the mortality trends are the decisive drivers of the care need-free life years (CFLY), the life years with care need (CLY), and, ultimately, the health scenarios.

**Methods:** This study uses administrative census data of all beneficiaries in Germany from the Statutory Long-Term Care Insurance 2001–2009. We compute the CFLY and CLY at age 65+ for 412 counties. The CFLY and CLY gains are decomposed into the effects of survival and of the prevalence of care need, and we investigate their linkages with the health scenarios by applying multinomial regression models.

**Results:** We show an overall increase in CFLY, which is higher for men than for women and higher for severe than for any care need. However, spatial variation in CFLY and in CLY has increased. In terms of the health scenarios, a majority of counties show an expansion of any care need but a compression of severe care need. There is high spatial heterogeneity, with expansion-counties surrounding compression-counties and vice versa, which is mainly caused by divergent trends in the prevalence of care need. We show that mortality is responsible for the absolute changes in CFLY and CLY, while morbidity is the decisive driver that determines the health scenario of a county.

**Conclusion:** Combining regionalized administrative data and advanced statistical methods permits a deeper insight into the complex relationship between health and mortality. Our findings demonstrate a compression of life years with severe care need, which however, depends on the region of residence. To attenuate regional inequalities, more efforts are needed that improve health by medical and infrastructural interventions and by the exchange of insights in the efficiency of small- and large-area policy measures between the vanguard and the rearguard counties. In future research, the underlying latent mechanisms should be investigated in more detail.

**Keywords:** Expansion, Compression, Dynamic equilibrium, Healthy life expectancy, Regions, Care need, Mortality, Regression, Time trends, Health inequality

* Correspondence: daniel.kreft@uni-rostock.de
[1]Institute for Sociology and Demography, University of Rostock and Rostock Center for the Study of Demographic Change, Ulmenstraße 69, D-18055 Rostock, Germany
Full list of author information is available at the end of the article

## Introduction & Background

### The health scenarios

Three hypothetical scenarios with contrasting assumptions about future developments of morbidity in populations with decreasing mortality were established and repeatedly examined. In Ernest Gruenberg's [1] and Morton Kramer's [2] theory of "Expansion of Morbidity," the general survival progress and the later-active (or even missing) improvements in health prevention and in recovery lead to an increasing duration of morbidity and a higher prevalence of health limitations. The contrary hypothesis is the "Compression of Morbidity" scenario by James Fries [3, 4], in which a general decrease in the incidence of morbidity is expected due to, for example, a healthier life style of the individuals, technological and medical advancements, and interventions in primary and secondary prevention of diseases. The morbidity shrinkage – combined with steadily improved survival rates – causes a postponement of unhealthy life years into the very last ages of life and results in a decline of the population's prevalence of chronic diseases in total. Fries [5, 6] later developed a modified and differentiated scenario: the absolute and the relative compression of morbidity. Absolute compression describes a situation in which the total number of unhealthy life years decreases, while there is a relative compression when the proportion of unhealthy life time to total remaining life time declines. Furthermore, relative compression is defined as a special case of absolute compression - differing in the development of the disabled life years. If the number of disabled life years is stable or shrinking, there is an absolute compression, and if there is a slight increase in the number of disabled life years (but lesser than the gain in non-disabled life years), then the situation is defined as a relative compression.

In conjunction with the compression scenarios, there are two expansion scenarios: the absolute and the relative expansion of morbidity. The total number of unhealthy life years increases in the absolute expansion scenario, while the proportion of unhealthy life time to total remaining life time gains in the relative compression scenario.

The idea of looking at relative more than at absolute changes in morbidity prevalence rates is one of the basics of the theory of "dynamic equilibrium" [7, 8]. This scenario integrates the frameworks of compression and expansion of morbidity. Manton [7] assumes that gains in life expectancy go together with increasing years in ill-health; however, the share of unhealthy to total remaining life years remains relatively constant. Furthermore, while the total number of persons with chronic diseases is growing, the prognosis according to the theory expects a shift from more to less and moderate severe diseases and disability states. Behavioral, technological, and medical progression are the causes of this redistribution and will lead to a general improvement in survival as well [9].

To evaluate these frameworks of the future trends in population's health status, summary measures were developed that combine information about morbidity and mortality data. One appropriate concept is the above-mentioned care need-free life years (CFLY). By combing the CFLY with the indicators life years with care need (CLY) and the health ratio (HR), five theoretical health scenarios can be identified (Table 1).

Until now, the CFLY indicator has been predominantly used for cross-country comparisons of time trends (e.g., [10, 11]). However – as mentioned above – the CFLY can equally be applied for regional comparisons within a country (e.g., [12, 13]).

A methodological problem occurs when time trends are studied based on changes in prevalence, because they can be the result of changes in the incidence, in the mortality of the prevalent population, and in the mortality of the non-prevalent population. Because longitudinal data on these three influencing factors are rare, Nusselder and Looman [14] introduced a decomposition method that allows for the retrospective separation of changes in prevalence (morbidity effect), changes in the survival of the population with morbidity (mortality effect on CLY, $\text{Mort}_{\Delta\text{CLY}}$), and changes in the survival of the population without morbidity (mortality effect on CFLY, $\text{Mort}_{\Delta\text{CFLY}}$). The two morbidity effects on CFLY and on CLY, are – by definition of a two-state decrement life table – the same in numbers but with opposite signs.

**Table 1** Scheme of combinations of care need-free life years, life years with care need and health ratio by scenario of future health development (given that life expectancy increase continues)

| | Disability-free life years | Disabled life years | Health ratio |
|---|---|---|---|
| Absolute Compression | ▲ | ▼= | ▲ |
| Relative Compression | ▲ | ▲ | ▲ |
| Dynamic Equilibrium[a] | ▲ | ▲ | = |
| Relative Expansion | ▲ | ▲ | ▼ |
| Absolute Expansion | ▼= | ▲ | ▼ |

*Note*: ▼: decrease; ▲: increase; =: stable

[a]With considering the shift in the severity of morbidity, special case of "stability" that is defined by the same scenario but without considering the shift in the severity of care need

A positive morbidity effect is defined as a decrease in prevalence. A positive $Mort_{\Delta CFLY}$ implies a decrease of mortality rates in the population without care need, and a positive $Mort_{\Delta CLY}$ is a decrease of mortality in the population with care need.

### Factors of and time trends in care need

#### *Factors of care need*

In our study care need is a complex, multidimensional concept of morbidity in contrast to the widely used health outcomes such as limitations in (instrumental) activities of daily living (ADL and IADL), self-rated health, or mobility limitations. Our measure of care need is based not only on an objective medical assessment of health problems due to IADL and ADL limitations according to the German Statutory Long-Term Care (SLTC) insurance, but also on the willingness to apply for benefits (see data section below).

In general, the risk of care need is affected by various determinants that can be differentiated into micro- and macro-level factors. Kibele [15], by adapting [16, 17], defines four subgroups of micro-level determinants: the socioeconomic status, lifestyle, living conditions, and human biology/genetic factors. Even if these factors are situated on the individual level, there is a spatial variation in the concentration of persons with specific health promoting or jeopardizing attributes in Germany (e.g., see review by [15]). In addition, three macro-level determinants can be identified: socioeconomic conditions, medical care provision, and environmental conditions (e.g., see review by [15]). Both micro- and macro-level factors influence – in a complex, interfering, and interplaying way - the disease burden situation in the particular German counties. Profound county differences were reported for a series of diseases and conditions all related to care need, such as dementia and hearing impairments [18], multiple sclerosis [19], smoking and obesity [20], depression [21], hypertension, diabetes mellitus, hypercholesterolemia [22], and acute stroke admission [23]. County differences also exist for all leading causes of death [15].

In addition, the decision to apply for SLTC- benefits depends on the individual and his or her family. In 2013, 71 % of the SLTC-beneficiaries received outpatient and informal care in their private homes; among these 66 % were only cared for by a family member [24]. Thus, the family (primarily the spouse and/or the children) plays an important role as care givers in the SLTC-system. One may assume that in most cases the decision of whether to apply for SLTC-benefits is discussed with and supported by the partner and the family. Potential factors influencing this decision may be the availability of a (distant) living partner/children, the amount of financial (individual or family) resources, the severity of the limitation or disease, the time consumption and psychological burden of care, the infrastructural situation in the residential area, and the normative, cultural, and other individual beliefs and concerns of all involved persons. Up to now, there has been a lack of studies that investigate these factors on the county level; however, Kreft [13] concluded that the risk of long-term care is higher in counties where there are more deprived households.

#### *Time trends in care need*

We identified six studies published since 2001 which analyze trends in care need in Germany (Table 2). The review indicates an inconsistent picture of the trends in

**Table 2** Selection of studies investigating the health scenarios in Germany, publication year 2001 through 2015

| Study | Type of health | Ages | Country/region | Time | Results | Regional comparison | Type of method |
|---|---|---|---|---|---|---|---|
| [25] | Long-term care (in general; incidence) | All ages | Germany | 1998–2006 | (Slight) **Compression** | no | Age standardized prevalence, incidence estimations |
| [26] | Long-term care (in general and severe) | All ages | North Rhine-Westfalia/Germany | 1999–2005 | Compression | no | Sullivan method |
| [27] | Long-term care (transition rates) | All ages | Berlin/Germany | 2000–2009 | **Compression** (but: policy influence assumed) | no | Transition models |
| [28] | Long-term care (by severity) | All ages | Germany | 1999–2007 | Dynamic equilibrium (Expansion for all types and stability for severe types of care) | Federal states and 3 regions | Sullivan method, standardized morbidity ratios |
| [29] | Long-term care (by severity of disability) | 60+ | Germany | 1999–2008 | Dynamic Equilibrium (Expansion for all types and stability for severe types) | no | Sullivan method |
| [30] | Long-term care (in general) | 60+ | Germany | 1999–2005 | **Relative expansion** | no | Sullivan method |

*Note*: Words in **bold** letters indicate that the results are interpreted with a direct link to the health scenarios

health in the last decades. Half (three) of the selected studies found a compression of long-term care [25–27]. The results of two studies can be interpreted as evidence for the dynamic equilibrium hypothesis [28, 29]. Only one study [30] found a relative expansion.

These findings for Germany match the findings for other European countries and the United States (see [31–33] for reviews). The three reviews give evidence for different trends by severity of a health problem and indicate a dynamic equilibrium with expansion in mild health problems and stability or compression in severe disability. However, the choice of the health indicator (e.g., incidence, prevalence, or composed measures), the characteristics of the population under study (e.g., age groups, inclusion of institutionalized persons), the choice of the time perspective (due to societal and medical changes), and the design of the data (survey or administrative) affect the comparability of the findings of the studies.

The studies of Hackmann and Moog [25] and Häcker and Hackmann [27] used different methods and data than the other studies that applied the Sullivan method. While Hackmann and Moog [25] estimated the age standardized prevalence of care need by using 2004/06 data from the German Ministry of Health and explored incidence rates based on the (arbitrary) assumption of a stable internal age structure, Häcker and Hackmann [27] computed a transition model that used individual level data for SLTC-recipients in Berlin, a highly urbanized German region. Thus, the findings are not comparable to our study. In contrast, Pinheiro and Krämer [26], Pattloch [28], Unger and colleagues [29], and Hoffmann and Nachtmann [30] used the Sullivan method and an administrative data source (the SLTC census, except Unger and colleagues [29], who used health claims data from the Gmündener Ersatzkasse/GEK). Results of these studies indicate an expansion/relative expansion of long-term care in general and stability in severe types of care (dynamic equilibrium). Only Pinheiro and Krämer [26] found a compression in general and severe care need, which may be explained by the above-average decrease in prevalence of care between 1999 and 2007 (see Pattloch [28]:153).

In sum, this study has two objectives. First, we investigate the trends in LE, CFLY, CLY, and HR on the level of counties and classify them according to the theoretical health scenarios: expansion, compression, and stability. Second, we explore whether the changes in mortality or in morbidity are the driving factors behind experiencing a specific health scenario. We examine this by decomposing the county-specific CFLY and CLY trends into the effects of morbidity and mortality.

***Hypothesis 1:*** Based on the findings of previous studies [12, 13, 15, 20, 34–48] we hypothesize that there are county-specific differences in the trends of the health indicators which may lead to a heterogeneous pattern of the health scenarios. Given the remarkable increase in life expectancy of East Germany since reunification, it is not obvious whether the distribution of county-specific health scenarios is similar to West Germany. In addition, there are large subnational differences in the patterns of selected chronic diseases, their direct (e.g., smoking and obesity) and indirect (e.g., socioeconomic deprivation) risk factors, the medical infrastructure, and the major causes of death [13, 15, 18–23] These health(−relevant) regional characteristics combined with the multiple factors that affect the decision to apply for SLTC may result in different health scenarios.

***Hypothesis 2:*** However, based on the previous hypothesis and on earlier research that points towards a compression or equilibrium scenario [30, 49], we expect that this is also true in most – but not all – counties.

***Hypothesis 3:*** Turning to the contributions of the mortality and morbidity effects to the health scenarios, we do not have a specific hypothesis. A priori it is not obvious whether the same factor drives both the absolute changes in years of life with and without care need, and the resulting health scenarios. The reason for this is that the health scenarios are the result of interfering developments in the three distinct indicators CFLY, CLY, and LE. However, a decomposition analysis of trends in ADL among the French population aged 65 and above concluded that the compression found from 2004 to 2008 was predominantly caused by the change in the disability component rather than in the mortality component [50]. Whether this is also true for Germany is not clear.

## Data and methods

### Data

This study is based on the German Statutory Long-Term Care (SLTC) Censuses for the years 2001, 2003, 2005, 2007, and 2009. The SLTC Census is an official mandatory register of all long-term informal and formal care and care allowance receivers living in private households and institutions in Germany. The register is updated every two years and covers more than 2 million recipients of long-term care benefits as defined by the German Social Code Book XI. The register includes individual level information about sex, age, year of observation, care level (level 1 to 3/case of hardship), and the official ID of the residential county (NUTS 3 level) on December 31st of each year; no additional socioeconomic or demographic information is available. We aggregated the individual micro data by 5-year age groups (65–69, 70–74, 75–79,80–84, 85+), by sex, by year, by county, and by care level (level 1+ versus level 2+).

As participation is mandatory, the SLTC Census is not biased by non-response. Another advantage is the

adequately high number of persons in need of care at the county level (Additional file 1: Table S1). To ensure data privacy, we use the total sample via remote access by the Research Data Centres of the Statistical Offices of the Federation and the Länder.

We combine the aggregated SLTC Census data with the vital data (population and death counts) of the official regional database of the National Statistical Office. Two problems with the data occur in the data management process.

First, the highest age group in the county-specific population statistics in 2001 is 75+, while in the other years there is a disaggregation in 5-year age groups until age 85 + .[1] Thus, we estimated the population for the 5-year age groups by using available data for 2003–2009 and by assuming a constant change of the population shares within persons at age 75+ by sexes and counties from 2001 to 2009. We use an extrapolation method to estimate the population at the age groups 75–79, 80–84, and 85 and older in 2001.[2]

Second, in the observation period, two large – Saxony-Anhalt in 2007 and Saxony in 2008 – and two small reforms – Hanover in 2001 and Aachen in 2009 – of the counties were carried out. Most of these reforms were fusions of counties, which are unproblematic in terms of data management. For these counties, the data of the affiliated counties are pooled. For six counties in Saxony-Anhalt[3] the reform of the counties fundamentally changed the geographical entities, which requires a more complex data management strategy. We choose an allocation of death counts and of the number of care receivers by using overall population based weights.[4] The underlying assumption of this strategy is that the deaths and the persons in need of care are equally distributed in area of the counties and are not clustered in specific parts within a county.

### Care need

The care levels represent the intensity of restrictions in basic and instrumental activities of daily living (ADL and IADL) over a longer period. They are separated by the frequency and the time consumption of care assistance by non-professionals: persons with care level 1 need assistance at least once a day that takes more than 45 min for essential personal care and at least 90 min in total for general help; persons with care level 2 and higher need assistance for at least three times a day that takes 120 min or longer for essential personal care and at least 180 min in total for general help. The intensity of care is specified during a substantial home examination by members of the German medical service of health insurance [51].

As only official registered care need is used as the health outcome, there may be undercoverage of care need in general due to a lack of knowledge or high barriers of entry – for example, for persons with a migration background. However, there could also be differences (illegal, therefore hidden) in the evaluation process of the care level, as lobbyism towards the medical services and the financial resources of the insurance agencies may vary within Germany. In addition, it can be assumed that there is also a continuing (perhaps policy driven) change of assessment of the potential beneficiaries by the medical services in the observation period [27]. Further limitations are potential county-specific differences between East and West German counties in terms of individual acceptance of social benefits, as well as socioeconomic differences in terms of private financial resources to compensate public benefits.

## Methods

### *Sullivan method*

We calculated care need-free life years (CFLY) and defined care need in terms of receiving financial and/or personnel support from the German SLTC insurance. Hereafter, the words long-term care, disability, and care need are used synonymously. The CFLY estimation is based on the Sullivan method [52] and on the Chiang method [53] for life expectancy (LE). We computed prevalence rates of care need separated by sex, age group ('under 60', '60–69', '70–74', '75–79', '80–84', '85+'), year of observation (2001, 2003, 2005, 2007, 2009), county, and care level.

We use two definitions of care need: all types of care (levels 1–3) versus severe type of care (level 2 and 3/case of hardship). The life years with care need (CLY) are calculated as the remaining total LE minus CFLY. The health ratio (HR) is the proportion of CFLY in total remaining LE. We estimate yearly LE, CFLY, CLY, and HR for both sexes and care levels, and for all 412 German counties within the borders of 2009. To reduce random fluctuations in the county's death rates, we use pooled 3-year death counts for the estimation of the abridged life tables.

### *Trend analysis*

In the first stage, we separately examine the temporal changes in the general level of the seven indicators (LE, $CFLY_{any}$, $CFLY_{severe}$, $CLY_{any}$, $CLY_{severe}$, $HR_{any}$, $HR_{severe}$). We combine the information of the indicators to classify the counties into the five established health scenarios plus regions with decreasing life expectancy (Table 1). To minimize random fluctuations in the indicators, we used pooled data for the two starting years (2001/2003) and the two final years (2007/2009). We define the trends as the estimated value in the last two years subtracting the estimated value in the first two years. An increase (a decrease) in an indicator is defined as a

positive (negative) change, while, since continuous variables are used, stability is defined as an indicator change between −0.1 and +0.1.

### *Decomposition*

In the second stage, we decompose county-specific $CFLY_{any}$, $CFLY_{severe}$, $CLY_{any}$, and $CLY_{severe}$ into the effects of morbidity and mortality, which measures the life years lost or gained due to changes in mortality or morbidity rates. We use the decomposition method by Nusselder and Looman [14], which is an extension of the Arriaga method [54]. We compare sex-specific CFLY and CLY in 2001/03 ($t_1$) versus 2007/09 ($t_2$). The change in the number of person-years with care need (CLY) for a particular county, sex, and care level is measured by

$$
\begin{aligned}
{}_iCLY_x = {}_i\mathrm{Mort}_{\Delta\mathrm{CLY},x} + {}_i\mathrm{Morb}_{\Delta\mathrm{CLY},x} = \left(\frac{{}_iprev_{x_{t1}} + {}_iprev_{x_{t2}}}{2}\right) \\
\times \Delta_i L_x + \left(\frac{{}_iL_{x_{t1}} + {}_iL_{x_{t2}}}{2}\right) \times \Delta_i prev_x, \qquad (1)
\end{aligned}
$$

where x depicts age, i the length of the age interval, ${}_iL_x$ the product of person-years lived, and ${}_iprev_x$ the prevalence of care need. The number of person-years without care need (CFLY) is decomposed in the same manner.

### Multinomial logistic regression

In the third stage, we estimated multinomial logistic regression models to analyze the association of the morbidity and mortality effects with the health scenarios. We used the three theoretical health scenarios (expansion, stability, compression) rather than the five categories presented in Table 1 due to the low number of counties in some of the categories. The explanatory variables are the mean centred morbidity (Morb) and mortality effects in CFLY ($\mathrm{Mort}_{\Delta\mathrm{CFLY}}$) and in CLY ($\mathrm{Mort}_{\Delta\mathrm{CLY}}$), which are measured in life days. To account for county-specific uncertainty of $CFLY_{any}$ and $CFLY_{severe}$ estimation, we use weighted regression models.[5]

The regression model for persons aged 65+ and of a particular sex and care level is defined by

$$
\begin{aligned}
Logit_{i,j} &= log\frac{Pr(Y_i = j)}{Pr(Y_i = j')} \\
&= \alpha_j + \beta_{1,j}\mathrm{Morb}_i + \beta_{2,j}\mathrm{Mort}_{\Delta\mathrm{CFLY},i} \\
&\quad + \beta_{3,j}\mathrm{Mort}_{\Delta\mathrm{CLY},i}, \qquad (2)
\end{aligned}
$$

where i depicts the county, j is the particular health scenario (stability or compression), j' is the reference health scenario (expansion), α is the intercept, and the βs are the estimated coefficients.

All calculations are performed using Stata 12.1 and a decomposition tool programmed in R by WJ Nusselder and CWN Looman.[6] The results are given as relative risk ratios (RRR) on the chance of being a "stability" or a "compression" county versus being an "expansion" county (reference) for both sexes aged 65+, and for any/severe care level.

## Results

In the period from 2001 to 2009, the number of persons in care need has increased from 2.04 to 2.34 million. Thus, the raw care need prevalence is about 2.5 % in 2001 and 2.9 % in 2009. Of these, nearly 50 % have care level 1 (2001: 0.89 million; 2009: 1.25 million persons). The majority are female (2001: 1.40 million; 2009: 1.57 million); however, the increase between 2001 and 2009 is higher for males (+20 %) than for females (+12 %). About 81 % (2001) respectively 83 % (2009) are 65 years and older and the total increase is solely due to these ages (+18 %). On the contrary, the absolute number of persons younger than 65 is nearly stable (+0.09 %) over time.

### Trends according to the five health scenarios

Taking the unweighted mean over all counties, remaining LE, $CFLY_{any}$, and $CFLY_{severe}$ have been continuously increasing for both sexes (Table 3). $CLY_{any}$ also increased, while there was no significant time trend for $CLY_{severe}$. An analysis of the time trends in HR – separated by men and women and by severity of care need – confirms the findings. The proportion of life years free from any care level ($HR_{any}$) decreased, while the proportion of life years free from severe care level ($HR_{severe}$) remained stable or even increased slightly.

In detail, mean male LE increased from 15.97 to 17.43 years and mean female LE rose from 19.26 to 20.55 years. Thus, the gain was higher for men (0.18 life years per annum) than for women (0.16 life years per annum). While the spatial variation in LE increased for men (from interquartile range IQR = 0.898 to 1.014), that of women decreased (from 0.900 to 0.808) in this period. CFLY shows an increase in both, $CFLY_{any}$ and $CFLY_{severe}$. Mean $CFLY_{any}$ rose from 14.39 years (IQR = 1.053) to 15.60 (IQR = 1.157) in men and from 16.22 (IQR = 1.049) to 17.17 years (IQR = 1.231) in women. $CFLY_{severe}$ has increased from 15.14 (IQR = 0.956) to 16.58 years (IQR = 1.082) in men and from 17.67 (IQR = 0.968) to 18.97 (IQR = 0.907) in women. Thus, the increase in $CFLE_{severe}$ is higher than in $CFLE_{any}$. Mean $CLY_{any}$ of males increased from 1.58 to 1.83 years and those of females from 3.05 to 3.38 years. In contrast, male $CLY_{severe}$ stagnated at around 0.85 and female $CLY_{severe}$ at around 1.61 years.

The trends are weakly correlated with the starting level in 2001/2003. While in the case of male LE, there is no association of the level with the trend component (Pearson correlation = -0.07, $p > 0.1$), the increase in female LE is lower in counties with a high LE starting level

**Table 3** Level (measured by the county-level mean) and spatial dispersion (measured by interquartile range; IQR) of life expectancy total, with and without any care level and with and without severe care level and the health ratios, men and women at age 65+, 2001–2009

| | | Men | | | | | Women | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2001 | 2003 | 2005 | 2007 | 2009 | 2001 | 2003 | 2005 | 2007 | 2009 |
| LE | Mean | 15.97 | 16.47 | 16.75 | 17.21 | 17.43 | 19.26 | 19.60 | 19.98 | 20.40 | 20.55 |
| | | [15.90–16.03] | [16.40–16.54] | [16.68–16.82] | [17.14–17.28] | [17.36–17.51] | [19.20–19.32] | [19.54–19.65] | [19.92–20.03] | [20.35–20.45] | [20.50–20.61] |
| | IQR | 0.898 | 0.906 | 0.960 | 0.993 | 1.014 | 0.900 | 0.858 | 0.815 | 0.796 | 0.808 |
| $CFLE_{any}$ | Mean | 14.39 | 14.85 | 15.03 | 15.39 | 15.60 | 16.22 | 16.53 | 16.76 | 17.03 | 17.17 |
| | | [14.32–14.46] | [14.78–14.93] | [14.95–15.10] | [15.31–15.47] | [15.51–15.69] | [16.14–16.29] | [16.45–16.60] | [16.68–16.84] | [16.95–17.11] | [17.09–17.26] |
| | IQR | 1.053 | 1.144 | 1.068 | 1.149 | 1.157 | 1.049 | 1.046 | 1.107 | 1.193 | 1.231 |
| $CLY_{any}$ | Mean | 1.58 | 1.62 | 1.72 | 1.82 | 1.83 | 3.05 | 3.07 | 3.22 | 3.37 | 3.38 |
| | | [1.56–1.60] | [1.59–1.64] | [1.70–1.74] | [1.79–1.85] | [1.81–1.86] | [3.01–3.08] | [3.03–3.11] | [3.18–3.26] | [3.32–3.42] | [3.33–3.44] |
| | IQR | 0.293 | 0.312 | 0.355 | 0.375 | 0.373 | 0.520 | 0.552 | 0.569 | 0.657 | 0.750 |
| $HR_{any}$ | Mean | 90.08 | 90.16 | 89.70 | 89.40 | 89.43 | 84.17 | 84.32 | 83.86 | 83.45 | 83.51 |
| | | [89.93–90.22] | [90.01–90.31] | [89.54–89.86] | [89.22–89.58] | [89.25–89.62] | [83.95–84.38] | [84.10–84.54] | [83.63–84.09] | [83.19–83.71] | [83.24–83.79] |
| | IQR | 1.880 | 1.940 | 2.327 | 2.529 | 2.462 | 3.076 | 2.959 | 3.133 | 3.466 | 3.849 |
| $CFLE_{severe}$ | Mean | 15.14 | 15.65 | 15.89 | 16.32 | 16.58 | 17.67 | 18.03 | 18.35 | 18.75 | 18.97 |
| | | [15.08–15.21] | [15.59–15.72] | [15.82–15.96] | [16.25–16.40] | [16.50–16.65] | [17.60–17.73] | [17.97–18.09] | [18.28–18.41] | [18.69–18.81] | [18.90–19.03] |
| | IQR | 0.956 | 1.055 | 1.043 | 1.081 | 1.082 | 0.968 | 0.931 | 0.909 | 0.914 | 0.907 |
| $CLY_{severe}$ | Mean | 0.82 | 0.82 | 0.86 | 0.88 | 0.86 | 1.59 | 1.57 | 1.63 | 1.65 | 1.59 |
| | | [0.81–0.84] | [0.80–0.83] | [0.87–0.87] | [0.87–0.90] | [0.87–0.87] | [1.57–1.62] | [1.55–1.59] | [1.61–1.66] | [1.62–1.68] | [1.56–1.62] |
| | IQR | 0.200 | 0.196 | 0.210 | 0.220 | 0.193 | 0.279 | 0.311 | 0.344 | 0.345 | 0.336 |
| $HR_{severe}$ | Mean | 94.84 | 95.04 | 94.86 | 94.84 | 95.06 | 91.72 | 91.98 | 91.81 | 91.89 | 92.26 |
| | | [94.75–94.92] | [94.95–95.13] | [94.76–94.96] | [94.74–94.95] | [94.97–95.16] | [91.60–91.85] | [91.86–92.11] | [91.68–91.94] | [91.75–92.03] | [92.13–92.39] |
| | IQR | 1.210 | 1.247 | 1.394 | 1.453 | 1.208 | 1.606 | 1.668 | 1.747 | 1.850 | 1.789 |

*Source*: Statistical Offices of the Federation and the Länder, Statutory Long-Term Care Censuses 2001–2009 & Regional database (2013); author's calculation

(-0.33, $p < 0.001$). For CFLY, there are inconsistent associations. There is a weak positive correlation in case of $CFLY_{any}$ in men (0.17, $p < 0.001$), but no correlations in male $CFLY_{severe}$ and in female $CFLY_{any}$ (both 0.06, $p > 0.1$). However, we did find a weak negative correlation in female $CFLY_{severe}$ (-0.18, $p < 0.001$). In CLY, there are no correlations in $CLY_{any}$ (men: -0.07; women: 0.03, both $p > 0.1$) and weak negative correlations in $CLY_{severe}$ (men: -0.20, $p < 0.001$; women: -0.11, $p = 0.03$).

We spatially plot selected variants by the starting level in 2001/2003 and by the trends up to 2007/2009, and detect notable clusters of counties with very favorable and very unfavorable combinations. In case of LE, CFLY, and HR, unfavorable combinations are defined as a low starting level and the lowest (more than one standard deviation below the county-level mean) change over the period. In the case of CLY, in contrast, unfavorable combinations are defined as a high starting level and the highest (more than one standard deviation above the county-level mean) change over the period. For the trends in LE, CFLY, CLY, and HR, there is a slight but consistent gradient between the most disadvantaged counties in the North, Middle and East of Germany – including eastern Bavaria – and the most advantaged counties in the South and West (Additional file 1: Table S2–S5).

By combining the trends in the various indictors into the health scenarios for all of Germany, we find a relative expansion for any care level for both sexes, but a stable trend in severe care level of males and a relative compression in severe care level of females.

In contrast to the picture of a nationwide consistent trend, the health scenario classification on level of counties reveals a high subnational heterogeneity (Fig. 1). Obviously, there is no clear east–west or north–south gap, but a high divergence within the particular federal states. Nevertheless, in case of any care level, the majority of the counties have experienced a relative expansion. Almost every county in the federal states Lower Saxony, Hesse, northern Rhineland-Palatinate, northern and eastern Bavaria, and the majority of the East German counties are in the relative expansion cluster. The highest spatial heterogeneity can be stated for Schleswig-Holstein, North Rhine-Westphalia, Baden-Württemberg,

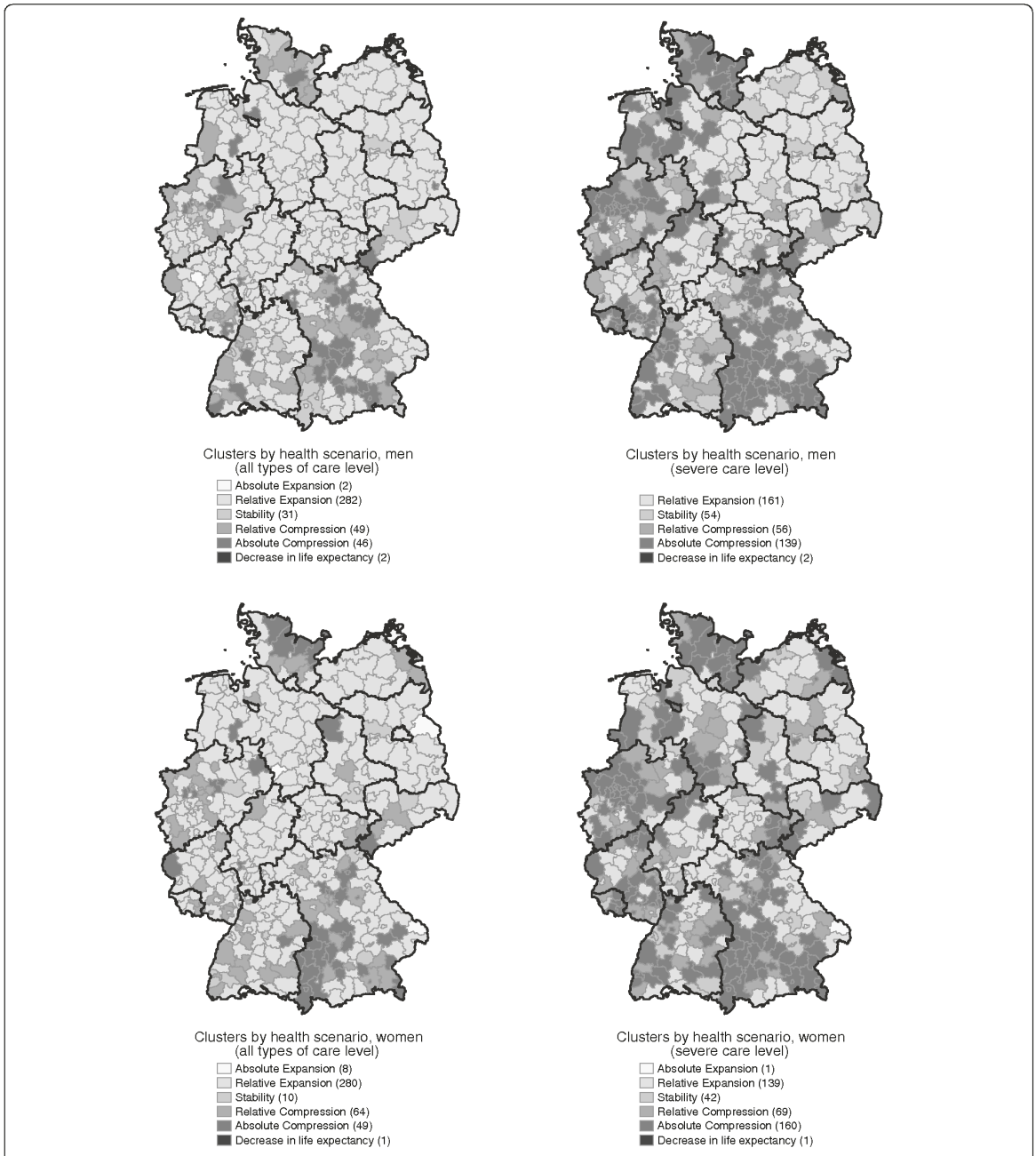



**Fig. 1** Clusters by health scenarios for any care level and for severe care level, men and women, age 65+, 2001/03–2007/09. Source: Statistical Offices of the Federation and the Länder, Statutory Long-Term Care Censuses 2001-2009 & Regional database (2013); author's calculations and mapping

and Saxony. The general spatial pattern of the health scenarios is consistent for men and women (Spearmans rho = 0.60); however there are some exceptions (some counties in Schleswig-Holstein, Saxony-Anhalt, North Rhine-Westphalia, and Bavaria).

In terms of trends in severe care levels, the number of counties experiencing an expansion is lower than in case of any care level. As a consequence, there are comparatively more counties classified as counties with relative and absolute compression. However, there is a higher

level of bipolarization with counties experiencing a relative expansion and counties experiencing a compression for males than for females. This is the explanation for the stable trend for males on the national level.

Looking at any and severe care level simultaneously, the majority of counties show either an expansion in both care levels or a dynamic equilibrium, including the shift from more to less severe levels as defined by Manton [7]. In case of men, we classify 161 out of 412 counties into these two groups and, in case of women, 137 out of 412 counties. In contrast, 93 counties (men) and 108 counties (women), respectively, experienced a compression in both levels. An expansion/equilibrium in any care level combined with a compression/equilibrium in severe care level is detected in 154 counties (men) respectively 161 counties (women).[7]

### Decomposition of the trends - the role of morbidity and mortality effects

Over all counties and for both sexes, the mortality trends have the highest effect on CFLY and CLY in absolute values. On average, from 81 up to 92 % of the increases in CFLY are caused by mortality reductions in CFLY and only 8 to 19 % by morbidity changes (Table 4). Mean $Mort_{\Delta CLY}$ is low, but the overall mean morbidity effect is even lower. The proportion of $Mort_{\Delta CLY}$ ranges between 135 and 656 %. Thus, survival improvements are of higher impact on CLY trend than on the trends in CFLY, especially in case of trends in $CLY_{severe}$. The spatial mapping of the trends of the mortality and morbidity effects shows high heterogeneity and no clear clusters (Additional file 1: Table S6–S8).

The results of the decomposition reveal a high variability in terms of combinations of the morbidity and the two mortality effects. We define the categories "low" ("high") as values less (more) than one standard deviation below (above) the mean, and "medium" as values close to the mean. By definition, most counties have medium morbidity and mortality effects. These counties are mostly expansion counties in case of any care level and mostly compression counties in case of severe care level.

Some combinations do not exist. These are the combinations of a low mortality effect in CLY trend ($Mort_{\Delta CLY}$) and a high mortality effect in CFLY trend ($Mort_{\Delta CFLY}$) – the most favorable trend – and vice versa – the most unfavorable trend.

The two counties Greifswald and Barnim in northeast Germany show the most unfavorable trends and are both experiencing an expansion in any and severe care need. Almost every county with a high morbidity effect is a compression county, while nearly all counties with low morbidity effects are expansion counties. The counties with the second most unfavorable trend ("low morbidity – high $Mort_{\Delta CLY}$ – medium $Mort_{\Delta CFLY}$") are counties in East Germany, in Lower Saxony, and Eastern Bavaria and for females (any care level), these are central Germany (Fig. 2). The counties with the most favorable trends are located in the South German regions and, for females, in the very north of Schleswig-Holstein. These counties are merely compression counties.

More insight can be gained from the association of the morbidity effects with each of the two mortality effects. We estimated bivariate linear regressions for each combination of the three effects differentiated by compression and expansion counties (Additional file 1: Table S9–S11). In terms of CFLY, both the morbidity and the mortality effect add up to additional healthy life years. Counties where morbidity improvements lead to large gains in CFLY are merely compression counties. This association is weakly dependent on $Mort_{\Delta CFLY}$, as indicated by the weak positive slope of the regression line (slopes = [0.040; 0.284]). The slope is similar in compression and expansion counties. The weak positive association is true for both sexes as well as for any and severe care level. In terms of CLY, the morbidity effect

**Table 4** Mean absolute and relative change in life expectancy, care need-free life years and life years with care need at age 65+ by sex and care level, 2001/03–2007/09

| | | Mean change in | | | CFLY change due to | | CLY change due to | |
|---|---|---|---|---|---|---|---|---|
| | | LE | CFLY | CLY | Mortality | Morbidity | Mortality | Morbidity |
| Any Care Level | Men | 1.179 | 0.965 | 0.214 | 0.890 | 0.075 | 0.289 | −0.075 |
| | | | | | 92 % | 8 % | 135 % | −35 % |
| | Women | 1.137 | 0.811 | 0.326 | 0.668 | 0.142 | 0.468 | −0.142 |
| | | | | | 82 % | 18 % | 144 % | −44 % |
| Severe Care Level | Men | 1.179 | 1.139 | 0.040 | 1.038 | 0.101 | 0.142 | −0.101 |
| | | | | | 91 % | 9 % | 356 % | −253 % |
| | Women | 1.137 | 1.100 | 0.037 | 0.893 | 0.207 | 0.244 | −0.207 |
| | | | | | 81 % | 19 % | 667 % | −565 % |

*Note*: All means are weighted by $1/\sum_{i=2001/03}^{2007/09}(\sigma^2(CFLY_i))$
*Source*: Statistical Offices of the Federation and the Länder, Statutory Long-Term Care Censuses 2001–2009 & Regional database (2013); author's calculations

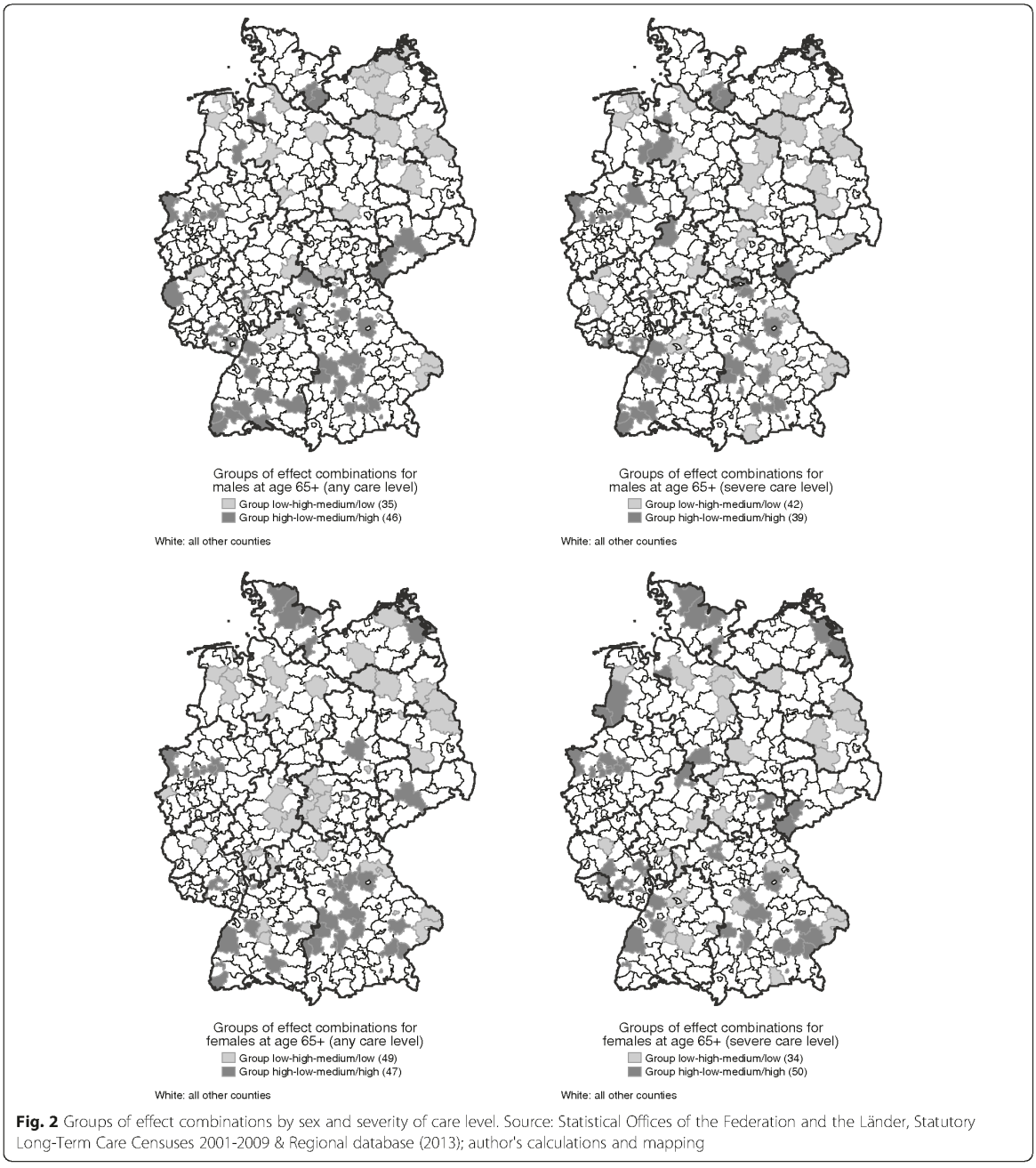



**Fig. 2** Groups of effect combinations by sex and severity of care level. Source: Statistical Offices of the Federation and the Länder, Statutory Long-Term Care Censuses 2001-2009 & Regional database (2013); author's calculations and mapping

must be larger than the mortality effect in terms of compression countries. Thus, the correlation of $Mort_{\Delta CLY}$ and morbidity effects is higher in the compression counties (slopes = [0.537; 0.632]) than in the expansion counties (slopes = [0.176; 0.391]).

Turning to the multinomial regression, we find that the morbidity effect has the highest impact on the health scenarios (Table 5). An increase of CFLY due to reductions in prevalence leads to a massively higher chance of being a dynamic equilibrium county (RRR = [1.271;2.679]) and a compression county (RRR = [1.640;9.893]). Additionally, a gain in $Mort_{\Delta CFLY}$ also results in a negligibly higher chance of experiencing stability (RRR = [1.012;1.052]) or a compression (RRR = [1.011;1.098]). The influence of $Mort_{\Delta CFLY}$

**Table 5** Results of the four multinomial regression models for males and females at age 65+ by care level, mean centred morbidity and mortality effects are measured in change in life days

| | Sex | Covariates (Health scenarios) | Cases (Counties) | Mortality effect in CLY | | Mortality effect in CFLE | | Morbidity effect in CFLE | | Pseudo | Miss- |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RRR | *p*-value | RRR | *p*-value | RRR | *p*-value | $R^2$ | sings |
| Any Care Level | Males | Ref: Expansion | 284 | 1 | | 1 | | 1 | | | |
| | | Stability | 31 | 0.531 | <0.001 | 1.052 | 0.001 | 2.341 | <0.001 | 0.95 | 2 |
| | | Compression | 95 | 0.251 | <0.001 | 1.098 | <0.001 | 5.980 | <0.001 | | |
| | Females | Ref: Expansion | 288 | 1 | | 1 | | 1 | | | |
| | | Stability | 10 | 0.851 | <0.001 | 1.021 | 0.064 | 1.271 | <0.001 | 0.91 | 1 |
| | | Compression | 113 | 0.722 | <0.001 | 1.011 | 0.442 | 1.640 | <0.001 | | |
| Severe Care Level | Males | Ref: Expansion | 161 | 1 | | 1 | | 1 | | | |
| | | Stability | 54 | 0.494 | 0.001 | 1.015 | 0.027 | 2.679 | 0.004 | 0.95 | 2 |
| | | Compression | 195 | 0.230 | <0.001 | 1.035 | <0.001 | 7.464 | <0.001 | | |
| | Females | Ref: Expansion | 140 | 1 | | 1 | | 1 | | | |
| | | Stability | 42 | 0.613 | <0.001 | 1.012 | 0.130 | 1.964 | <0.001 | 0.95 | 1 |
| | | Compression | 229 | 0.205 | <0.001 | 1.017 | 0.115 | 9.893 | <0.001 | | |

*Note*: counties are weighted by $1/\sum_{i=2001/03}^{2007/09}(\sigma^2(CFLY_i))$
*Source*: Statistical Offices of the Federation and the Länder, Statutory Long-Term Care Censuses 2001–2009 & Regional database (2013); author's calculations

is statistically significant for males only. On the contrary, an increase in $Mort_{\Delta CLY}$ leads to a significant decrease in the chance of a county to experience stability (RRR = [0.494;0.851]) or a compression (RRR = [0.205;0.722]).

## Discussion

To our knowledge, this is one of the first studies that explores trends in life years with and without care need and in the resulting health scenarios on a small-area level. Our study confirms that there is high county-level heterogeneity in the trends of the health indicators and in the health scenarios.

Turning to our first research question, the stratified investigation of the trends by care level shows that there are different care need trends in any and in severe care level. While the majority of counties experience a relative expansion of any care level, the mean remaining life span with a severe care level shows stability or compression. For both sexes, the majority of the counties experience a similar health scenario as the whole country. One exception is males with severe care level. For those, the aggregation of the expansion and compression counties to the total country level leads to the wrong conclusion of a stable trend. By combining these trends, our findings confirm the extended theory of dynamic equilibrium that assumes an expansion of morbidity with a shift from severe to moderate types of morbidity [7]. Thus, our conclusions are consistent with previous findings [28, 29, 56, 57].

The diversity in the trends in the health indicators and the notable subnational heterogeneity in terms of the health scenarios cause a disparity in the level of current and future challenges in public health and in social policy according to financial, infrastructural, sociohumanitarian, and welfare state aspects. In the most disadvantaged situation are those counties where the population shows an absolute expansion of care need. The most favorable position is found in counties experiencing an absolute compression. In contrast to the spatial pattern of LE [15], there was no indication for a clear northeast versus southwest gap in both, the health scenarios and the sole trends in the particular indicators.

These findings are strong evidence that there are profound differences between quantity (life expectancy) and quality (care-free life years, health ratio) of life time in the longitudinal trend of the indicators. The classification of the counties by starting level and by trend of the health indicators observed over time unfolds the expected spatial pattern showing counties with unfavorable levels and trends in the North, East and Middle of Germany versus counties with favorable levels and trends in the South and West. Hence, the vanguard counties increased their lead over the rearguard counties in 2001–2009. Furthermore, our study shows that through all counties the higher the level of female LE, of female $CFLY_{severe,}$ and of $CLY_{severe}$ for both sexes in 2001/2003, the lower the changes until 2007/2009. This is an indication for an upper level of these indicators. Only for male CFLY does there seem to be an accelerating process of increase which indicates a much higher potential of gains in life years without care need in future.

We explain these findings by a complex interference of different epidemiological processes. On the one hand,

regional disparities are expected to be the result of divergent historical regional developments and current regional conditions that have joint interfering, mediating, and suppressing regional specific effects. Those can be period and/or cohort effects on the behavior, the psychosocial capacity, and the material situation over the life course (timing and duration) of the individuals [58] that in turn have an indirect effect on the total population's composition. On the other hand, the disparities are the direct result of different compositions of the county's population due to the continuous processes of selectivity because of regional specific trends in mortality and migration [59–61].

Turning to our second research question, where we did not have a specific a priori hypothesis, we find that in absolute terms, by far the majority of the absolute increase in disability-free life years and disabled life years is caused by the increase in the survival of the non-disabled and disabled. In other words, the decrease of mortality rates is decisive for the number of additional years with and without care need. In terms of the health scenarios, however, the morbidity effects, respectively the trends in the prevalence of care need, are the decisive drivers of the chance to experience a compression or an expansion. The mortality effects on the change in disabled life years and on the change in disability-free life years are of much lower importance. This can be stated for both sexes and for any and severe care levels. Thus, slight absolute changes in the prevalence rates of care need have a very high impact on a county's health scenario. These findings confirm the results of Cambois and colleagues [50].

One explanation for the differences between any and severe care level is that the findings are evidence for the dynamic equilibrium theory assuming a shift from severe to moderate care need. Improvements in health services, a higher awareness of health problems, increased medical knowledge, earlier diagnostics, and better and less risky surgical and medical interventions lead to an enlargement of life time with (severe) physical and mental limitations [33, 62]. Another explanation for the expansion is that the increase is a result of a changed behavior of the elderly in terms of acceptance of social benefits, which can be described as a shift from a "gratitude" generation to a "demand" generation. One indication for this argument is the disproportional increase in the initial health evaluations by the medical services of the STLC insurance. Between 2001 and 2009, there was a gain of 23 % [63], while the population at age 65+ increased only by 9 % [64]. The different trends of the two care level groups may be only the result of a higher restriction in legal acceptance assuming that the higher the care level, the more intensive the medical evaluations and the higher the legal and individual barriers. Indirect evidence for the higher restrictions are the decisions of the re-evaluations of more than 40 % of the care receivers conducted annually by the medical services. For example, in 2006, 45.8 % (outpatient) and 69.7 % (inpatient) of the re-evaluated persons in care level 1 were upgraded to a higher care level, while it was only 36.6 and 56.3 % respectively of the persons in care level 2 [65].

Our study has profound strengths. One advantage is the large number of persons included in the STLC censuses, allowing us to investigate trends on subnational level. Because the census is mandatory for all private and public STLC beneficiaries, from an administrative and health care planning point of view, the data are not biased by missing records or problems of loss due to follow-up. The health outcome itself is another advantage, because it is an objective, nationally standardized evaluation by medical experts of the health insurance companies. A third strength is that we assume only a marginal bias due to cultural differences in the definition of care need, as all SLTC regulations are harmonized and binding for all counties. We used the established healthy life years measure that allows comparisons of the health situation even for small populations and only if cross-sectional data for the individuals is available. The use of the advanced method of decomposition by Nusselder and Looman [14] provides deeper insights in the complex interactions of changes in the subnational mortality and morbidity patterns and how these affect health scenarios in Germany. The longitudinal design of the data of the counties is an advantage in many ways; e.g., to investigate the stepwise changes and to compare baseline level with time trends.

However, there are also limitations. First, because only aggregated data was accessible, we are not able to identify whether the disparities are the result of changes in the population's composition due to 1) (health-related) selective migration and selective mortality or are 2) causally related to the life time accumulation or coping mechanisms on the residential hazardous conditions of the individuals. Second, there is also the restriction that the design of the study did not allow us to reveal whether specific cohort or period effects in care need cause a higher magnitude and a higher pace of the county-specific changes. Third, a limitation caused by the design of the study may be the definition and the restrictions in the temporal and cross-county comparability of the health indicator. Fourth, another potential bias may be the quality of the data for the sex- and age-specific population in the counties. Because the population information (unlike birth and death statistics) is not based on registers or a census, but rather on extrapolation estimations, unregistered in- and out-migration may lead to a bias that is expected to be higher at the oldest age groups [66].[8] Post-analyses, however, show that the

bias is marginal. Fifth, registration problems of the SLTC census for the years prior to 2009 may affect the results. Until 2008, an unknown number of persons with semi-inpatient care were double-counted, leading to an over-coverage of persons with care need [67]. Because the share of persons in semi-inpatient care to all persons with care need is very low – in Germany in total about 2 % [67] – this bias is also expected to be marginal. Sixth, yet another limitation is that we do not have county-specific population data by age groups beyond age 85; thus, we are not able to analyze the trends in the internal composition and in the regional disparities at the highest age groups. The prevalence of care need at these ages, however, is very high and therefore regional disparities in CFLY and CLY may be underestimated. Seventh, methodological problems may be caused by using prevalence data with the Sullivan's method instead of individual-level panel data about specific transitions in a multi-state model. Prevalence data overlook the duration of care need or the complexity of possible transitions, which leads to a large bias when the transition rates are highly fluctuable ([68]:86). One study ([28]:101), however, concluded that the limitations of the Sullivan method are acceptable for SLTC data, as the transition rates are assumed to be very stable (incidence/mortality) or very low (rehabilitation). Another problem with the Sullivan method is the dichotomization of the health outcome (with/without care need) which is a simplification of a complex morbidity continuum. We use the strategy of Pattloch [28] to face this problem by analyzing the trends in care need by different levels of severity.

## Conclusion

Our study shows a high diversity in care need challenges on level of counties in Germany. While some counties show very positive trends in terms of a compression of care need, others are confronted with a growing proportion of persons in care need living longer with disability. Overall, the shift from severe to moderate care need is a favorable development considering the financial and emotional burden for individuals and society.

Furthermore, our study detects that the place of residence is another important influence factor of the trends in care need. The study demonstrates that there is a complex interaction between trends in care need prevalence and mortality rates. Since we found that the prevalence is the main driver of the health scenarios, higher efforts are required to reduce the prevalence rates. This is of particular importance in counties in the north and the east of Germany that already have the highest share of persons in care need. In future research it will be important to investigate the trends in the new[9] care level 0 and the causes of the diversity in the mortality and morbidity effects. Thus, one of the emerging questions is whether the specific living conditions in the counties and their changes over time are associated with the trends in care need and mortality. Previous studies [13, 44, 69–71] have found associations of regional characteristics with small-area health conditions, but studies about health trends are rare. Further investigations are needed to uncover the underlying mechanisms of health aging to understand and to deal with the challenges of an increasingly more heterogeneous aging society.

## Endnotes

[1]An additional disaggregation of the population data at the ages 85–89, 90–95, and so on is not available on a county level due to data privacy laws.

[2]For instance: If there is a $\%P_{Men,85+,county\ 1,2003}$(proportion of men at age 85+ to all men at age 75+ in county 1 in 2003) of 15 % and a $\%P_{Men,85+,county\ 1,2005}$ of 16 %, the estimation of $\%P_{Men,85+,county\ 1,2001}$ is 14 %.

[3]The counties are Harz, Salzlandkreis, Jerichower Land, Anhalt-Bitterfeld, Wittenberg, and Dessau-Roßlau.

[4]The overall population weights are based on the total population counts for those years 2001–2006 in which we have information for the old and the new regional entities. For each single year, the (positive or negative) difference between the population of the new and of the old ($P_{old}$) entities equals the population that experienced an administrative change ($P_{change}$). In the last step, the population weights are computed by $P_{change}$ divided by $P_{old}$.

[5]The county- and sex-specific precision weights are computed by 1 dividing by the variance of $CFLY_{any}$, respectively $CFLY_{severe}$ at age 65 + . For further information for the calculation of the variance and the standard errors of CFLY, see [55].

[6]The decomposition tool and the user guide are available on request (contact: w.nusselder@erasmusmc.nl)

[7]The remaining 4 (men) or 6 (women) counties show inconsistent combinations for both levels or a LE decrease.

[8]By comparing the extrapolation results and the results of the official population census in 2011, we show that the cumulated overestimation of the population 65+ in 2011 is only about 1.89 % in Germany as total and only 1.42 % in the unweighted median of all counties. Further, estimated partial CFLY, CLY, HR and LE for the ages 65–84 are highly correlated with those at age 65+ (correlations range from r(LE, females, 2007/09) = 0.86 to r(HR, any care, females, 2007/09) = 0.97)

[9]Care level 0 was introduced in 2008 and covers persons with permanent significant limitations in everyday life competence, who have a need for assistance in the field of basic nursing and household assistance, but who do not yet fulfill the requirements for the qualification into the nursing care level 1.

## Additional files

**Additional file 1: Table S1.** Mid-year population, deaths, and number of persons with any and severe care level by sex at age 65+ in 2001, 2003, 2005, 2007, and 2009, Germany. **Table S2.** LE trend by county for men and women at age 65, 2001/03-2007/09. **Table S3.** CFLY trend by county and severity of care need for men and women at age 65, 2001/03-2007/09. **Table S4.** CLY trend by county and severity of care need for men and women at age 65, 2001/03-2007/09. **Table S5.** HR trend by county and severity of care need for men and women at age 65, 2001/03-2007/09 (PP=percentage points). **Table S6.** Decomposition results: Effects of mortality on the CFLY trend by county, sex and severity of disability for persons at age 65+, 2001/03-2007/09. **Table S7.** Decomposition results: Effects of mortality on the CLY trend by county, sex and severity of care need for persons at age 65+, 2001/03-2007/09. **Table S8.** Decomposition results: Effects of morbidity by county, sex and severity of care need for persons at age 65+, 2001/03-2007/09. **Table S9.** Scatterplots of morbidity effects and mortality effects on the CFLY trend at age 65+ by care level and sex (only counties with expansion or compression included), higher symbol size indicates a higher estimation precision/a lower uncertainty. **Table S10.** Scatterplots of morbidity effects and mortality effects on the CLY trend at age 65+ by care level and sex (only counties with expansion or compression included), higher symbol size indicates a higher estimation precision/a lower uncertainty. **Table S11.** Scatterplots of mortality effects on CFLY trend and mortality effects on CLY trend at age 65+ by care level and sex (only counties with expansion or compression included), higher symbol size indicates a higher estimation precision/a lower uncertainty. (DOCX 5.91 MB)

**Additional file 2:** County-specific study results. (XLS 398 kb)

### Acknowledgements
The authors gratefully acknowledge Wilma Nusselder, Viviana Egidi, Renée Lüskow and the colleagues of the Statistical Offices of the Federation and the Länder.

### Authors' contributions
DK designed the study, acquired the data, carried out the analysis, and wrote the first version of the manuscript. GD helped in the design of the study and revised the manuscript. Both authors read and approved the final manuscript.

### Competing interests
The authors declare that they have no competing interests.

### Endnote
To ensure reproducibility and transparency of the study results, the computed summary health measures, the decomposition results, and the different health scenario classifications can be found in an additional tabular data [see Additional file 2].

### Author details
[1]Institute for Sociology and Demography, University of Rostock and Rostock Center for the Study of Demographic Change, Ulmenstraße 69, D-18055 Rostock, Germany. [2]Institute for Sociology and Demography, University of Rostock, German Center for Neurodegenerative Diseases, and Rostock Center for the Study of Demographic Change, Ulmenstraße 69, D-18055 Rostock, Germany.

Received: 23 December 2015 Accepted: 30 June 2016
Published online: 13 July 2016

### References
1. Gruenberg EM. The failures of success. The Millbank Memorial Fund Quarterly. Health Soc. 1977;55(1):3–24.
2. Kramer M. The rising pandemic of mental disorders and associated chronic diseases and disabilities. Acta Psychiatr Scand. 1980;62(S285):282–97. doi:10.1111/j.1600-0447.1980.tb07714.x.
3. Fries JF. Aging, natural death and the compression of morbidity. N Engl J Med. 1980;303(3):130–5.
4. Fries JF. The Compression of morbidity: near or far? Milbank Q. 1989;67(2): 208–32. http://www.jstor.org/stable/3350138.
5. Fries JF. Measuring and Monitoring Success in Compressing Morbidity. Ann Intern Med. 2003;139(5, part 2):455–9. doi:10.7326/0003-4819-139-5_Part_2-200309021-00015.
6. Fries JF. The Compression of Morbidity. Milbank Q. 2005;83(4):801–23.
7. Manton KG. Changing concepts of morbidity and mortality in the elderly population. Health Soc. 1982;60(2):183–244.
8. Manton KG, Corder L, Stallard E. Chronic disability trends in elderly United States populations: 1982–1994. Proc Natl Acad Sci U S A. 1997;94(6):2593–8.
9. Graham P, Blakely T, Davis P, et al. Compression, expansion, or dynamic equilibrium? The evolution of health expectancy in New Zealand. J Epidemiol Community Health. 2004;58(8):659–66. doi:10.1136/jech.2003.014910.
10. Lievre A, Jusot F, Barnay T, et al. Healthy working life expectancies at age 50 in Europe: a new indicator. J Nutr Health Aging. 2007;11(6):508–14.
11. Jagger C, Gillies C, Moscone F, et al. Inequalities in healthy life years in the 25 countries of the European Union in 2005: a cross-national meta-regression analysis. The Lancet. 2008;372(9656):2124–31.
12. Seko R, Hashimoto S, Kawado M, et al. Trends in life expectancy with care needs based on long-term care insurance data in Japan. J Epidemiol. 2012. doi:10.2188/jea.JE20110069.
13. Kreft D. Spatial Patterns in German Long-term Care and their Relationship with Socioeconomic Factors. In: Doblhammer G, editor. Health among the Elderly in Germany: New Evidence on Disease, Disability and Care Need. Opladen, Berlin, Toronto: Barbara Budrich; 2015.
14. Nusselder W, Looman CW. Decomposition of differences in health expectancy by cause. Demography. 2004;41(2):315–34.
15. Kibele E. Regional Mortality Differences in Germany. Dordrecht: Springer Science + Business Media; 2012.
16. Lalonde M. A new perspective on the health of Canadians. Ottawa: Government of Canada; 1974.
17. Lalonde M. A new perspective on the health of Canadians A working document. Ottawa: Government of Canada; 1981.
18. Teipel S, Fritze T, Ovari A, et al. Regional Pattern of Dementia and Prevalence of Hearing Impairment in Germany. J Am Geriatr Soc. 2015;63(8):1527–33. doi:10.1111/jgs.13561.
19. Petersen G, Wittmann R, Arndt V, et al. Epidemiologie der Multiplen Sklerose in Deutschland: Regionale Unterschiede und Versorgungsstruktur in Abrechnungsdaten der gesetzlichen Krankenversicherung. Nervenarzt. 2014;85(8):990–8. doi:10.1007/s00115-014-4097-4.
20. Kroll LE, Lampert T. Regionalisierung von Gesundheitsindikatoren: Ergebnisse aus der GEDA-Studie 2009. Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz. 2011;55(1):129–40. doi:10.1007/s00103-011-1403-1.
21. Erhart M, Stillfried D von. Analyse regionaler Unterschiede in der Prävalenz und Versorgung depressiver Störungen auf Basis vertragsärztlicher Abrechungsdaten – Teil 1 Prävalenz. Versorgungsatlas. Berlin: Zentralinstitut für die kassenärztliche Versorgung in Deutschland; 2012. p. 1-15.
22. Doblhammer G. Spatial patterns of dementia prevalence and its vas cular risk factors in Germany. In: Doblhammer G, editor. Health among the Elderly in Germany: New Evidence on Disease, Disability and Care Need. Opladen, Berlin, Toronto: Barbara Budrich; 2015.
23. Stolz E, Hamann GF, Kaps M, et al. Regional differences in acute stroke admission and thrombolysis rates in the German federal state of Hesse. Dtsch Arztebl Int. 2011;108(36):607–11. doi:10.3238/arztebl.2011.0607.
24. Statistisches Bundesamt. Pflegestatistik - Pflege im Rahmen der Pflegeversicherung - Ländervergleich - Pflegebedürftige 2013. 2016.
25. Hackmann T, Moog S. Die Auswirkungen der steigenden Lebenserwartung auf die Prävalenz der Pflegebedürftigkeit in Deutschland. ZVersWiss. 2009; 98(1):73–89. doi:10.1007/s12297-008-0045-3.
26. Pinheiro P, Krämer A. Calculation of health expectancies with administrative data for North Rhine-Westphalia, a Federal State of Germany, 1999–2005. Popul Health Metr. 2009;7:4. doi:10.1186/1478-7954-7-4.
27. Häcker J, Hackmann T. Los(t) in long-term care: Empirical evidence from German data 2000–2009. Health Econ. 2012;21(12):1427–43. doi:10.1002/hec.1805.
28. Pattloch D. Pflegebedürftigkeitsfreie Lebenserwartung in Deutschland. Ein Beitrag zur Debatte um die Kompression von Morbidität. Doctor Thesis 2010.
29. Unger R, Müller R, Rothgang H. Lebenserwartung in und ohne Pflegebedürftigkeit. Ausmaß und Entwicklungstendenzen in Deutschland Gesundheitswesen. 2011;73(05):292–7. doi:10.1055/s-0031-1271715.
30. Hoffmann E, Nachtmann N. Old age, the need of long-term care and healthy life expectancy. In: Doblhammer G, Scholz R, editors. Ageing, Care Need and Quality of Life. The Perspectives of Care Givers and People in Need of Care. Wiesbaden: Springer VS Research; 2010. p. 162–76.

31. Freedman VA, Martin LG, Schoeni RF. Recent trends in disability and functioning among older adults in the United States: a systematic review. JAMA. 2002;288:3137–46.
32. Christensen K, Doblhammer G, Rau R, et al. Ageing populations: the challenges ahead. The Lancet. 2009;374:1196–208.
33. Crimmins EM, Beltran-Sanchez H. Mortality and morbidity trends: is there compression of morbidity? J Gerontol B Psychol Sci Soc Sci. 2010;66B(1):75–86. doi:10.1093/geronb/gbq088.
34. Wolf C. Wohnquartier und Gesundheit: Eine Mehrebenenanalyse. In: Kecskes R, Wagner M, Wolf C, editors. Angewandte Soziologie. Wiesbaden: VS Verlag für Sozialwissenschaften; 2004. p. 103–26.
35. Breckenkamp J, Mielck A, Razum O. Health inequalities in Germany: do regional-level variables explain differentials in cardiovascular risk? BMC Public Health. 2007;7:132. doi:10.1186/1471-2458-7-132.
36. Dragano N, Bobak M, Wege N, et al. Neighbourhood socioeconomic status and cardiovascular risk factors: a multilevel analysis of nine cities in the Czech Republic and Germany. BMC Public Health. 2007;7:255. doi:10.1186/1471-2458-7-255.
37. Queste A. Analyse kleinräumiger Mortalitätsraten in Deutschland. Bielefeld: Landesinstitut für den Öffentlichen Gesundheitsdienst NRW; 2007.
38. Strohmeier KP, Schultz A, Bardehle D, et al. Sozialräumliche Clusteranalyse der Kreise und kreisfreien Städte und Gesundheitsindikatoren in NRW. Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)). 2007;69(1):26–33. doi:10.1055/s-2007-960491.
39. Kemptner D, Wildner M, Abu-Omar K, et al. Regionale Unterschiede des Gesundheitsverhaltens in Bayern - Mehrebenenanalyse einer bevölkerungsrepräsentativen Befragung in Verbindung mit sozioökonomischen Strukturdaten. Das Gesundheitswesen. 2008;70(1):28–37. doi:10.1055/s-2007-1022523.
40. Razum O, Altenhöner T, Breckenkamp J, et al. Social epidemiology after the German reunification: East vs. West or poor vs. rich? Int J Public Health. 2008;53(1):13–22.
41. Voigtländer S, Berg-Beckhoff G, Razum O. Gesundheitliche Ungleichheit: Der Beitrag kontextueller Merkmale. Frankfurt am Main: Peter Lang; 2008.
42. Voigtländer S, Berger U, Razum O. The impact of regional and neighbourhood deprivation on physical health in Germany: a multilevel study. BMC Public Health. 2010;10(1):403. doi:10.1186/1471-2458-10-403.
43. Voigtländer S, Berger U, Razum O. Zunehmende regionale Unterschiede bei den Lebensverhältnissen in Deutschland und ihre Bedeutung für die Erklärung gesundheitlicher Ungleichheit. Gesundheitswesen. 2010;72(5):301–8. doi:10.1055/s-0029-1233487.
44. Diehl K, Schneider S. How relevant are district characteristics in explaining subjective health in Germany? – A multilevel analysis. Soc Sci Med. 2011; 72(7):1205–10. doi:10.1016/j.socscimed.2011.02.013.
45. Latzitis N, Sundmacher L, Busse R. Regionale Unterschiede der Lebenserwartung in Deutschland auf Ebene der Kreise und kreisfreien Städte und deren möglichen Determinanten. Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)). 2011;73(4):217–28. doi:10.1055/s-0030-1252035.
46. Kibele E. Individual- and area-level effects on mortality risk in Germany, both East and West, among male Germans aged 65+. Int J Public Health. 2014; 59(3):439–48. doi:10.1007/s00038-013-0480-3.
47. Kreft D, Doblhammer G. Contextual and individual determinants of health among Aussiedler and native Germans. Health Place. 2012;18(5):1046–55. doi:10.1016/j.healthplace.2012.05.008.
48. Maier W, Fairburn J, Mielck A. Regionale Deprivation und Mortalität in Bayern. Entwicklung eines 'Index Multipler Deprivation' auf Gemeindeebene. Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany)). 2012;74(7):416–25. doi:10.1055/s-0031-1280846.
49. Ziegler U, Doblhammer G. Cohort Changes in the Incidence of Care Need in West Germany Between 1986 and 2005. Eur J Popul. 2008;24(4):347–62. doi:10.1007/s10680-007-9144-4.
50. Cambois E, Blachier A, Robine J. Aging and health in France: an unexpected expansion of disability in mid-adulthood over recent years. Eur J Public Health. 2013;23(4):575–81. doi:10.1093/eurpub/cks136.
51. Arntz M, Sacchetto R, Spermann A, et al. The German Social Long-Term Care Insurance: Structure and Reform Options: IZA Discussion paper No. 2625 2007.
52. Sullivan DF. A single index of mortality and morbidity. HSMHA Health Rep. 1971;86(4):347–54.
53. Chiang CL. The life table and its applications. Malabar: Robert E. Krieger; 1984.
54. Arriaga EE. Measuring and explaining the change in life expectancies. Demography. 1984;21(1):83–96. http://www.jstor.org/stable/2061029.
55. Jagger C, Cox B, Le Roy S, et al. Health Expectancy Calculation by the Sullivan Method: A Practical Guide. EHEMU Technical Report 2006; 3rd Edition.
56. Gärtner K, Scholz RD. Lebenserwartung in Gesundheit. In: Lebensstile, Lebensphasen, Lebensqualität Interdisziplinäre Analysen von Gesundheit und Sterblichkeit aus dem Lebenserwartungssurvey des BIB. 2005. p. 311–31.
57. Unger R, Schulze A. Können wir (alle) überhaupt länger arbeiten?: Trends in der gesunden Lebenserwartung nach Sozialschicht in Deutschland. Zeitschrift für Bevölkerungswissenschaft. 2013;38:545–64.
58. Bartley M. Health Inequality. An Introduction to Theories, Concepts and Methods. Cambridge: Polity Press; 2004.
59. Zajacova A, Burgard SA. Healthier, wealthier, and wiser: a demonstration of compositional changes in aging cohorts due to selective mortality. Popul Res Policy Rev. 2013;32(3):311–24. doi:10.1007/s11113-013-9273-x.
60. Tong S. Migration bias in ecologic studies. Eur J Epidemiol. 2000;16(4):365–9. doi:10.1023/A:1007698700119.
61. Kibele E, Janssen F. Distortion of regional old-age mortality due to late-life migration in the Netherlands. Demographic Res. 2013;29(5):105–32.
62. Robine J, Mormiche P, Sermet C. Examination of the Causes and Mechanisms of the Increase in Disability-Free Life Expectancy. J Ageing Health. 1998;10(2):171–91.
63. Medical Advisory of Social Health Insurance. Expertise statistics in terms of the reasons for expertise (nursing care insurance): In- and outpatient first expertises and expertise recommendation of need of care carried out by medical services ("Medizinische Dienste"). Classification: years, expertise results. 2014.
64. Statistische Ämter des Bundes und der Länder. GENESIS-Datenbank [GENESIS database] 2015. Available at: https://www-genesis.destatis.de/genesis/online.
65. Medizinischer Dienst der Spitzenverbände der Krankenkassen e.V. Pflegebericht des Medizinischen Dienstes 2006. 2007.
66. Jdanov DA, Scholz RD, Shkolnikov V. Official population statistics and the Human Mortality Database estimates of populations aged 80+ in Germany and nine other European countries. DemRes. 2005;13:335–62. doi:10.4054/DemRes.2005.13.14.
67. Statistische Ämter des Bundes und der Länder. Pflegestatistik 2009, Pflege im Rahmen der Pflegeversicherung: Kreisvergleich 2012.
68. Mathers C, Robine J. How good is Sullivan's method for monitoring changes in population health expectancies. J Epidemiol Community Health. 1997;51:80–6.
69. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health out Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review socioeconomic critical review. J Epidemiol Community Health. 2001;55:111–22.
70. Kawachi I, Berkman LF, editors. Neighborhoods and Health. New York: Oxford University Press; 2003.
71. Diez-Roux AV, Mair C. Neighborhoods and health. Ann N Y Acad Sci. 2010; 1186(1):125–45. doi:10.1111/j.1749-6632.2009.05333.x.

## 3. Study 3



Health & Place 18 (2012) 1046–1055

Contents lists available at SciVerse ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

# Contextual and individual determinants of health among Aussiedler and native Germans

Daniel Kreft*, Gabriele Doblhammer

*University of Rostock, Department of Sociology and Demography, Rostock Center for the Study of Demographic Change, Ulmenstraße 69, D-18055 Rostock, Mecklenburg-Vorpommern, Germany*

ARTICLE INFO

*Article history:*
Received 2 September 2011
Received in revised form
25 May 2012
Accepted 31 May 2012
Available online 19 June 2012

*Keywords:*
Health disparities
Ethnic German immigrants
Social gradient
Healthy migrant effect
Multilevel logistic regression analysis

ABSTRACT

Aussiedler, also referred to as ethnic German immigrants from countries of the former Soviet Union and other parts of Eastern Europe, constitute one of the largest immigrant groups in Germany. Little is known about their health relative to the health of native Germans. Using the German Microcensus 2005, which includes information about the health of 10,022 Aussiedler and 322,813 native Germans aged 20+ we find that in both groups high regional centrality depresses health, as does living in a region with low GDP. The proportion of foreigners does not have any consistent effect. The two groups differ with respect to educational gradients in health: there is none for Aussiedler, while there is a steep gradient for native Germans. Aussiedler who have lived in Germany for less than 15 years are healthier than native Germans which supports the healthy migrant hypothesis. Their deteriorating health status by duration of stay suggests that migration, deprivation and discrimination may have negative effects on the health of Aussiedler.



## 1. Introduction

In the years immediately following reunification, the Federal Republic of Germany experienced a high level of net in-migration, largely caused by the inflow of ethnic German immigrants. Ethnic German immigrants (also called resettlers or Aussiedler) are (descendants of) emigrants who moved from what is now German territory to Eastern Europe before the 20th century. Hoping to improve their living conditions in terms of wealth, job opportunities and social acceptance, many of these descendents decided to migrate to Germany (Greiner, 2002). These trends were further promoted by the socio-political and economic collapse in the countries of the former Soviet Union and the passage of legislation affecting Aussiedler in-migration (the pro-return-migration policy of the German government) in the 1990s (Kyobutungi et al., 2006a).

In the 21st century, Aussiedler immigration has almost stopped. However, due to many years of very high levels of in-migration, the Aussiedler population in Germany has grown rapidly. With almost 3.27 million registered persons or about 4% of Germany's population in 2009, Aussiedler are the largest group of immigrants in present-day Germany (Federal Statistical Office, 2010). However, the number of studies on this group is still low.

This study has two aims. First, we will explore whether a selection effect in terms of health – the so called healthy migrant effect (e.g., Kliewer, 1992) – exists among Aussiedler, and whether the health disparity attenuates with the duration of stay in Germany.

Second, we will examine whether contextual factors of the living environment affect the health of migrants beyond their individual characteristics.

### 1.1. Why investigate the health of Aussiedler?

Aussiedler are a distinct group of migrants; different from, for example, Turkish migrants, who constitute the second largest group of migrants in Germany (they represent about 3% of Germany's population in 2009; Federal Statistical Office, 2010). One of the special characteristics of Aussiedler results from the unique German policy on Aussiedler. They are legally recognized as "Germans by status", they can directly acquire citizenship and they are entitled to participate in the health and welfare system, with all its rights and responsibilities. Until the 1990s, German immigration policy called for the permanent integration of Aussiedler, but only temporary integration for most of the so-called "guest workers" (labour migrants, like Turkish migrants). Aussiedler have access to the full range of government assistance programmes (financial transfers, government-funded integration programmes and language courses, etc.), which may promote

* Corresponding author. Tel.: +43 381 498 4328; fax: +43 381 498 4395.
*E-mail addresses:* kreft@rostockerzentrum.de, daniel.kreft2@uni-rostock.de (D. Kreft), doblhammer@rostockerzentrum.de (G. Doblhammer).

1353-8292/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.healthplace.2012.05.008

integration and social participation. These benefits may help to reduce some of the negative effects on health due to socio-economic deprivation, problems of integration and migration stress. By contrast, most of the other groups of immigrants (especially non-EU migrants) do not have that privileged legal status (Kosubek, 1998). However, German policy on Aussiedler also covers restrictive guidelines, like the assignment of a place of residence to Aussiedler in Germany, which is of interest when analysing spatial aspects of health. Until 2010, Aussiedler who requested social benefits shortly after in-migration were assigned to one the various regions of Germany based on an official quota system. Although Ronellenfitsch et al. (2006) considered the assignment to be a quasi-random procedure, it can be assumed that systematic trends of trans-regional migration (especially the migration flows from eastern to western Germany) affected the composition of the regional Aussiedler population in terms of socioeconomic characteristics (Haug and Sauer, 2007). In addition, Aussiedler live in urban and peripheral areas and were not found to be as concentrated in highly urbanised regions as other groups of migrants, like Turkish migrants.

Aussiedler have achieved a high level of social and economic integration in German society (Woellert et al., 2009), in part because of the intensive promotion by German social policy. The integration of Aussiedler can be considered as an example of "best practice", which makes them an interesting study population beyond the German context. First, they can be regarded as a sort of benchmark when analysing the effectiveness of integration policies, e.g., in terms of social and public health aspects. This may help to develop future acculturation and naturalisation strategies and to evaluate their consequences. Second, their degree of integration, together with their high levels of education, makes them an attractive population for health research on migrants in general. Considering the well-documented favourable effects of high levels of education on health, the confounding effect of education on health in the Aussiedler population is expected to be smaller than in other migrant groups. Thus, positive or negative effects of living circumstances, life style as well as selection effects such as the healthy migrant effect should be better visible because they are less confounded.

### 1.2. State of research—the health of Aussiedler

Studies about the mortality and morbidity of Aussiedler are rare. Relative to native Germans, Aussiedler have lower levels of overall and of cardiovascular mortality (Ronellenfitsch et al., 2006), the same level of all-cancer mortality for male Aussiedler, but higher lung cancer mortality, lower all-cancer mortality (especially lung and breast cancer mortality) for female Aussiedler (Kyobutungi et al., 2006b) and a significantly higher risk of non-natural mortality for male Aussiedler, especially in suicide (Kyobutungi et al., 2006a). The latter seems to be an indicator of significant mental health problems (overview of these studies see Becher et al., 2007).

The results of studies of the health of Aussiedler have so far been inconsistent. Shortly after in-migration, Aussiedler have worse self-rated health and a higher number of reported complaints, but a lower frequency of visits to practitioners and specialists compared to native Germans (Wittig et al., 2004). The negative health effects of the strain of the migration experience, together with unchanged, traditional health-seeking behaviours, may explain this paradox.

Divergent results have been reported concerning the health of Aussiedler by the duration of stay. While the level of health satisfaction of immigrants from Eastern Europe has been found to be deteriorating (Ronellenfitsch and Razum, 2004), Aussiedler in Augsburg (Bavaria) have reported improvements in self-perceived health by increasing duration of stay (Aparicio et al., 2004).

### 1.3. State of research—effects of regional characteristics on health

In recent years, the number of international studies examining contextual effects on health has grown rapidly. For many contextual small-level characteristics, effects on self-rated health, cardiovascular morbidity, risk factors and mortality have been detected; however these effects have generally been found to be smaller than the effects of individual factors (e.g., reviews by Pickett and Pearl (2001) or Riva et al. (2007)). Poor self-rated health is, for example, strongly associated with bad socioeconomic conditions in a region; negative perceptions of environmental conditions in the area; and lower levels of social capital, political engagement and transport wealth. Due to divergent measurements of health or methodological and conceptual problems, the conclusions we can draw from the literature are limited (Riva et al., 2007).

In the case of Germany, there are relatively few (but a rapidly increasing) number of studies investigating contextual effects on health. The findings on the effects of area-level characteristics on mortality (Queste, 2007; Breckenkamp et al., 2007; Kibele, 2008) and health (Wolf, 2004; Kemptner et al., 2008) have been inconsistent. While no evidence was found for effects of regional deprivation on cardiovascular mortality in the mid-1980s (Breckenkamp et al., 2007), the unemployment rate, the share of employees with university degree (both sexes), living space (males) and GDP per capita (females) were shown to be associated with the mortality of people aged 65+ in 1998 to 2004 (Kibele, 2008).

In a study of Bavarian regions, socioeconomic disparities were shown to have a negative effect on self-rated health and health behaviours (e.g., physical inactivity, alcohol consumption, obesity, unhealthy diet) (Kemptner et al., 2008). Individuals living in regions with a high unemployment rate, a high degree of rurality, a high proportion of elderly people (aged 65+) and a low proportion of foreigners have been found to have statistically significant higher odds of poor self-rated health (Diehl and Schneider, 2011). Lower levels of infrastructure (Voigtländer et al., 2008) and a higher degree of isolation of the elderly (Cassel, 1976), which may affect their ability to reach their physicians or participate in social events, are explanations for the detrimental effects of rurality. The more vibrant social life and cultural richness in regions with a high degree of ethnic diversity may promote health (Diehl and Schneider, 2011).

Ecological factors also play a role in explaining the association between regional deprivation and health. The adjustments for environmental characteristics of the neighbourhood (perceived air pollution, perceived noise and perceived distance to recreational resources) weaken the effect of economic deprivation on health. However, the relationship between health disadvantages and socioeconomic deprivation at the level of neighbourhoods (as measured by the average purchasing power) and regions (as measured, for example, by unemployment rates) does not completely disappear (Voigtländer et al., 2010).

The number of studies that have focused on the contextual effects on the health of migrants is significantly lower. In Belgium, immigrants from Turkey and Morocco have poorer self-perceived health than native Belgians (Lorant et al., 2008). High unemployment, poor environmental conditions, a lack of public amenities, a poor social environment and a low density of non-natives in a region have been shown to have significantly negative effects on the health status. Controlling for individual socio-economic status and contextual factors were found to reduce the migrants' health disadvantage. These results are an indicator of the "double jeopardy" faced by migrants: risks at the individual level and at

the contextual level lead to poor health among migrants (Lorant et al., 2008).

All studies mentioned above explored effects of a few selected regional characteristics on the individual health of the total population. One aim of our study is to analyse if these effects differ in magnitude and tendency between native Germans and Aussiedler.

## 2. Data and methods

### 2.1. Data

With a sample of nearly 820,000 persons, the German Microcensus is well-suited for analysing living conditions on a subnational level for ethnic minorities in Germany. The Microcensus is an annual representative cross-sectional and multi-purpose survey with information about general socio-demographic, economic and behavioural aspects of life (Federal Statistical Office, 2012).

The survey year 2005 of the German Microcensus (hereafter referred to as Microcensus 2005) has been chosen for this analysis because it combines detailed information about migratory background and information on individuals' health status. To meet the requirements of the German data protection law and to ensure an adequate case number per region, the regional level will be defined as "spatial planning regions" (*Raumordnungsregionen*). Due to the very low number of Aussiedler in the East German regions, the analysis is limited to persons living in households in regions in West Germany and Berlin (the eastern and western parts of the city) only.

To collect information about the individuals' residential regions in 2005, the INKAR 2007 database is used. The INKAR 2007 database of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) covers a wide range of indicators on divergent administrative levels. It is also the first release of the INKAR dataset that includes data from the year 2005. Many indicators are obtained from the database of the national statistical office, while other factors are directly measured by the Institute staff (BBSR, 2007).

### 2.2. Variables

#### 2.2.1. Migration status

The Microcensus 2005 includes information on country of birth, year of immigration, naturalisation status and previous and present citizenship. By combining these facts, it is possible to approximate the migration status. Native Germans are defined as persons holding German citizenship not acquired by an act of naturalisation, and who were born in Germany in its present boundaries. German citizens who moved to Germany before 1949 are also classified as native Germans. Aussiedler are assumed to be foreign-born persons[1] with German citizenship (as well as with additional citizenships) not acquired by an act of naturalisation, and who moved to Germany after 1949 (definitions based on Federal Statistical Office, 2007, p, 325–330).

Our analysis covers a total of 11,489 Aussiedler (2.97% of the whole sample) aged 20 years and older. The reference group is made up of 375,762 native Germans aged 20+ (97.03%). By using the information on the year of immigration, the duration of stay in Germany is computed. This information will be used to stratify Aussiedler into four subgroups by length of stay: Aussiedler who have been living in Germany for less than 15 years (in-migration after 1990), for 15 to 30 years (in-migration after 1975) and for more than 30 years (in-migration before 1975). Persons with missing information on the year of immigration are combined in an additional category. The stratification is used to analyse health disparities among different immigration cohorts of Aussiedler.

#### 2.2.2. Health outcomes

The Microcensus 2005 includes a health module in addition to the standard programme with a limited set of indicators. In the following analysis, the general health status is measured by the following questions: "Have you been ill or had an accidental injury within the last four weeks [before the interview]?" and "How long lasts (did last) your illness or your injury?". In this study all persons with an illness that lasts (lasted) at least four weeks are defined as unhealthy. The time frame of four weeks and more was chosen in order to exclude persons with short-term illnesses (e.g., flu or other infections). Because answering this question is optional, the number of cases with missing information is higher than for most of the other variables. In sum, 52,949 native Germans (14.09% out of the total sample) and nearly 1467 Aussiedler (12.77%) had to be excluded from the analysis due to missing health information. In total, 322,813 native Germans (96.99% of the final sample) and 10,022 Aussiedler (3.01%) remain in the sample under study.

#### 2.2.3. Control variables on individual level

When analysing contextual effects on individual health outcomes, the effects of personal characteristics will be controlled for. These individual level variables are age (in 10-year age groups), sex, family status (single, married – living together, married – living apart, divorced, widowed), net equivalent income (up to €450, more than €450 to €640, more than €640 to €1040, €1040 to €1600, more than €1600), education (no degree=no degree and not in education, low degree=lower secondary degree, medium degree=secondary degree, high degree=higher education/university entrance qualification, in education/missing), body mass index (underweight=body mass index of less than 18.5, normal=bmi up to 25, light overweight=bmi up to 30, high overweight=bmi of more than 30) and smoking habits (never smoker, former smoker, (current) smoker, missing). In addition, the quarter of the year of the interview will be included in the models to control for the seasonal effects of health.

#### 2.2.4. Contextual variables

Inspired by the literature (e.g., Pickett and Pearl, 2001; Riva et al., 2007; Lorant et al., 2008; Van Oyen et al., 2010; Voigtländer et al., 2010; Diehl and Schneider, 2011) three contextual factors are included in the models: centrality of regional population distribution, gross domestic product (GDP) per capita and proportion of foreigners in a region. The indicators are selected on the basis of their high validity in terms of cross-regional comparability and due to their frequent use in previous studies. The latter permits us to compare our results with earlier findings.

The centrality of a region is an indicator for settlement structure and population agglomeration, but also of the regional cohesion. Centrality is defined as the percentage of persons in the region who live less than 30 min journey away from the next regional centre (*Oberzentrum*), and it is measured by the BBSR.

The gross domestic product (GDP) per capita of a region is an indicator for the economic performance/structure and the socio-economic composition of the regional population. The economic performance itself can be seen as an indicator for the (financial) scope of action of regional policy administration.

[1] Born in Poland, the Czech Republic, Slovakia, Slovenia, Hungary, Romania, Bulgaria, the Russian Federation, Estonia, Latvia, Lithuania and other countries of the former Soviet Union, which are the legally recognised main resettlement regions ("Aussiedlungsregionen"). Ethnic Germans/persons of German origin from other regions than these resettlement regions are not defined as Aussiedler by German law.

The proportion of foreigners in a region is an indicator of the attractiveness of a region as a destination of immigration (e.g., in terms of regional social capital, such as established communities and networks of immigrant groups or the regional social climate/level of acceptance of immigrants).

The macro variables are grouped into three categories: persons who live in the 10% of the western German regions with the lowest level of centrality/lowest GPD per capita/lowest proportion of foreigners, persons in the 10% of the regions with the highest level of centrality/highest GPD per capita/highest proportion of foreigners and persons in the remaining regions.

### 2.3. Statistical methods

Binary logistic multilevel regression models are used to model the effects of individual and contextual variables on an individual's health status (Snijders and Bosker, 1999). In the following analysis, random-intercept models will be calculated. All estimations are performed using the "xtlogit" routine in STATA version 10.1 (Rabe-Hesketh and Skrondal, 2005). We choose the median odds ratio (MOR) as a measure of heterogeneity on the level of regions (Larsen and Merlo, 2005). The MOR ranges from 1 (no variability between the regions) to very high values (high between region variance).

## 3. Results

The spatial distribution of foreign-born Aussiedler differs considerably between East and West Germany, with most Aussiedler being concentrated in the highly urbanised regions of Western Germany (Fig. 1). In the West, the proportion of Aussiedler exceeds 1.7% in almost all regions, except in parts of Bavaria, Rhineland-Palatinate and north-western Germany. The percentages are highest (up to 5.1%) in the mostly highly urbanised regions of Hessen, North Rhine-Westphalia, Lower Saxony, Baden-Württemberg and Bremen. In East Germany, the proportion is generally below 0.6%, with the notable exception of Berlin (1.3%).

Native Germans and Aussiedler differ in terms of their health, family status, education and income (Table A1 in the appendix). 7% of the native Germans are in poor health. The proportion of unhealthy people is highest among Aussiedler who have been living in Germany for more than 30 years (11%). Those living in Germany for up to 15 years are the healthiest (5% in poor health). The differences are significant.

Corresponding to the stratification variable (duration of stay), the age structures of the sub-groups differ significantly. Native Germans have a higher mean age (51.6 years) than Aussiedler living in Germany for less than 30 years (41.0 years for $<15$ years; 44.8 years for 15 to $<30$ years), the Aussiedler population with long-term residence have the highest average age (61.9 years for $>30$ years). The differences in mean age are highly significant (see Table A2 in the appendix).

The gender distribution does not differ between the five subgroups, with women slightly outnumbering men. This is also true for the timing of the interviews, which were mainly performed in the fourth quarter of 2005. The family status differs slightly between the subgroups. Most Aussiedler and native Germans are married and live together with their partners while the percentage of single persons is smallest among Aussiedler ($>30$ years) and is highest among native Germans. The proportions of divorced and widowed people among Aussiedler living in the country for more than 30 years are notably higher than among native Germans.

The majority of Aussiedler have low levels of education. The percentage of persons with no education is slightly (but significantly) higher for Aussiedler (about 6% to 8%) than for native Germans (about 2%). Most of the native Germans and Aussiedler have a net equivalence income of between €640 and €1600, but there are statistically significant differences between the subgroups. The mean income of Aussiedler rises with an increasing duration of stay (€898 for $<15$ years to €1558 for $>30$ years, €1576 for native Germans). The proportion of persons with an income of less than €640 is highest for Aussiedler ($<15$ years; about 31%) and is smallest for Aussiedler ($>30$ years) and native

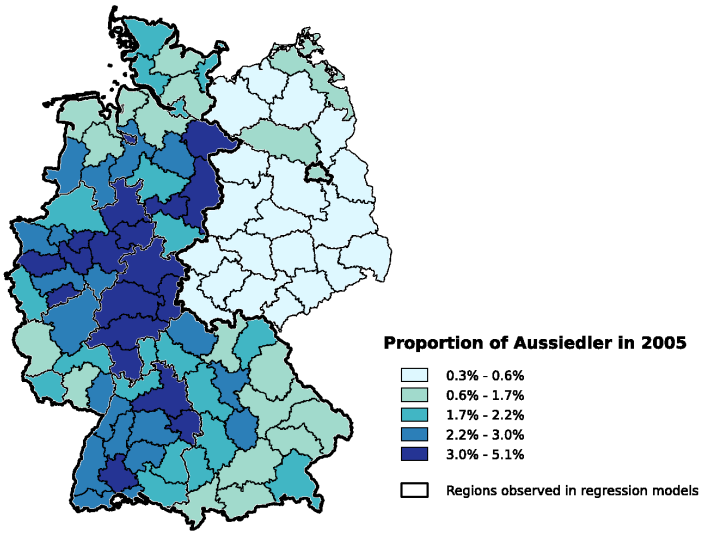



**Fig. 1.** Proportion of Aussiedler by region in 2005.
*Source:* Microcensus 2005, Statistische Ämter des Bundes und der Länder, Bundesamt für Kartographie und Geodäsie
Note: The number of cases for West German regions ranges from 978 to 16,353 native Germans (mean = 4304) and from 18 to 653 Aussiedler (mean=134), while the numbers for East German regions are from 1579 to 6811 native Germans (mean = 3809) and from 6 to 38 Aussiedler (mean = 17).

Germans (about 6%). The differences in income between native Germans and Aussiedler are mostly significant.

The body mass index of Aussiedler does not differ from that of native Germans. Among Aussiedler, however, there is a trend towards light and high overweight with increasing duration of stay (light/high overweight: about 41% for $<15$ years and about 47% for $>30$ years). Most persons have never smoked, but Aussiedler (about 47% to 51%) have a higher proportion of never smokers than native Germans (about 44%). Smoking prevalence (about 22%) does not significantly differ between the subgroups (except Aussiedler $>30$ years: 17%).

In all of the subgroups, the vast majority live in regions of average centrality, with an average GDP per capita and with an average proportion of foreigners. However, with an increasing duration of stay, Aussiedler are concentrated in regions with the highest centrality, the highest GDP per capita or the highest proportion of foreigners.

Our multivariate analysis consists of three nested models. In the first model, which we call the baseline model, we estimate the risk of poor health for the five subgroups without controlling for any individual characteristic. The extended model controls for age and sex, while the final model includes both individual characteristics (education and net equivalence income, the quarter of the year of the interview, family status, smoking habits and body mass index) and macro factors (centrality of population distribution, GDP per capita and proportion of foreigners).

The first column of Table 1 shows that, in the baseline model, Aussiedler with a duration of stay of less than 30 years have better health than native Germans, while Aussiedler who have been living in Germany for more than 30 years have worse health. All disparities are highly significant.

After controlling for the individual characteristics and the macro factors (see Table 1, model III) we find that Aussiedler who have been in Germany for less than 15 years have a slight health advantage (OR=0.77, $p=0.160$) compared to Aussiedler living more than 15 years in Germany and to native Germans. The comparison of the between-region-variance (BRV) shows an increase of 11% in model II and a decrease of 27% in model III as compared to the unadjusted model I. With a reduction in MOR from 1.22 (model I) to 1.19 (model III) some unaccounted regional variance is still remaining.

We use the final model to show the effects of the individual characteristics (Table A3 in the appendix) and the effects of the macro factors (Table 2) on the health of native Germans and Aussiedler.

In general, the effects of the individual factors are the same for Aussiedler and native Germans. However, two interesting differences emerge.

First, native Germans and Aussiedler differ in the effects of education on health. While native Germans with no degree or a low degree have the greatest health disadvantage, there is no consistent, statistically significant educational gradient in the health of Aussiedler. A significant social gradient does, however, exist for the effect of income on health. For both native Germans and Aussiedler, the health of individuals with low income is

**Table 2**
Odds of longstanding illness among native Germans and Aussiedler: contextual variables only, odds ratio and 95% CI from multilevel regression.
Source: Microcensus 2005, INKAR 2007, Statistische Ämter des Bundes und der Länder.

| Covariates | Native Germans | | Aussiedler | |
|---|---|---|---|---|
| | *N*=322,813 | | *N*=10,022 | |
| | OR | 95% CI | OR | 95% CI |
| Centrality of population distribution | | | | |
| Low centrality | **1** | | **1** | |
| Average centrality | 1.26 | (1.07,1.47) | 1.48 | (0.93,2.37) |
| High centrality | 1.44 | (1.12,1.85) | 1.84 | (1.10,3.08) |
| Gross domestic product per capita | | | | |
| Low GDP per capita | **1** | | **1** | |
| Average GDP per capita | 0.86 | (0.74,1.00) | 0.91 | (0.63,1.31) |
| High GDP per capita | 0.66 | (0.50,0.87) | 0.56 | (0.36,0.89) |
| Proportion of foreigners | | | | |
| Low proportion of foreigners | **1** | | **1** | |
| Average proportion of foreigners | 0.85 | (0.73,0.99) | 1.17 | (0.72,1.89) |
| High proportion of foreigners | 0.89 | (0.70,1.14) | 1.55 | (0.90,2.66) |

Controlled for age, sex, quarter of the year of the interview, family status, education, income, body mass index, smoking habits, and duration of stay (Aussiedler only).

**Table 1**
Odds of longstanding illness for native Germans and Aussiedler: odds ratio, 95% CI from multilevel regression and random effects (variance, median odds ratio and percentage of explained variance)
Source: Microcensus 2005, INKAR 2007, Statistische Ämter des Bundes und der Länder

| | Model I | | Model II | | Model III | |
|---|---|---|---|---|---|---|
| | *N*=332,835 | | *N*=332,835 | | *N*=332,835 | |
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Native Germans | **1** | | **1** | | **1** | |
| Aussiedler (<15 years) | 0.60 | (0.43,0.84) | 1.05 | (0.74,1.49) | 0.77 | (0.54,1.11) |
| Aussiedler (15 to <30 years) | 0.78 | (0.71,0.87) | 1.13 | (1.01,1.26) | 0.99 | (0.89,1.11) |
| Aussiedler (30+ years) | 1.58 | (1.40,1.79) | 1.09 | (0.97,1.23) | 1.04 | (0.91,1.17) |
| Aussiedler (no information) | 0.30 | (0.20,0.44) | 0.70 | (0.47,1.04) | 0.67 | (0.45,1.00) |
| **Random effects** | | | | | | |
| Between region variation [a] | 0.045 | | 0.050 | | 0.033 | |
| MOR [b] | 1.22 | | 1.24 | | 1.19 | |
| % explained variation [c] | | | −11% | | 27% | |

Note: Model I—Baseline model
Model II—Extended baseline model, controlled for age and sex
Model III—Final model, controlled for all individual (age, sex, quarter of the year of the interview, family status, education, income, body mass index, and smoking habits) and macro factors (centrality of population distribution, GDP per capita, and proportion of foreigners)

[a] Variance on level of the regions.
[b] Median odds ratio.
[c] Compared to the baseline model.

worse than the health of individuals with high income. This effect is more pronounced for Aussiedler than for native Germans.

Second, the effect of the body mass index differs. In general, individuals with high overweight have worse health than those with normal weight. Underweight native Germans have worse health, while underweight Aussiedler have no significant health disadvantage.

Native Germans living in highly urbanised regions have the highest risk of poor health (OR=1.44, $p=0.004$) (Table 2). High centrality also has a negative effect on the health of Aussiedler (OR=1.84, $p=0.020$).

Native Germans living in regions with a high GDP per capita have the lowest risk of poor health, while those living in economically disadvantaged regions have the highest (OR=0.66, $p=0.003$). Aussiedler living in economically prosperous regions have better health than Aussiedler living in regions with low GDP (OR=0.56, $p=0.013$).

The proportion of foreigners shows different effects on the health of Aussiedler and native Germans. While a high proportion of foreigners has no effect on the health of native Germans (OR=0.89, $p=0.361$), it increases the risk of Aussiedler (OR=1.55, $p=0.115$). However, these effects are not statistically significant, neither for native Germans nor for Aussiedler.

Including macro factors in the model improves the goodness of fit for native Germans (LR-test: $p=0.009$) and Aussiedler (LR-test: $p=0.037$) significantly (Table 3). Both the individual and contextual factors reduce the BRV. For native Germans, the BRV decreases by 15% when including variables on individual level and by 34% when additionally including contextual level factors. However, the majority of the BRV is not explained by the indicators (MOR of model IV 1.24; model VI 1.19). In comparison, the BRV of Aussiedler (0.029) is lower than that for native Germans (0.050). The individual level variables explain less for Aussiedler (BRV reduction 8%), while macro factors markedly reduce the BRV (BRV reduction more than 99%). The MOR shows the same trend with a reduction from 1.18 (model IV) to 1.00 (model VI).

**Table 3**
Improvements in models' goodness of fit (measured by likelihood ratio tests and regional variance)
Source: Microcensus 2005, INKAR 2007, Statistische Ämter des Bundes und der Länder

| | Native Germans $N=322,813$ | Aussiedler $N=10,022$ |
|---|---|---|
| **Model IV** | | |
| Between region variation [a] | 0.050 | 0.029 |
| MOR [b] | 1.24 | 1.18 |
| Log Likelihood | −83,588.11 | −2,373.08 |
| **Model V** | | |
| Between region variation [a] | 0.043 | 0.026 |
| MOR [b] | 1.22 | 1.17 |
| % explained variation [c] | 15% | 8% |
| Log Likelihood | −81,838.07 | −2,318.06 |
| Additional degrees of freedom | ***23*** | ***23*** |
| Significance (likelihood ratio test) | < 0.001 | < 0.001 |
| **Modell VI** | | |
| Between region variation [a] | 0.033 | < 0.001 |
| MOR [b] | 1.19 | 1.00 |
| % explained variation [c] | 34% | > 99% |
| Log Likelihood | -81,829.50 | -2,311.34 |
| Additional degrees of freedom | ***6*** | ***6*** |
| Significance (likelihood ratio test) | 0.009 | 0.037 |
| **Modell VI** | | |
| Between region variation [a] | 0.033 | < 0.001 |
| MOR [b] | 1.19 | 1.00 |
| % explained variation [c] | 34% | > 99% |
| Log Likelihood | -81,829.50 | -2,311.34 |
| Additional degrees of freedom | ***6*** | ***6*** |
| Significance (likelihood ratio test) | 0.009 | 0.037 |

Note: Model IV—Extended baseline model, controlled for age, sex and duration of stay (for Aussiedler only)
Model V—Extended model, controlled for all individual factors (age, sex, quarter of the year of the interview, family status, education, income, body mass index, and smoking habits)
Model VI—Final model, controlled for all individual and macro factors (centrality of population distribution, GDP per capita, and proportion of foreigners)

[a] Variance on level of the regions.
[b] Median odds ratio.
[c] Compared to the the extended baseline model (model IV).

## 4. Discussion

This is the first study that investigates contextual and individual effects on the health of Aussiedler relative to native Germans. Aussiedler living less than 15 years in Germany have a slight health advantage compared to native Germans and to Aussiedler living more than 15 years in Germany which indicates both the existence of a healthy migrant effect and the existence of negative effects of social deprivation on health. The health disadvantage of Aussiedler with a long duration of stay in Germany is primarily the result of their individual characteristics. Once these characteristics are controlled for, the differences between the Aussiedler population and native Germans are attenuated. We identified significant contextual effects of GDP and centrality on the health of Aussiedler and native Germans, which are similar for both groups. Individual characteristics affect the health of Aussiedler in a manner similar to the health of native Germans, with the exception of education, where no significant health gradient exists for Aussiedler. In contrast to this finding, income differentials in health appear to be larger among the Aussiedler population than among native Germans.

### 4.1. Interpretation

The negative association between duration of stay and the health of Aussiedler is one of the key findings of this study. The possible explanations for this relationship are the effect of socioeconomic deprivation, such as a high risk of unemployment, and the effects of a climate of discrimination and increased stress. Furthermore, deprivation may have an effect on the choice of an (unhealthy) living area. Our results are contrary to the findings of Aparicio et al. (2004), who reported better health with increasing duration of stay. This may be explained by their study group, since Aparicio et al. (2004) investigated Aussiedler living in a relatively wealthy urban region (Augsburg/Bavaria) and the surrounding areas only. In such a setting, a high cost of living may encourage the out-migration of badly integrated, economically unsuccessful (or unhealthy) persons, while the remaining persons might be a very selective group.

The significant and strong effects for the two macro factors regional economic performance and centrality are the second key finding. The correlation of high regional GDP with better health among both Aussiedler and native Germans, independent of the socioeconomic status of the individuals, is in line with reports from other studies (e.g., Pickett & Pearl, 2001; Riva et al., 2007). The detrimental effects of urbanity on health are in agreement with the conclusions of Watt et al. (1994), who attribute the disadvantage to higher levels of stress or unfavourable environmental conditions in urban regions (such as higher levels of air pollution and noise). Other studies have come to contradictory conclusions. For example, Diehl and Schneider (2011) detected higher odds of poor health for persons living in areas with a

higher degree of rurality. Confounding effects of hazards at the small area level may cause this divergent conclusion. Based on the findings of Voigtländer et al. (2010), health disparities between persons in urban and rural regions might be reduced if the effects are additionally adjusted for the environmental characteristics of the neighbourhood.

In this analysis, the effects of regional ethnic concentration on health are not consistent. Therefore, our study does not confirm the findings of Lorant et al. (2008) or of Diehl and Schneider (2011). However, our findings are in agreement with those of Karlsen et al. (2002). They found no general ethnic density effect for native inhabitants and selected ethnic minorities in the UK. Contrary to Lorant et al. (2008), the authors estimated separate models for migrants and natives to directly compare the effects, as we did. Moreover, Karlsen et al. (2002) and our study additionally adjusted for particular macro factors in contrast to Diehl and Schneider (2011). Thus, diverging model specifications and confounding between the variables may explain the different results.

Turning to individual-level characteristics, the most notable point is the absence of an educational gradient in the health of Aussiedler. A weak association between education and socioeconomic status may explain this finding, and suggests the presence of problems in the integration of Aussiedler into the labour market. In contrast to the policy-promoted integration in social and linguistic terms, restrictions and (indirect) discrimination still exist at the labour market. Aussiedler with high levels of education tend to work in lower positions than they would in their countries of birth/origin (Greif et al., 2003). Thus, the demand and the potential of economic integration of Aussiedler are still high. Another important finding is that the health gradient by income is steeper among Aussiedler than among native Germans. The differences may be the result of a more distinct selection effect in the job market among Aussiedler than among native Germans. Aussiedler who achieve higher job positions may differ greatly from Aussiedler in lower or moderate occupational positions (e.g., in terms of job qualifications, willingness to retrain, flexibility, mobility, motivation or health).

In sum, while there is an indication of problems of integrating Aussiedler in the labour market, the equal link of settlement structure, economic performance and individual health status of the two subgroups underlines the relative high social integration of Aussiedler in the regional context of the host country. Therefore, Aussiedler and native Germans who live in highly urbanised regions and/or in economically disadvantaged regions should be focus groups in future public health interventions.

### 4.2. Strengths and limitations

The major strength of this study is the use of the German Microcensus, which covers a wide range of variables on the individual level, has a sufficient number of cases at the level of regions, and allows us to identify migrants by their place of birth/origin, as well as by their current nationality. This is important when studying Aussiedler, since they acquire German nationality right after migration.

This study has several limitations. The first and most important of these is the operationalisation of health in the Microcensus. In the questionnaire, no definition of "being ill" is given, and respondents are not asked about the severity of the reported illness. We tried to overcome this limitation by restricting poor health to those individuals that reported a duration of a minimum of four weeks suffering from health problems. The relatively high item non-response in the health variable is an additional problem, since it can be assumed that non-respondents are predominantly in poor health (Goldberg et al., 2001).

We conducted sensitivity analyses of different model specifications such as various health outcomes, age as a continuous variable, strategies for excluding missing values in the covariates, as well as sex-specific models to check the validity of the findings. In sum, results only changed marginally which confirms the robustness of our analysis.

One limitation that applies to all studies about migrants' health is the cross-cultural validity of the health indicator. Even if the interviewers were advised to define "being ill" (which they were not), the individual awareness of morbidity could differ significantly between native Germans and Aussiedler. Additionally, the health assessment may vary between the particular immigration cohorts, e.g., due to changes in health-seeking behaviour by different countries of origin or by increasing duration of stay (Aparicio et al., 2004). Finally, we do not have information about the health situation of Aussiedler before they moved to Germany. Therefore interpreting our results in terms of a health selection process in migration has to be cautious.

Second, there are problems with the identification of Aussiedler in the data. Due to the fact that Aussiedler have to be identified by combining various facts (country of birth, year of immigration, current nationality, citizenship by naturalisation?) under specific assumptions (Federal Statistical Office, 2007), a misclassification bias cannot be fully excluded. Nevertheless, the misclassification bias is expected to be low.

Third, we know the duration of the stay in Germany, but do not have information about the duration of the stay in a particular region and the duration of the exposure to the contextual factors. Because of the cross-sectional design of the Microcensus, the analysis is not suitable for detecting causality. Thus, it is not possible to exclude the effect of selective in-migration and clustering of unhealthy persons in specific regions (e.g., urban regions with a good medical infrastructure). These effects lead to worse health situations in the corresponding regions, independent of regional distinctions (Norman et al., 2005). Systematic trends of return migration to the country of origin, or of onward migration to other countries, may lead to an additional selection bias, which may in turn affect the validity of the analysis.

Fourth, a general limitation lies in the validity of the chosen regional indicators themselves. For most of the contextual factors, the theoretical causal association with the health outcome on the level of individuals is unclear. Thus, the indicators are more proxies of confounding variables (like environment and ecological conditions) than causes of good or poor health themselves. The choice of regional units is an additional problem in the interpretation of indicators. The larger the spatial unit, the larger the overlaid heterogeneity of living conditions within a region. Most environmental factors, for example, lose explanatory power if very large spatial units are chosen for analysis. Although the choice of regional level in the Microcensus is restricted to ensure privacy, spatial planning regions are expected to be a suitable choice in our analysis.

### 4.3. Conclusion

This study sheds new light on the determinants of the health of Aussiedler relative to the health of their native German counterparts. Future research should explore whether individual and contextual factors vary over time by using data from the recently available Microcensus 2009. This may give an indication about trends in the integration process. Additionally, we consider to expand the number of regional characteristics such as the level of multiple deprivation, of social integration and participation, or environmental hazards.

Germany is facing the ageing of its migrant population, and with more migrants reaching old age, health issues will become more important. Gaining knowledge about the determinants of the health of ethnic minorities at the individual and regional levels can be useful in developing policy strategies to reduce inequalities in health, and to enable migrants to reach old age in good health.

**Table A1**
Characteristics of native Germans and Aussiedler by duration of stay in Germany (in percent); 95% confidence intervals (CI) in parentheses
Source: Microcensus 2005, Statistische Ämter des Bundes und der Länder

| Proportion in % | Native Germans | | Aussiedler (< 15 years) | | Aussiedler (15 to < 30 years) | | Aussiedler (30+ years) | | Aussiedler (no information) | |
|---|---|---|---|---|---|---|---|---|---|---|
| *N* | 375,762 | | 764 | | 6776 | | 2804 | | 1145 | |
| Health status | | | | | | | | | | |
| Healthy | 78.7 | (78.6; 78.8) | 81.8 | (79.1; 84.5) | 81.5 | (80.6; 82.4) | 76.9 | (75.3; 78.4) | 83.1 | (80.9; 85.2) |
| Unhealthy | 7.2 | (7.1; 7.3) | 4.6 | (3.1; 6.1) | 5.8 | (5.3; 6.4) | 11.1 | (9.9; 12.2) | 2.3 | (1.4; 3.1) |
| Missing | 14.1 | (14.0; 14.2) | 13.6 | (11.2; 16.0) | 12.6 | (11.8; 13.4) | 12.1 | (10.9; 13.3) | 14.7 | (12.6; 16.7) |
| Age group | | | | | | | | | | |
| 20 to less than 30 years old | 12.3 | (12.2; 12.4) | 33.1 | (29.8; 36.5) | 23.7 | (22.7; 24.7) | – | | 23.0 | (20.5; 25.4) |
| 30 to less than 40 years old | 16.3 | (16.1; 16.4) | 21.1 | (18.0; 24.0) | 17.7 | (16.7; 18.6) | 6.5 | (5.5; 7.4) | 26.6 | (24.0; 29.1) |
| 40 to less than 50 years old | 19.6 | (19.5; 19.7) | 16.6 | (14.0; 19.3) | 22.7 | (21.7; 23.7) | 13.8 | (12.6; 15.1) | 32.4 | (29.7; 35.1) |
| 50 to less than 60 years old | 15.9 | (15.8; 16.0) | 14.4 | (11.9; 16.9) | 15.7 | (14.8; 16.6) | 17.9 | (16.5; 19.4) | 17.0 | (14.9; 19.2) |
| 60 to less than 70 years old | 17.4 | (17.3; 17.5) | 7.6 | (5.7; 9.5) | 10.0 | (9.3; 10.7) | */* | | */* | |
| 70 to less than 80 years old | 11.9 | (11.8; 12.0) | 5.4 | (3.8; 7.0) | 7.5 | (6.9; 8.2) | */* | | */* | |
| 80 years and older | 6.6 | (6.5; 6.7) | 1.8 | (0.9; 2.8) | 2.7 | (2.3; 3.1) | 7.7 | (6.7; 8.7) | 0.5 | (0.2; 0.8) |
| Sex | | | | | | | | | | |
| Males | 47.2 | (47.1; 47.4) | 47.8 | (44.2; 51.3) | 48.1 | (46.9; 49.3) | 45.2 | (43.3; 47.0) | 48.9 | (46.0; 51.8) |
| Females | 52.8 | (52.6; 52.9) | 52.2 | (48.7; 55.8) | 51.9 | (50.7; 53.1) | 54.8 | (53.0; 56.7) | 51.1 | (48.2; 54.0) |
| Quarter of the year of the interview | | | | | | | | | | |
| 1st quarter | 21.3 | (21.2; 21.4) | 17.3 | (14.6; 20.0) | 20.5 | (19.6; 21.5) | 22.8 | (21.2; 24.3) | 23.3 | (20.9; 25.8) |
| 2nd quarter | 24.8 | (24.7; 24.9) | 25.3 | (22.2; 28.3) | 24.8 | (23.8; 25.9) | 22.9 | (21.3; 24.5) | 27.2 | (24.6; 29.7) |
| 3rd quarter | 25.6 | (25.5; 25.8) | 22.5 | (19.5; 25.5) | 26.1 | (25.1; 27.2) | 24.7 | (23.1; 26.3) | 22.4 | (20.0; 24.9) |
| 4th quarter | 28.3 | (28.1; 28.4) | 34.9 | (31.6; 38.3) | 28.5 | (27.4; 29.6) | 29.6 | (27.9; 31.3) | 27.1 | (24.5; 29.6) |
| Family status | | | | | | | | | | |
| Single | 23.9 | (23.7; 24.0) | 22.3 | (19.3; 25.2) | 21.6 | (20.6; 22.6) | 10.0 | (8.9; 11.1) | 30.2 | (27.6; 32.9) |
| Married—living together | 56.4 | (56.3; 56.6) | 63.5 | (60.1; 66.9) | 64.3 | (63.1; 65.4) | 62.4 | (60.7; 64.2) | 59.5 | (56.6; 62.3) |
| Married—living apart | 1.9 | (1.9; 2.0) | 3.7 | (2.3; 5.0) | 2.4 | (2.0; 2.7) | 1.8 | (1.3; 2.3) | 1.8 | (1.1; 2.6) |
| Divorced | 7.3 | (7.2; 7.4) | 6.0 | (4.3; 7.7) | 5.1 | (4.6; 5.6) | 8.7 | (7.7; 9.7) | 6.9 | (5.4; 8.4) |
| Widowed | 10.5 | (10.4; 10.6) | 4.6 | (3.1; 6.1) | 6.7 | (6.1; 7.3) | 17.0 | (15.6; 18.4) | 1.6 | (0.9; 2.3) |
| Education | | | | | | | | | | |
| No degree | 1.8 | (1.7; 1.8) | 7.5 | (5.6; 9.3) | 6.7 | (6.1; 7.2) | 6.0 | (5.1; 6.9) | 4.8 | (3.6; 6.0) |
| Low degree | 48.4 | (48.3; 48.6) | 43.2 | (39.7; 46.7) | 42.4 | (41.2; 43.6) | 56.2 | (54.3; 58.0) | 39.2 | (36.4; 42.0) |
| Medium degree | 24.4 | (24.3; 24.5) | 28.5 | (25.3; 31.7) | 26.7 | (25.6; 27.8) | 18.0 | (16.6; 19.4) | 27.2 | (24.6; 29.7) |
| High degree | 24.1 | (24.0; 24.3) | 19.0 | (16.2; 21.8) | 23.1 | (22.1; 24.1) | 19.3 | (17.9; 20.8) | 27.2 | (24.7; 29.8) |
| In education / missing information | 1.2 | (1.2; 1.2) | 1.8 | (0.9; 2.8) | 1.2 | (0.9; 1.4) | 0.5 | (0.3; 0.8) | 1.6 | (0.9; 2.3) |
| Net equivalence income | | | | | | | | | | |
| Up to €480 | 2.1 | (2.0; 2.1) | 10.2 | (8.1; 12.4) | 3.0 | (2.5; 3.4) | 1.9 | (1.4; 2.4) | 5.1 | (3.8; 6.3) |
| More than €480 to €640 | 3.7 | (3.6; 3.8) | 20.4 | (17.6; 23.3) | 6.9 | (6.3; 7.5) | 3.4 | (2.7; 4.1) | 4.1 | (3.0; 5.3) |
| More than €640 to €1040 | 18.8 | (18.7; 18.9) | 41.6 | (38.1; 45.1) | 32.6 | (31.5; 33.7) | 21.0 | (19.5; 22.6) | 25.6 | (23.1; 28.1) |
| More than €1040 to €1600 | 32.1 | (32.0; 32.3) | 16.5 | (13.9; 19.1) | 34.7 | (33.5; 35.8) | 35.5 | (33.7; 37.3) | 29.3 | (26.6; 31.9) |
| More than €1600 | 34.5 | (34.3; 34.6) | 6.3 | (4.6; 8.0) | 17.5 | (16.6; 18.4) | 31.8 | (30.1; 33.5) | 26.4 | (23.8; 28.9) |
| Missing information | 8.8 | (8.7; 8.9) | 5.0 | (3.4; 6.5) | 5.4 | (4.8; 5.9) | 6.4 | (5.5; 7.3) | 9.6 | (7.9; 11.3) |
| Body mass index | | | | | | | | | | |
| Underweight | 1.7 | (1.7; 1.8) | 2.5 | (1.4; 3.6) | 1.5 | (1.3; 1.8) | 1.4 | (1.0; 1.8) | 2.1 | (1.3; 2.9) |
| Normal weight | 37.5 | (37.3; 37.6) | 34.0 | (30.7; 37.4) | 35.3 | (34.2; 36.5) | 32.2 | (30.4; 33.9) | 41.7 | (38.8; 44.5) |
| Light overweight | 27.4 | (27.3; 27.6) | 27.2 | (24.1; 30.4) | 28.8 | (27.7; 29.9) | 33.8 | (32.0; 35.5) | 23.2 | (20.8; 25.7) |
| High overweight | 9.8 | (9.7; 9.9) | 14.0 | (11.5; 16.5) | 13.2 | (12.4; 14.0) | 13.3 | (12.0; 14.6) | 9.5 | (7.8; 11.2) |
| Missing information | 23.6 | (23.5; 23.7) | 22.3 | (19.3; 25.2) | 21.2 | (20.2; 22.1) | 19.4 | (17.9; 20.8) | 23.5 | (21.0; 26.0) |
| Smoking habits | | | | | | | | | | |
| Never smoker | 43.6 | (43.4; 43.7) | 50.7 | (47.1; 54.2) | 48.6 | (47.4; 49.8) | 47.2 | (45.4; 49.1) | 39.5 | (36.6; 42.3) |
| Former smoker | 18.1 | (18.0; 18.3) | 8.9 | (6.9; 10.9) | 13.9 | (13.1; 14.8) | 22.1 | (20.5; 23.6) | 15.2 | (13.1; 17.3) |
| Smoker | 21.9 | (21.8; 22.0) | 25.3 | (22.2; 28.3) | 23.0 | (22.0; 24.0) | 17.0 | (15.6; 18.4) | 27.9 | (25.3; 17.3) |
| Missing information | 16.4 | (16.3; 16.5) | 15.2 | (12.6; 17.7) | 14.4 | (13.6; 15.3) | 13.7 | (12.4; 15.0) | 17.4 | (15.2; 19.6) |
| Centrality of population distribution | | | | | | | | | | |
| Regions with low centrality | 5.1 | (5.0; 5.1) | 4.3 | (2.9; 5.8) | 4.1 | (3.6; 4.6) | 3.2 | (2.6; 3.9) | 6.9 | (5.4; 8.4) |
| Regions with average centrality | 74.7 | (74.6; 74.9) | 74.1 | (71.0; 77.2) | 71.9 | (70.8; 72.9) | 70.0 | (68.3; 71.7) | 72.4 | (69.8; 75.0) |
| Regions with high centrality | 20.2 | (20.1; 20.4) | 21.6 | (18.7; 24.5) | 24.1 | (23.0; 25.1) | 26.7 | (25.1; 28.4) | 20.7 | (18.4; 23.0) |
| Gross domestic product | | | | | | | | | | |
| Regions with low GDP | 6.1 | (6.0; 6.2) | 6.2 | (4.4; 7.9) | 4.5 | (4.0; 5.0) | 4.4 | (3.7; 5.2) | 6.8 | (5.4; 8.3) |
| Regions with average GDP | 73.5 | (73.4; 73.7) | 72.6 | (69.5; 75.8) | 71.6 | (70.5; 72.7) | 66.2 | (64.4; 67.9) | 70.4 | (67.7; 73.0) |
| Regions with high GDP | 20.4 | (20.2; 20.5) | 21.2 | (18.3; 24.1) | 23.9 | (22.9; 24.9) | 29.4 | (27.7; 31.1) | 22.8 | (20.4; 25.2) |
| Proportion of foreigners | | | | | | | | | | |
| Regions with low proportion | 6.6 | (6.5; 6.7) | 5.8 | (4.1; 7.4) | 2.7 | (2.3; 3.1) | 2.9 | (2.3; 3.5) | 5.7 | (4.3; 7.0) |
| Regions with average proportion | 72.1 | (72.0; 72.3) | 72.8 | (69.6; 75.9) | 78.6 | (77.7; 79.6) | 70.9 | (69.2; 72.6) | 76.9 | (74.5; 79.4) |
| Regions with high proportion | 21.2 | (21.1; 21.4) | 21.5 | (18.6; 24.4) | 18.7 | (17.8; 19.6) | 26.2 | (24.5; 27.8) | 17.4 | (15.2; 19.6) |

*/* Data not available (due to privacy regulations).

**Table A2**
Mean age, mean net equivalence income and mean body mass index for native Germans and Aussiedler, 95% CI in parentheses.
Source: Microcensus 2005, Statistische Ämter des Bundes und der Länder.

| | Native Germans | Aussiedler (< 15 years) | Aussiedler (15 to < 30 years) | Aussiedler (30+ years) | Aussiedler (no information) | ANOVA p-value |
|---|---|---|---|---|---|---|
| **Mean age** | 51.62 *(51.57, 51.67)* | 40.97 *(39.85, 42.09)* | 44.76 *(44.36, 45.16)* | 61.87 *(61.39, 62.34)* | 38.96 *(38.35, 39.56)* | < 0.001 |
| **Mean net equivalence income** | 1576.04 *(1573.13, 1578.95)* | 897.89 *(850.45, 945.33)* | 1246.63 *(1229.38, 1263.88)* | 1558.25 *(1523.21, 1593.29)* | 1432.04 *(1379.49, 1484.59)* | < 0.001 |
| **Mean body mass index** | 25.55 *(25.54, 25.57)* | 26.13 *(25.73, 26.54)* | 25.94 *(25.82, 26.06)* | 26.34 *(26.17, 26.51)* | 25.10 *(24.81, 25.40)* | < 0.001 |

**Table A3**
Odds of longstanding illness among native Germans and Aussiedler: individual level variables only, odds ratio and 95% CI from multilevel regression.
Source: Microcensus 2005, INKAR 2007, Statistische Ämter des Bundes und der Länder.

| Covariates | Native Germans | | Aussiedler | |
|---|---|---|---|---|
| | *N*=322,813 | | *N*=10,022 | |
| | OR | 95% CI | OR | 95% CI |
| Group | | | | |
| Native Germans | | | | |
| Aussiedler (< 15 years) | | | **1** | |
| Aussiedler (15 to < 30 years) | | | 1.35 | (0.92, 1.98 ) |
| Aussiedler (30+ years) | | | 1.42 | (0.95, 2.12 ) |
| Aussiedler (no information) | | | 1.00 | (0.58, 1.73 ) |
| Age group | | | | |
| 20 to less than 30 years old | 0.36 | (0.33, 0.40) | 0.30 | (0.18, 0.49 ) |
| 30 to less than 40 years old | 0.66 | ( 0.62, 0.71 ) | 0.42 | (0.26, 0.66 ) |
| 40 to less than 50 years old | **1** | | **1** | |
| 50 to less than 60 years old | 2.01 | (1.90, 2.12 ) | 2.61 | (1.95, 3.49 ) |
| 60 to less than 70 years old | 3.04 | (2.89, 3.20 ) | 3.70 | (2.74, 5.00 ) |
| 70 to less than 80 years old | 5.25 | (4.98, 5.53 ) | 5.54 | (4.05, 7.58 ) |
| 80 years and older | 7.28 | (6.87, 7.72 ) | 7.45 | (5.09, 10.90 ) |
| Sex | | | | |
| Males | **1** | | **1** | |
| Females | 1.02 | ( 0.99, 1.05 ) | 1.00 | (0.83, 1.19 ) |
| Quarter of the year of the interview | | | | |
| 1st quarter | **1** | | **1** | |
| 2nd quarter | 1.12 | (1.08, 1.17 ) | 1.02 | (0.81, 1.27 ) |
| 3rd quarter | 1.14 | (1.09, 1.18 ) | 1.05 | (0.84, 1.31 ) |
| 4th quarter | 1.16 | (1.12, 1.21 ) | 0.99 | (0.80, 1.24 ) |
| Family status | | | | |
| Single | 1.37 | ( 1.31, 1.44 ) | 1.15 | ( 0.84, 1.57 ) |
| Married—living together | **1** | | **1** | |
| Married—living apart | 1.44 | (1.31, 1.58 ) | 1.41 | (0.88, 2.27 ) |
| Divorced | 1.48 | (1.41, 1.55 ) | 1.06 | (0.77, 1.44 ) |
| Widowed | 1.20 | (1.16, 1,25) | 1.06 | (0.84, 1.57) |
| Education | | | | |
| No degree | 1.57 | (1.45, 1.71 ) | 1.16 | (0.90, 1.48 ) |
| Low degree | **1** | | **1** | |
| Medium degree | 0.81 | (0.78, 0.84 ) | 0.93 | (0.74, 1.17 ) |
| High degree | 0.69 | (0.66, 0.72 ) | 0.87 | (0.68, 1.12 ) |
| In education/missing information | 1.86 | (1.60, 2.15 ) | 0.60 | (0.14, 2.54 ) |
| Net equivalence income | | | | |
| Up to €480 | 1.14 | (1.04, 1.24 ) | 1.47 | (0.95, 2.27 ) |
| More than €480 to €640 | 1.31 | (1.23, 1.40 ) | 1.37 | (1.03, 1.83 ) |
| More than €640 to €1040 | **1** | | **1** | |
| More than €1040 to €1600 | 0.83 | (0.80, 0.86 ) | 0.68 | (0.56, 0.82 ) |
| More than €1600 | 0.69 | (0.66, 0.71 ) | 0.50 | (0.39, 0.65 ) |
| Missing information | 0.99 | (0.94, 1.04 ) | 0.59 | (0.39, 0.89 ) |
| Body mass index | | | | |
| Underweight | 1.91 | (1.75, 2.08 ) | 1.50 | (0.78, 2.89 ) |
| Normal weight | **1** | | **1** | |
| Light overweight | 1.02 | (0.99, 1.05 ) | 1.02 | (0.84, 1.23 ) |
| High overweight | 1.45 | (1.40, 1.51 ) | 1.36 | (1.09, 1.70 ) |
| Missing information | 1.00 | (0.95, 1.05 ) | 0.97 | (0.69, 1.35 ) |
| Smoking habits | | | | |
| Never smoker | **1** | | **1** | |
| Former smoker | 1.39 | (1.35, 1.44 ) | 1.17 | (0.95, 1.45 ) |
| Smoker | 1.22 | (1.18, 1.27 ) | 1.15 | (0.91, 1.44 ) |
| Missing information | 0.97 | (0.89, 1.05 ) | 0.26 | (0.10, 0.68 ) |

Controlled for centrality of population distribution, GDP per capita, and proportion of foreigners

## Acknowledgements

The authors gratefully acknowledge Miriam Hills, Nadja Milewski, Till Wollenberg, the colleagues of the Research Data Centre of the Statistical Office of Berlin/Brandenburg, and the two anonymous reviewers.

## Appendix A

See Tables A1–A3.

## Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.healthplace.2012.05.008.

## References

Aparicio, M.L., Doring, A., Mielck, A., Holle, R., 2004. Unterschiede zwischen Aussiedlern und der übrigen deutschen Bevölkerung bezüglich Gesundheit. Gesundheitsversorgung und Gesundheitsverhalten: eine vergleichende Analyse anhand des KORA-Surveys 2000. Soz Praventivmed 50 (2), 107–118.

BBSR, 2007. Übersicht und Beschreibung der Indikatoren und Karten zur Raum- und Stadtentwicklung in Deutschland und in Europa des Bundesinstituts für Bau-, Stadt- und Raumplanung. (Overview and Description of the Indicators and the Maps of the Spatial Development in Germany and Europe of the Federal Institute for Research on Building, Urban Affairs and Spatial Development) [< http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/ INKAR/Ausgaben/INKAR2007.html>, February 2012].

Becher, H., Razum, O., Kyobutungi, C., Laki, J., Ott, J.J., Ronellenfitsch, U., Winkler, V., 2007. Mortalität von Aussiedlern aus der ehemaligen Sowjetunion. Ergebnisse einer Kohortenstudie. Deutsches Ärzteblatt 104, A1655–A1661.

Breckenkamp, J., Mielck, A., Razum, O., 2007. Health inequalities in Germany: do regional-level variables explain differentials in cardiovascular risk? BMC Public Health 7, 132.

Cassel, J., 1976. The contribution of the social environment to host resistance. The fourth Wade Hampton Frost lecture. American Journal of Epidemiology 104, 107–123.

Diehl, K., Schneider, S., 2011. How relevant are district characteristics in explaining subjective health in Germany?—A multilevel analysis. Social Science & Medicine 72 (7), 1205–1210.

Federal statistical office, 2012. Microcensus. Overview and Description. [<https://www.destatis.de/DE/Meta/AbisZ/Mikrozensus.html>, May 2012].

Federal statistical office, 2010. Fachserie 1 Reihe 2.2. Bevölkerung und Erwerbstätigkeit. Bevölkerung mit Migrationshintergrund. Ergebnisse des Mikrozensus 2009.

Federal statistical office, 2007. Fachserie 1 Reihe 2.2 Bevölkerung und Erwerbstätigkeit. Bevölkerung mit Migrationshintergrund. Ergebnisse des Mikrozensus 2005.

Goldberg, M., Chastang, J.F., Leclerc, A., Zins, M., Bonenfant, S., Bugel, I., et al., 2001. Socioeconomic, demographic, occupational, and health factors associated with participation in a long-term epidemiologic survey: a prospective study of the French GAZEL cohort and its target population. American Journal of Epidemiology 154 (4), 373–384.

Greif, S., Gediga, G., Janikowski, A., 2003. Erwerbslosigkeit und beruflicher Abstieg von Aussiedlerinnen und Aussiedlern. p.81-106. In: Baade, K., Oltmer, J. (Eds.), Aussiedler: deutsche Einwanderer aus Osteuropa. IMIS-Schriften 8, 2nd Edition V&R unipress, Göttingen.

Greiner, J., 2002. Zuwanderung und Integration von Aussiedler – Russlanddeutsche Aussiedler in der Bundesrepublik Deutschland. p.48. In: Collatz, J. (Ed.), Psychosoziale Betreuung und Psychiatrische Behandlung von Spätaussiedlern. Verlag für Wiss. und Bildung, Berlin.

Haug, S., Sauer, L., 2007. Zuwanderung und Integration von (Spät-)Aussiedlern. Ermittlung und Bewertung der Auswirkungen des Wohnortzuweisungsgesetzes. Forschungsstudie im Auftrag des Bundesministeriums des Innern.
Karlsen, S., Nazroo, J.Y., Stephenson, R., 2002. Ethnicity, environment and health: putting ethnic inequalities in health in their place. Social Science & Medicine 55 (9), 1647–1661.
Kemptner, D., Wildner, M., Abu-Omar, K., Caselmann, W.H., Kerscher, G., Reitmeir, P., Mielck, A., Rütten, A., 2008. Regionale Unterschiede des Gesundheitsverhaltens in Bayern—Mehrebenenanalyse einer bevölkerungsrepräsentativen Befragung in Verbindung mit sozioökonomischen Strukturdaten. Gesundheitswesen 70, 28–37.
Kibele, E., 2008. Explaining Small-Area Mortality Variation Among Pensioners in Germany: the Effect of Individual Characteristics and Context. 2nd HMD Symposium, June 13-14, 2008 at the Max Planck Institute for Demographic Research.
Kliewer, E., 1992. Epidemiology of diseases among migrants. International Migration 30, 141–164.
Kosubek, S., 1998. Asylbewerber und Aussiedler. Rechte. Leistungen, Hilfen. Handbuch für Helfer. Beltz, Weinheim, Basel.
Kyobutungi, C., Ronellenfitsch, U., Razum, O., Becher, H., 2006a. Mortality from external causes among ethnic German immigrants from former Soviet Union countries in Germany. European Journal of Public Health 16, 376–382.
Kyobutungi, C., Ronellenfitsch, U., Razum, O., Becher, H., 2006b. Mortality from cancer among ethnic German immigrants from the former Soviet Union, in Germany. European Journal of Cancer 42, 2577–2584.
Larsen, K., Merlo, J., 2005. Appropriate assessment of neighborhood effects on individual health: integrating random and fixed effects in multilevel logistic regression. American Journal of Epidemiology, 81–88.
Lorant, V., Van Oyen, H., Thomas, I., 2008. Contextual factors and immigrants' health status: double jeopardy. Health and Place 14 (4), 678–692.
Norman, P., Boyle, P., Rees, P., 2005. Selective migration, health and deprivation: a longitudinal analysis. Social Science & Medicine 60, 2755–2771.
Pickett, K.E., Pearl, M., 2001. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. Journal of Epidemiology and Community Health 55, 111–122.
Queste, A., 2007. Analyse kleinräumiger Mortalitätsraten in Deutschland, 22 of Wissenschaftliche Reihe. Landesinstitut für den öffentlichen Gesundheitsdienst des Landes Nordrhein-Westfalen (lögd), Bielefeld.
Rabe-Hesketh, S., Skrondal, A., 2005. Multilevel and Longitudinal Modeling Using Stata. College Station. Stata Press, Texas.
Riva, M., Gauvin, L., Barnett, T.A., 2007. Toward the next generation of research into small area effects on health: a synthesis of multilevel investigations published since July 1998. Journal of Epidemiology and Community Health 61, 853–861.
Ronellenfitsch, U., Kyobutungi, C., Becher, H., Razum, O., 2006. All-cause and cardiovascular mortality among ethnic German immigrants from the Former Soviet Union: a cohort study. BMC Public Health 6, 16.
Ronellenfitsch, U., Razum, O., 2004. Deteriorating health satisfaction among immigrants from Eastern Europe to Germany. International Journal for Equity in Health 3, 4.
Snijders, T.A.B., Bosker, R.J., 1999. Multilevel Analysis. An Introduction to Basic and Advanced Multilevel Modeling. SAGE Publications, London.
Van Oyen, H., Cox, B., Nusselder, W., Jagger, C., Cambois, E., Robine, J.M., 2010. Gender gaps in life expectancy and expected years with activity limitations at age 50 in the European Union: associations with macro-level structural factors. European Journal of Ageing 7, 229–239.
Voigtländer, S., Berg-Beckhoff, G., Razum, O., 2008. Gesundheitliche Ungleichheit: Der Beitrag kontextueller Merkmale. Peter Lang Verlag, Frankfurt am Main.
Voigtländer, S., Berger, U., Razum., O., 2010. The impact of regional and neighbourhood deprivation on physical health in Germany: a multilevel study. BMC Public Health 10, 403.
Watt, I.S., Franks, A.J., Sheldon, T.A., 1994. Health and health care of rural populations in the UK: is it better or worse? Journal of Epidemiology & Community Health 48, 16–21.
Wittig, U., Merbach, M., Siefen, RG., Brähler, E., 2004. Beschwerden und Inanspruchnahme des Gesundheitswesens von Spätaussiedlern bei Einreise nach Deutschland. Gesundheitswesen 66 (2), 85–92.
Woellert, F., Kröhnert, S., Sippel, L., Klingholz, 2009. Ungenutzte Potentiale. Zur Lage der Integration in Deutschland. Berlin-Institut für Bevölkerung und Entwicklung.
Wolf, C., 2004. Wohnquartier und Gesundheit: Eine Mehrebenenanalyse. In: Kecskes, R., Wagner, M., Wolf, C. (Eds.), Angewandte Soziologie. VS Verlag für Sozialwissenschaften, Wiesbaden, pp. 103–126.

# IX. Supplementary material

*Figure 19: Spatial mapping of the ratio of the mortality component in CLY to the mortality component in CFLY at age 65, severe care level, 2001/03-2007/09*

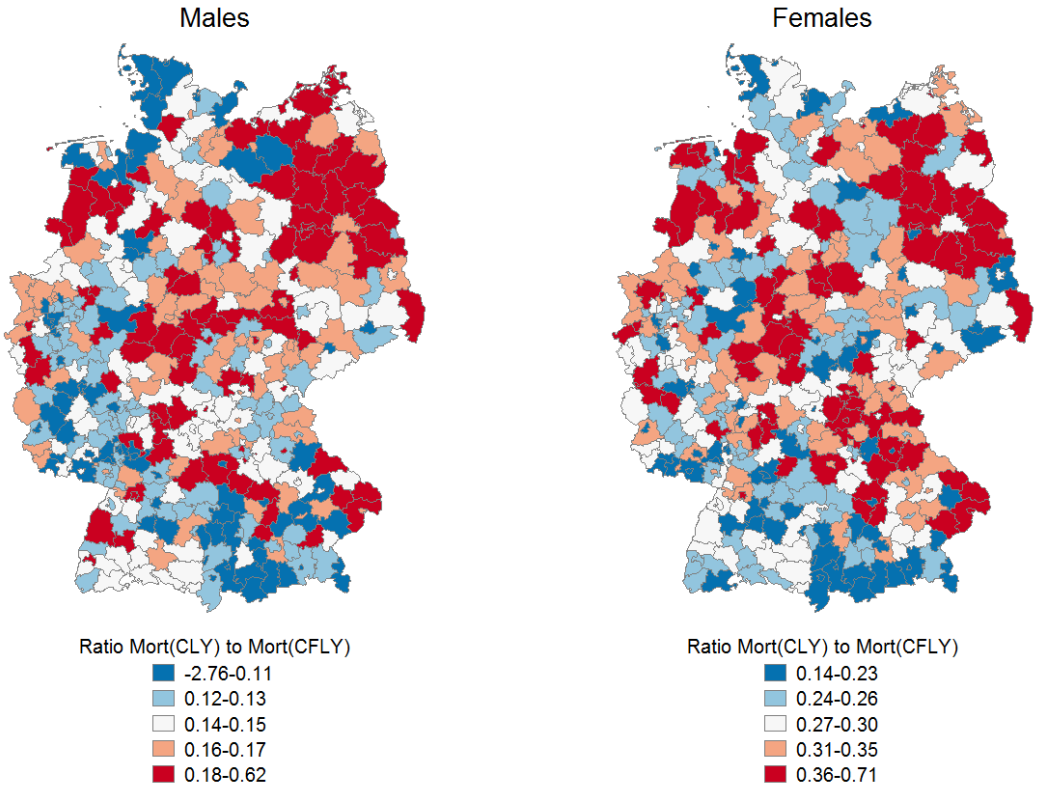
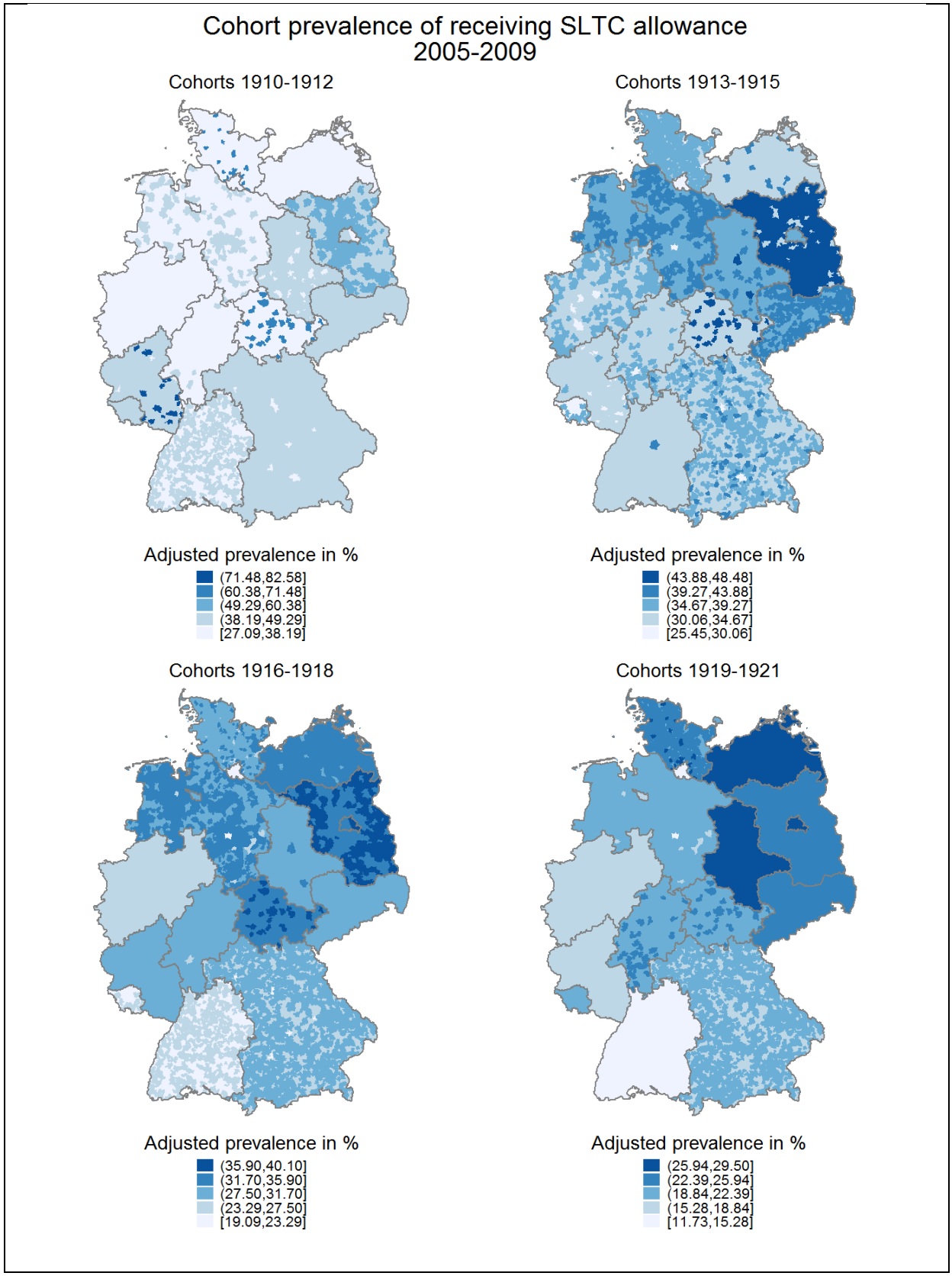
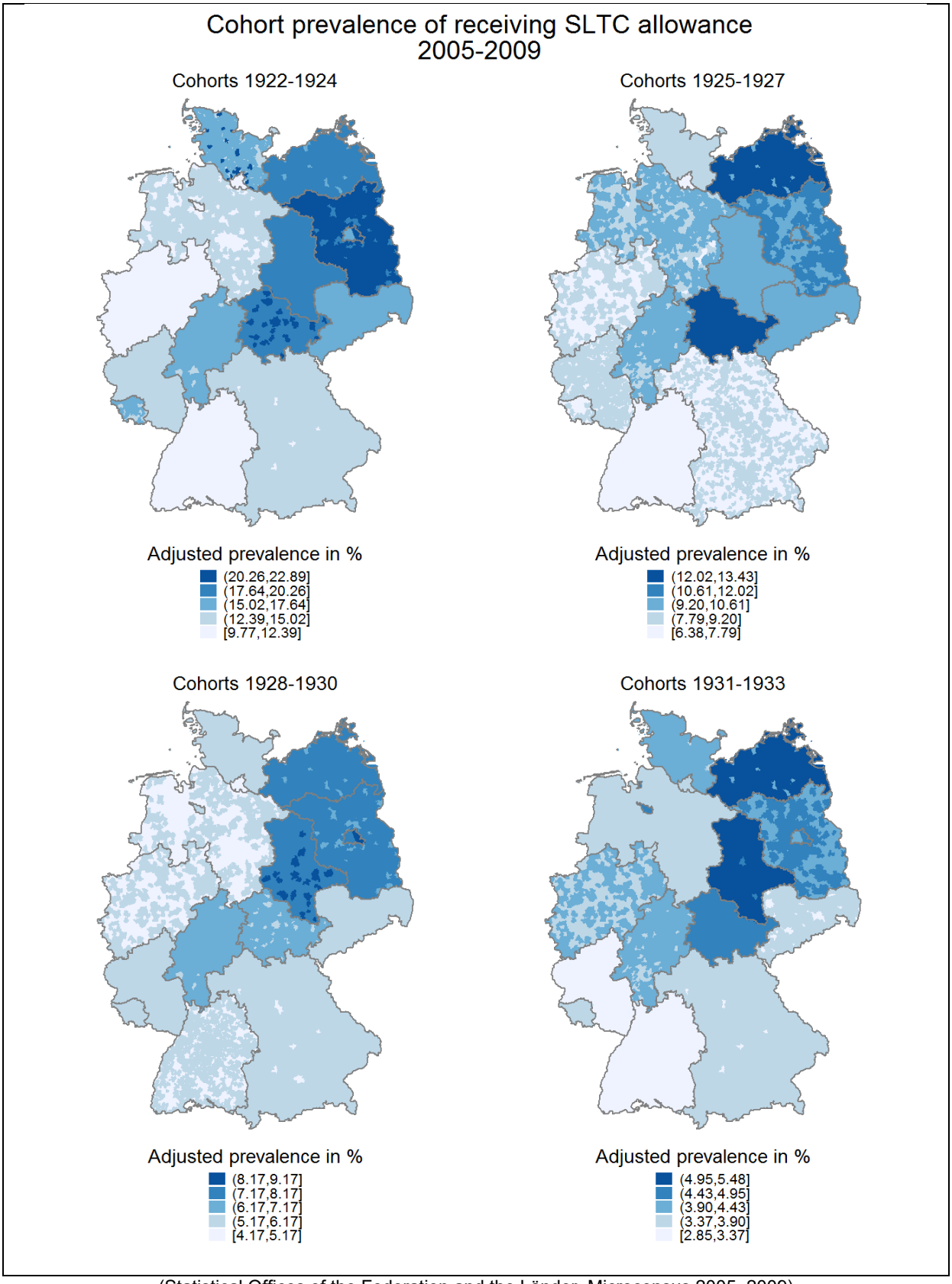


*Figure 20: Spatial mapping of adjusted prevalence of receiving SLTC allowance of the cohorts 1910-12, 1913-15, 1916-18, 1919-21, persons at age 65+, 2005-2009*



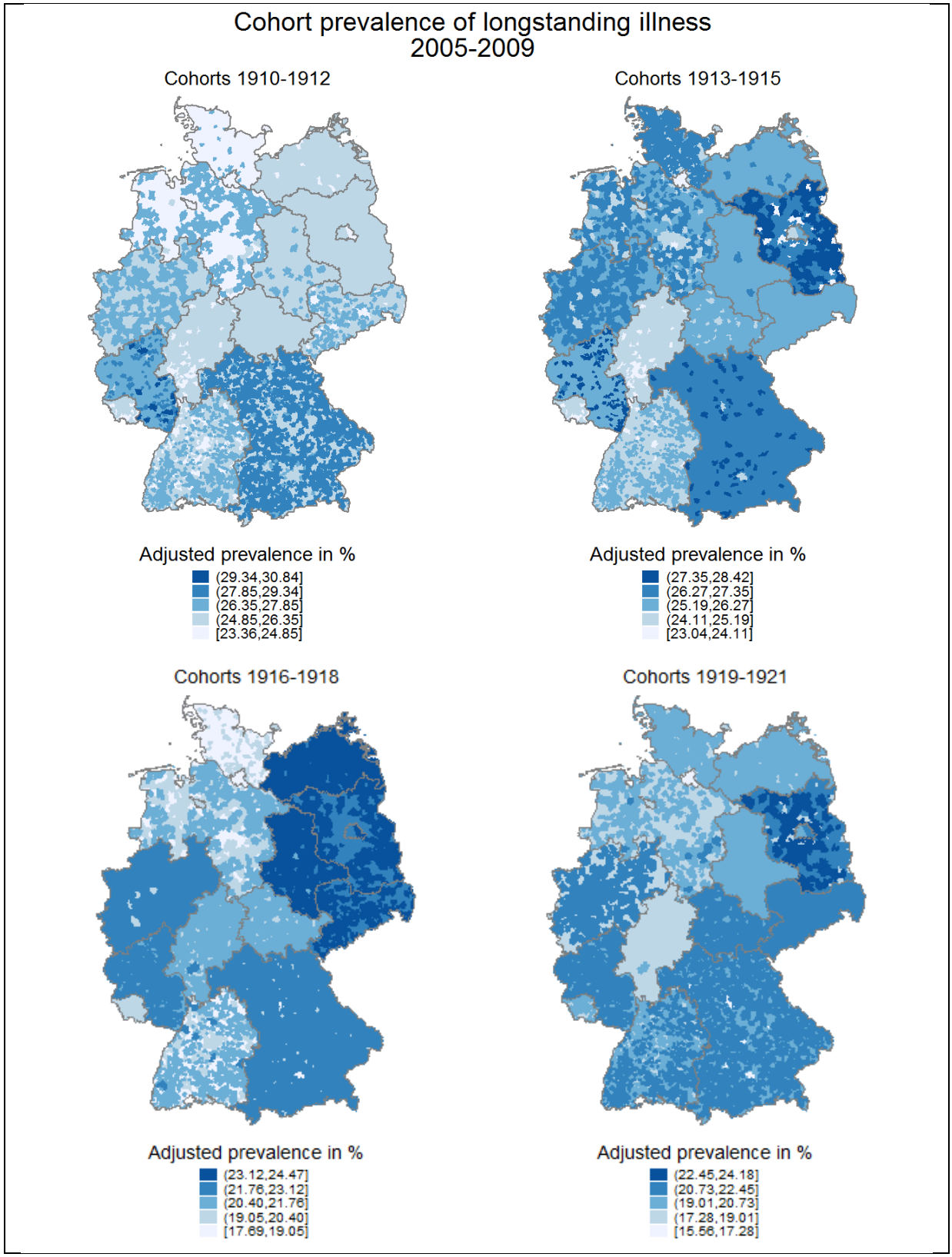

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 21: Spatial mapping of adjusted prevalence of receiving SLTC allowance of the cohorts 1922-24, 1925-27, 1928-30, 1931-33, persons at age 65+, 2005-2009*



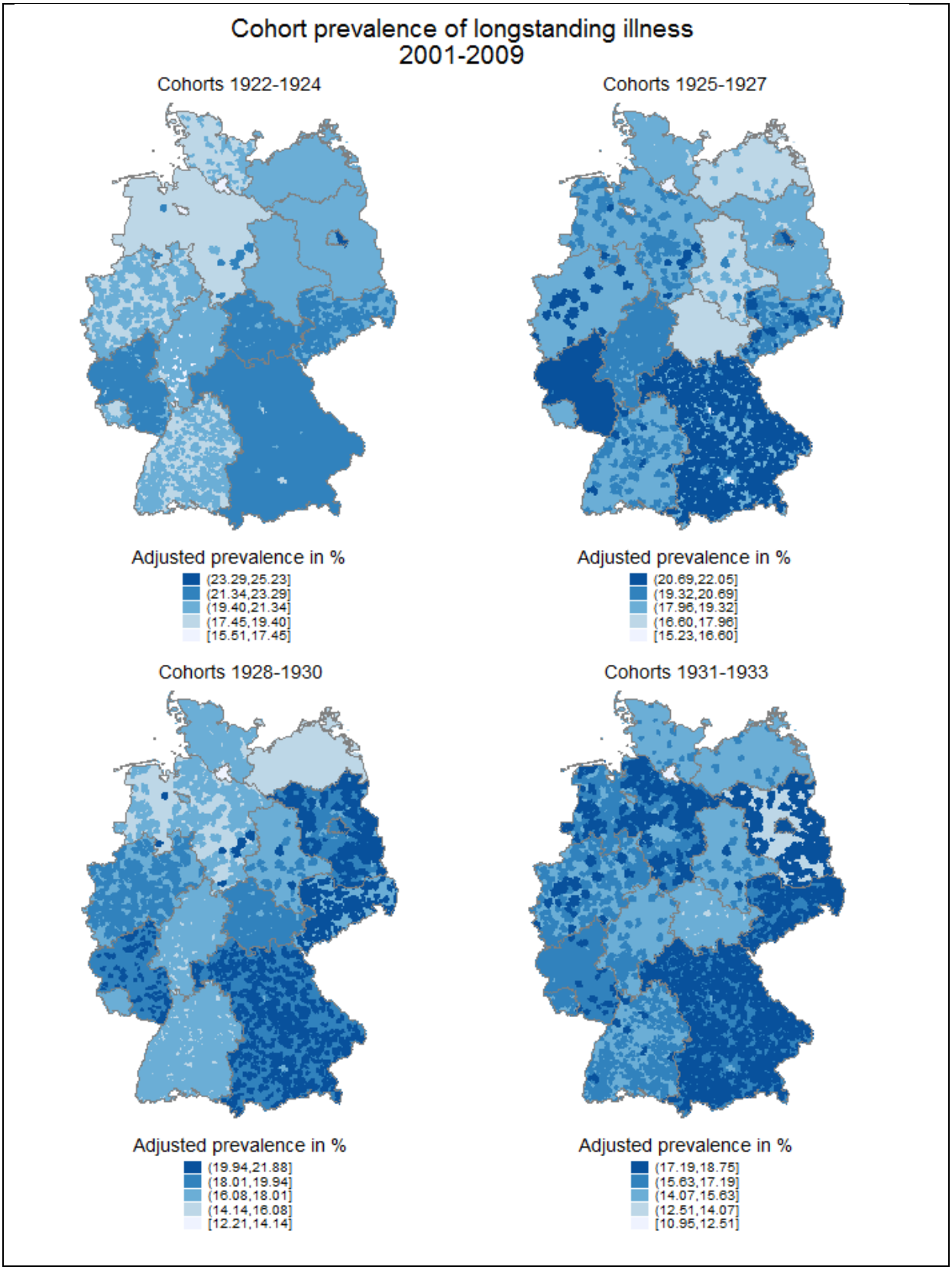

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 22: Spatial mapping of adjusted prevalence of longstanding illness of the cohorts 1910-12, 1913-15, 1916-18, 1919-21, persons at age 65+, 2005-2009*



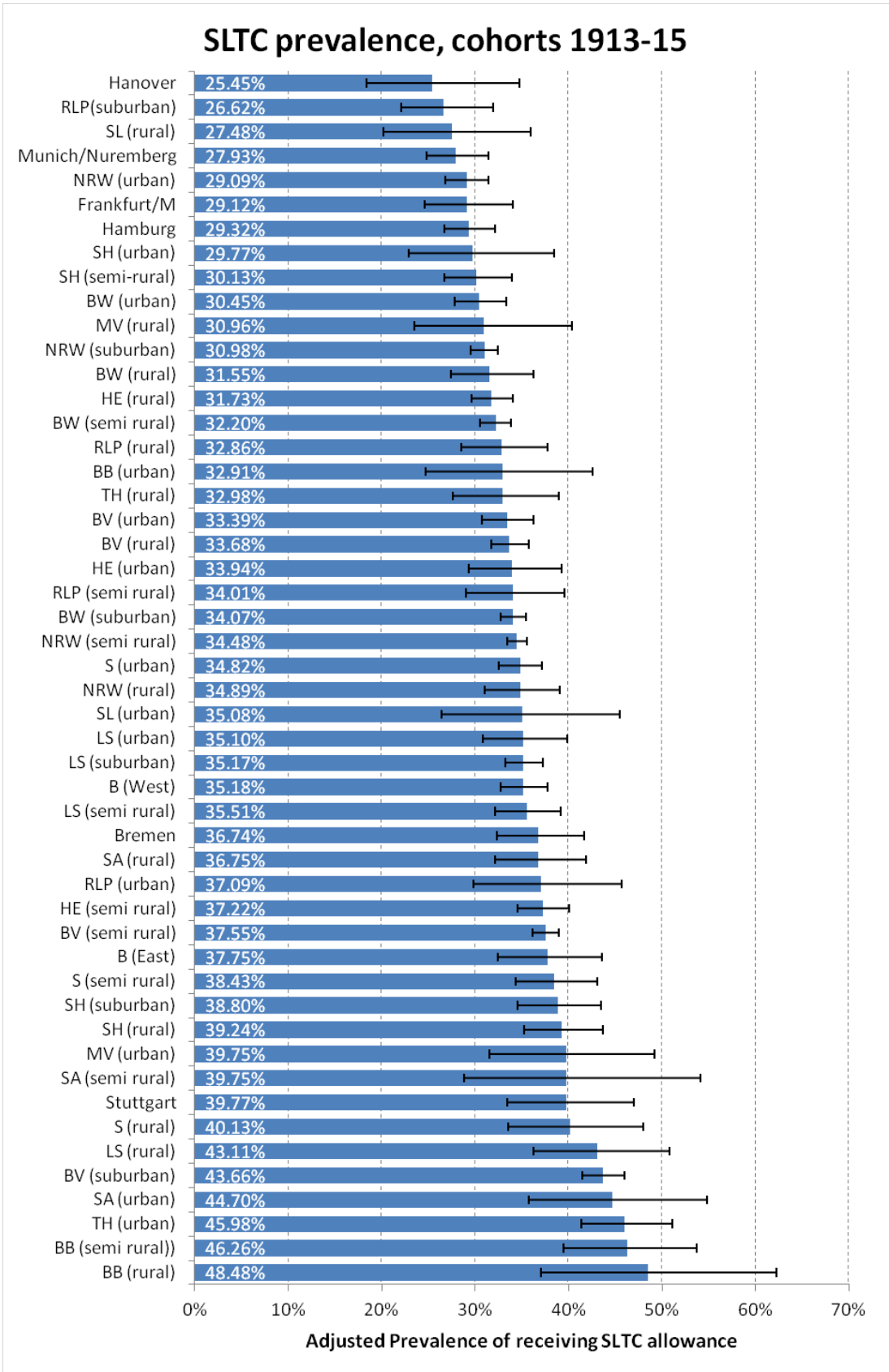

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 23: Spatial mapping of adjusted prevalence of longstanding illness of the cohorts 1922-24, 1925-27, 1928-30, 1931-33, persons at age 65+, 2005-2009*



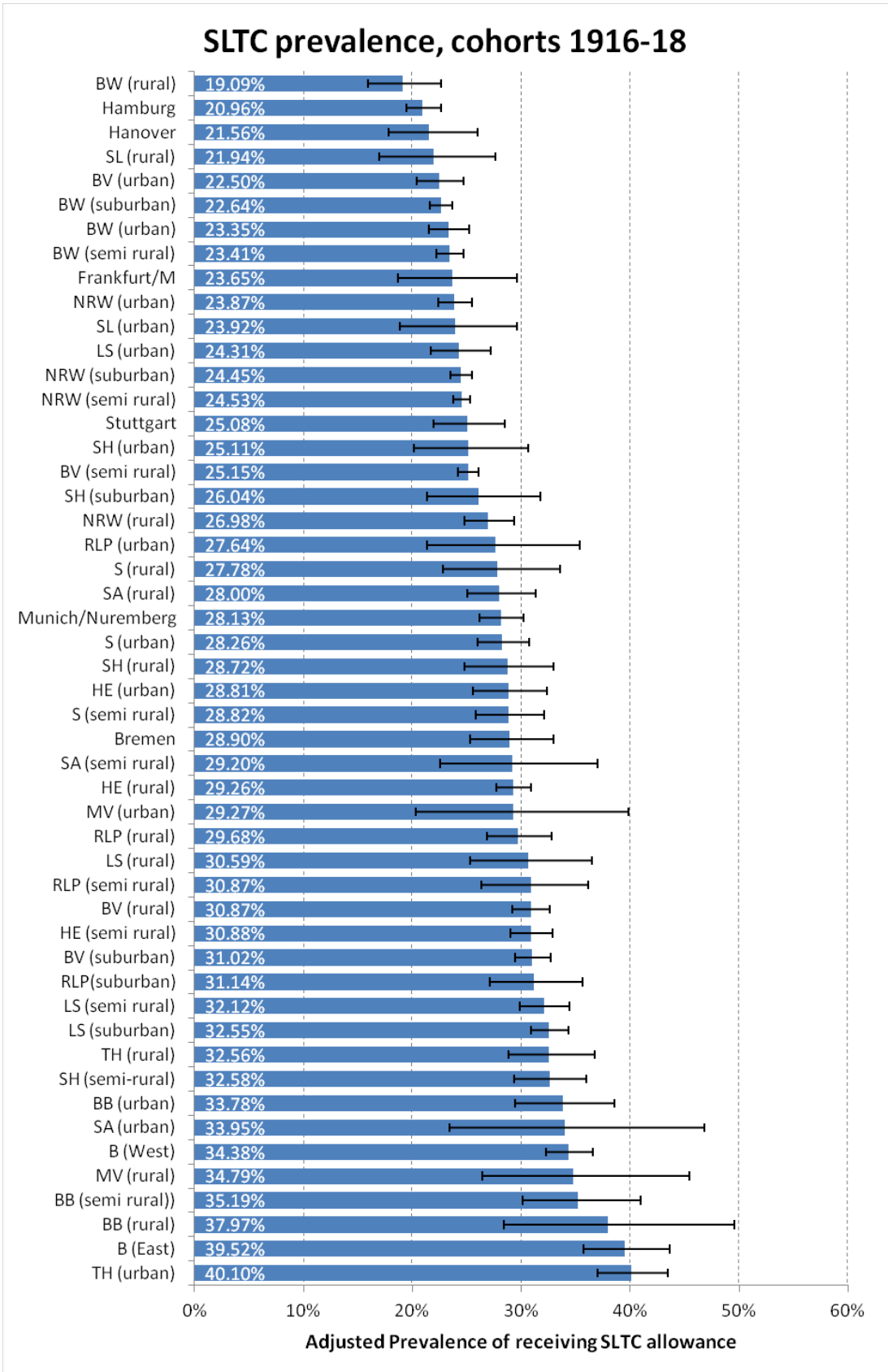

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 24: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1913-15, persons at age 65+, 2005-2009*



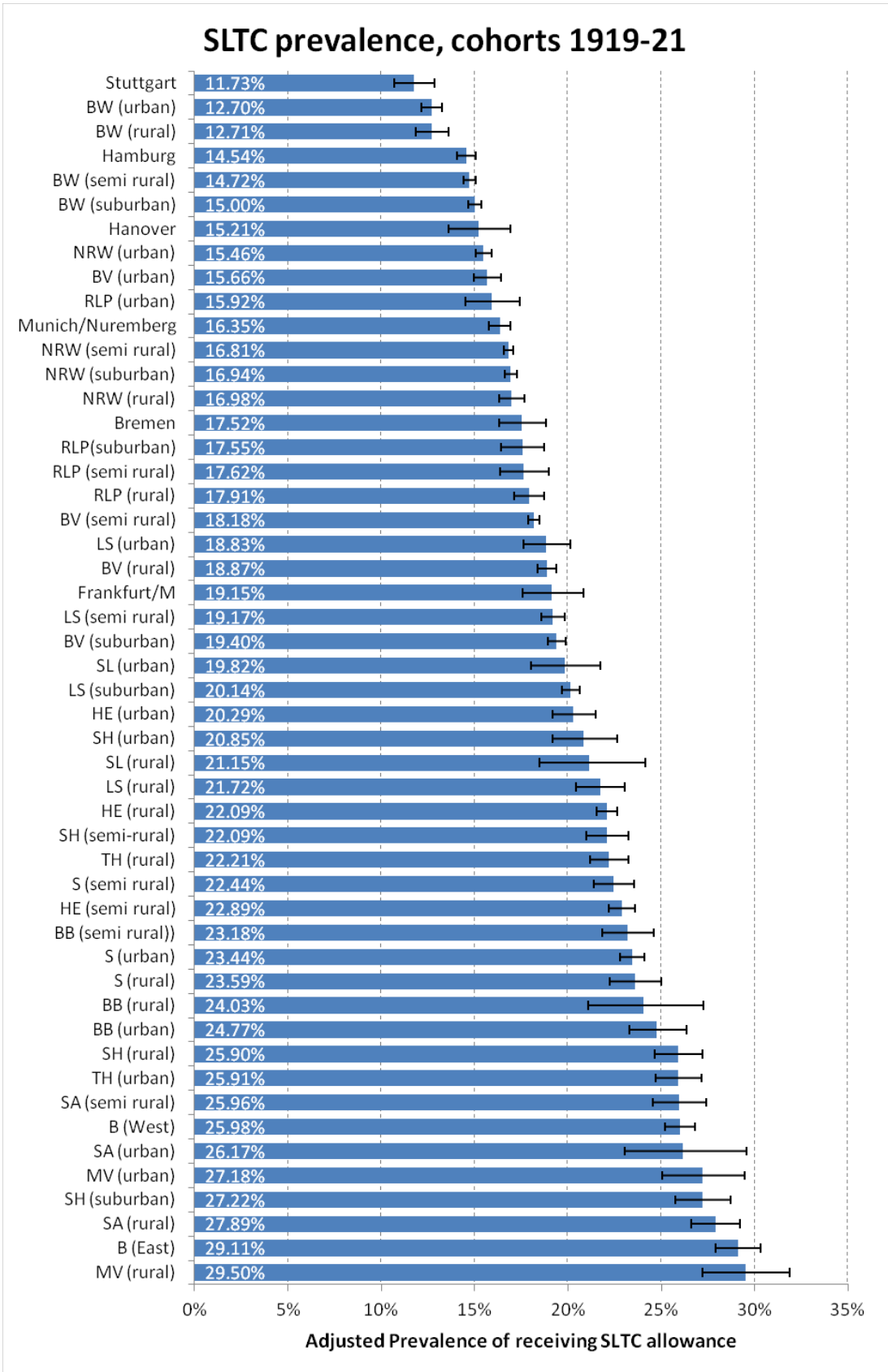

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 25: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1916-18, persons at age 65+, 2005-2009*



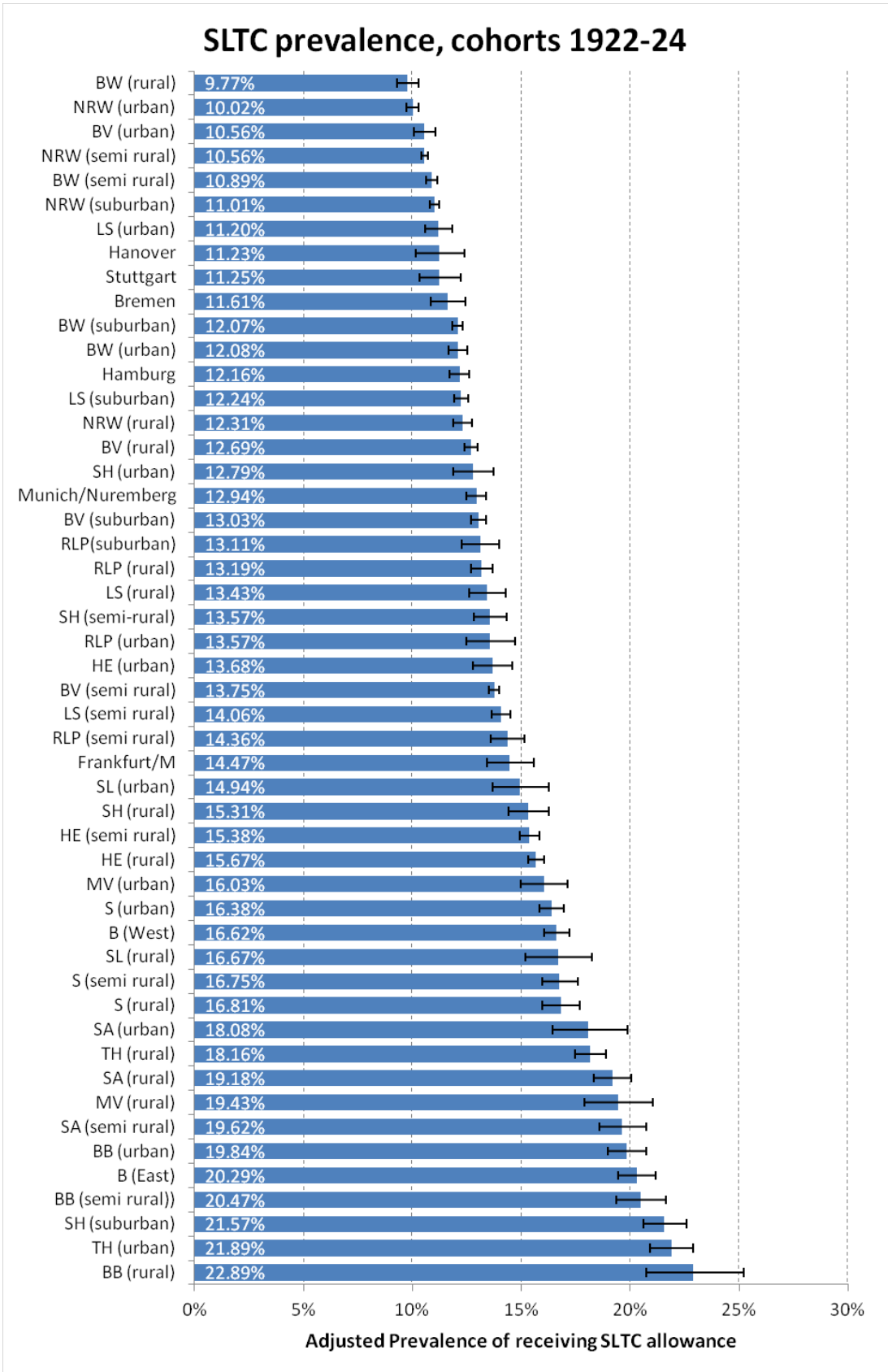

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 26: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1919-21, persons at age 65+, 2005-2009*



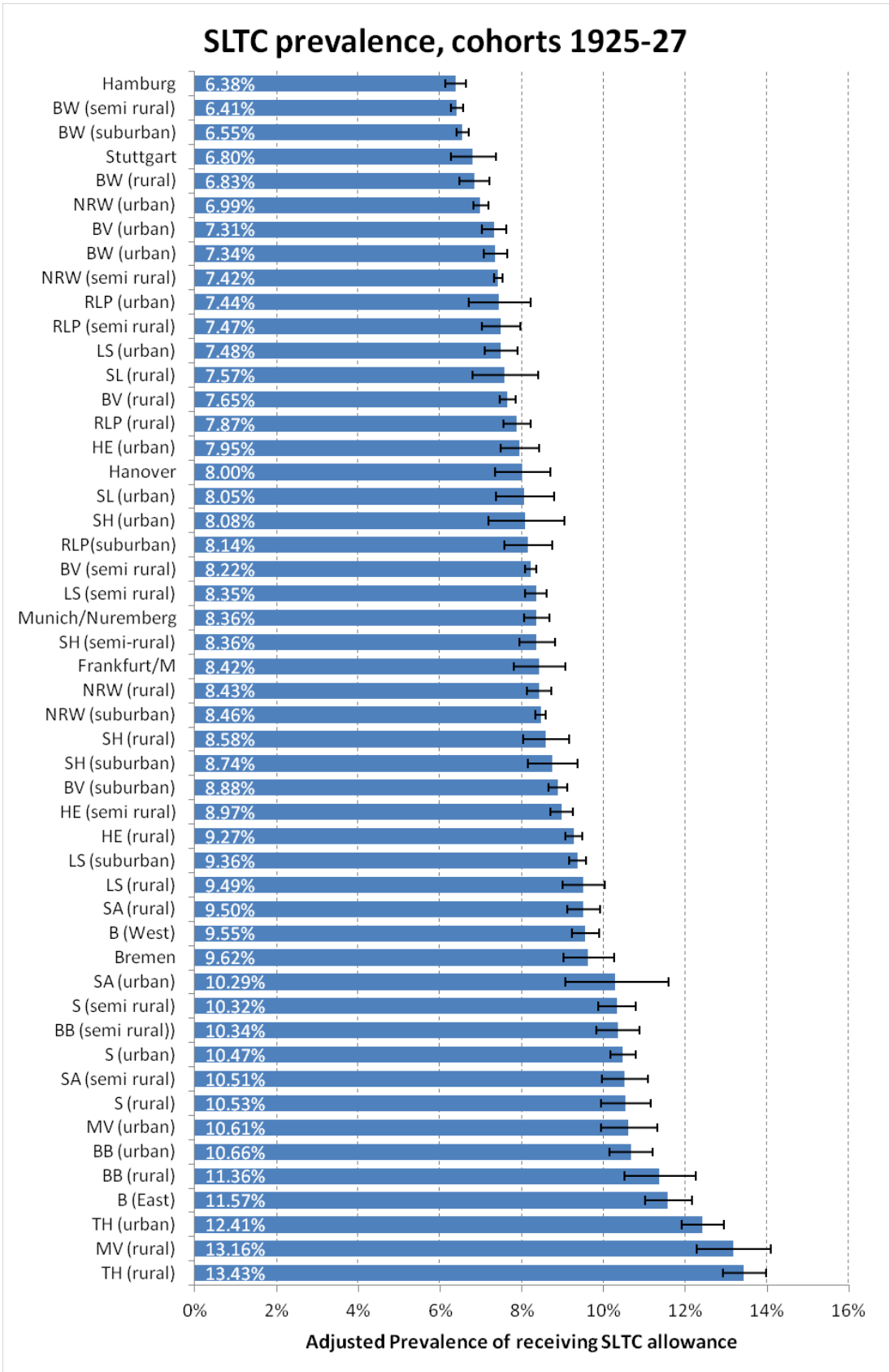

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 27: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1922-24, persons at age 65+, 2005-2009*



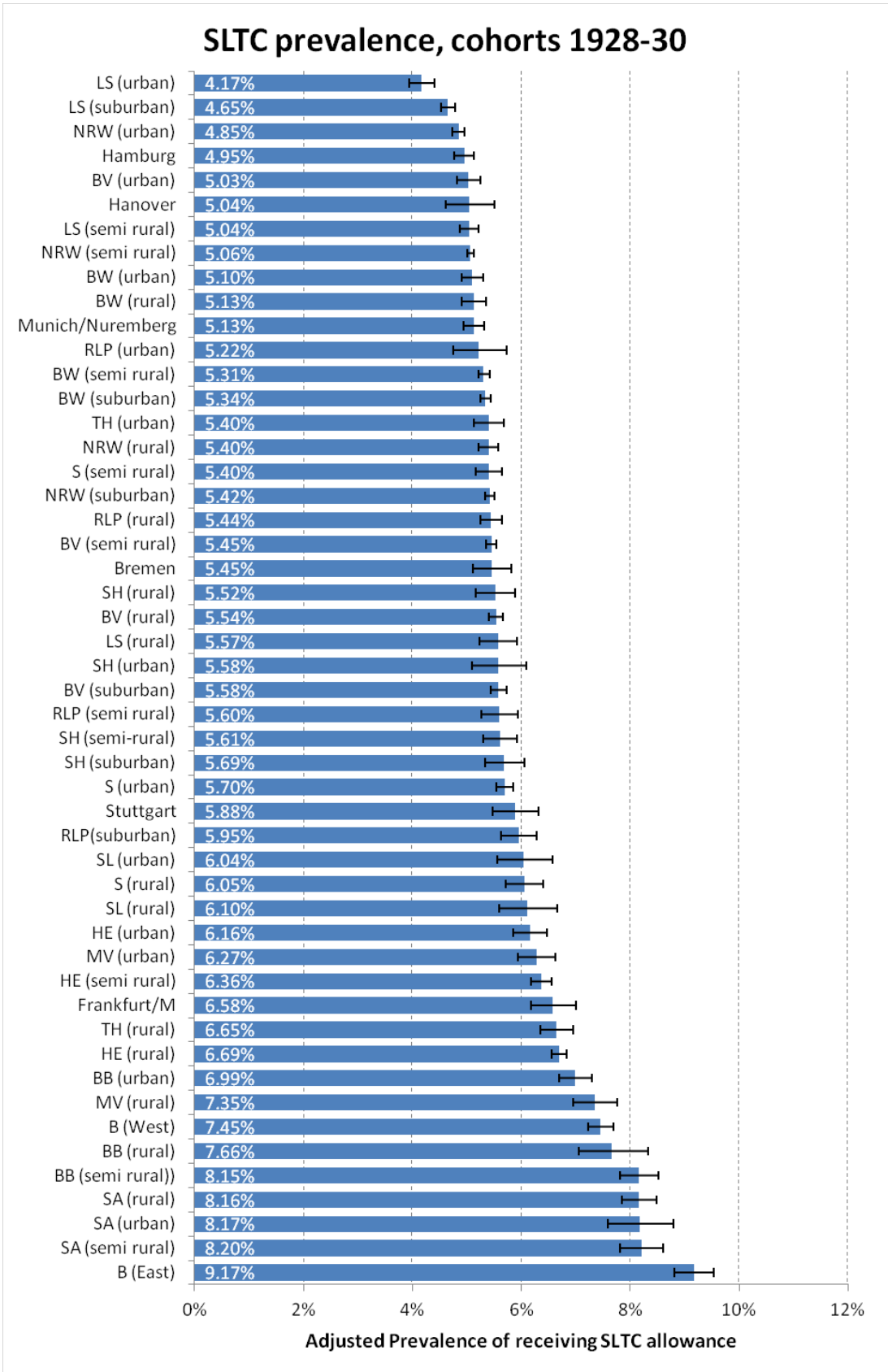

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 28: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1925-27, persons at age 65+, 2005-2009*



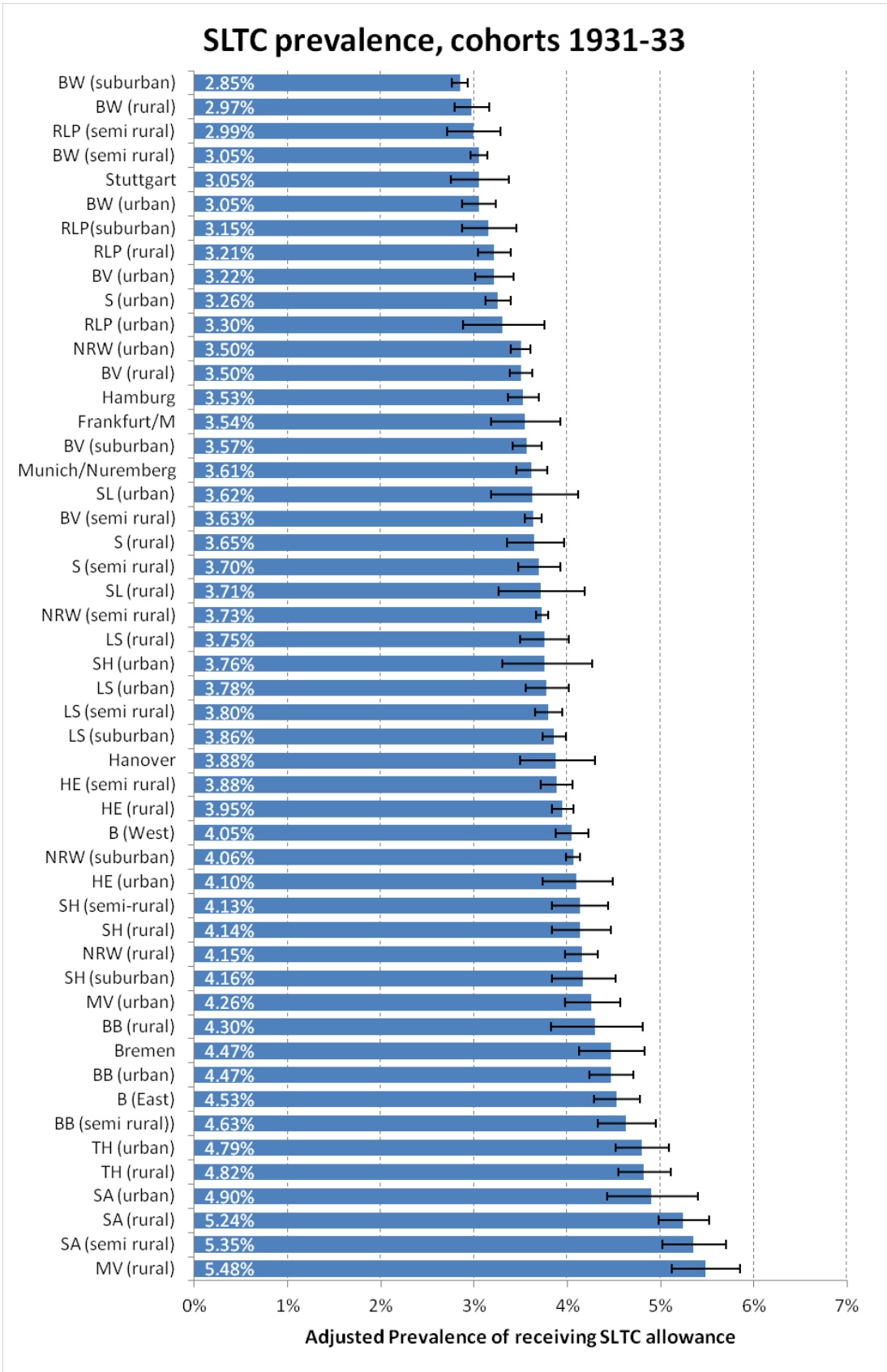

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 29: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1928-30, persons at age 65+, 2005-2009*



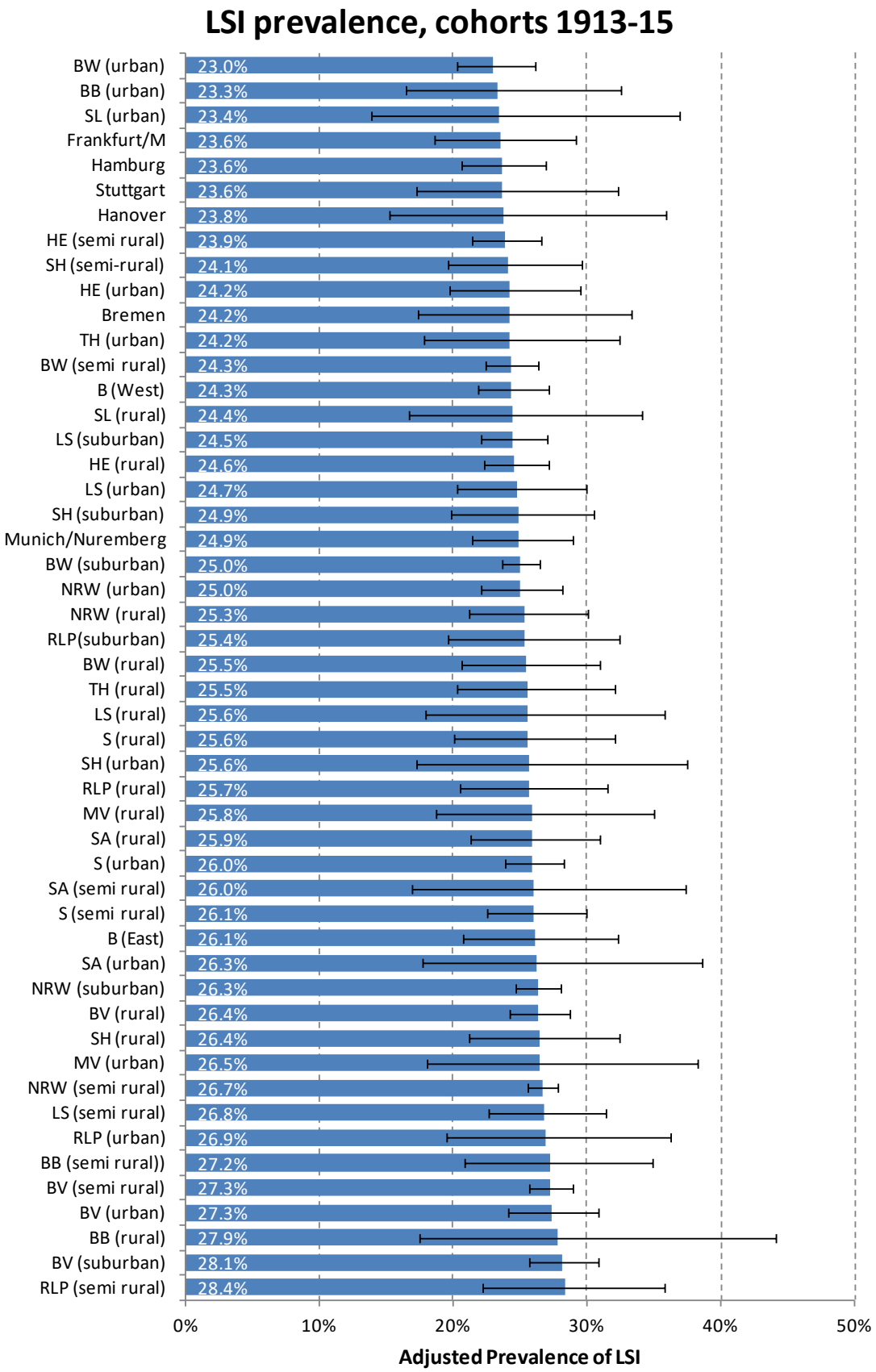

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 30: Adjusted prevalence of receiving SLTC allowance by regions, cohorts 1931-33, persons at age 65+, 2005-2009*



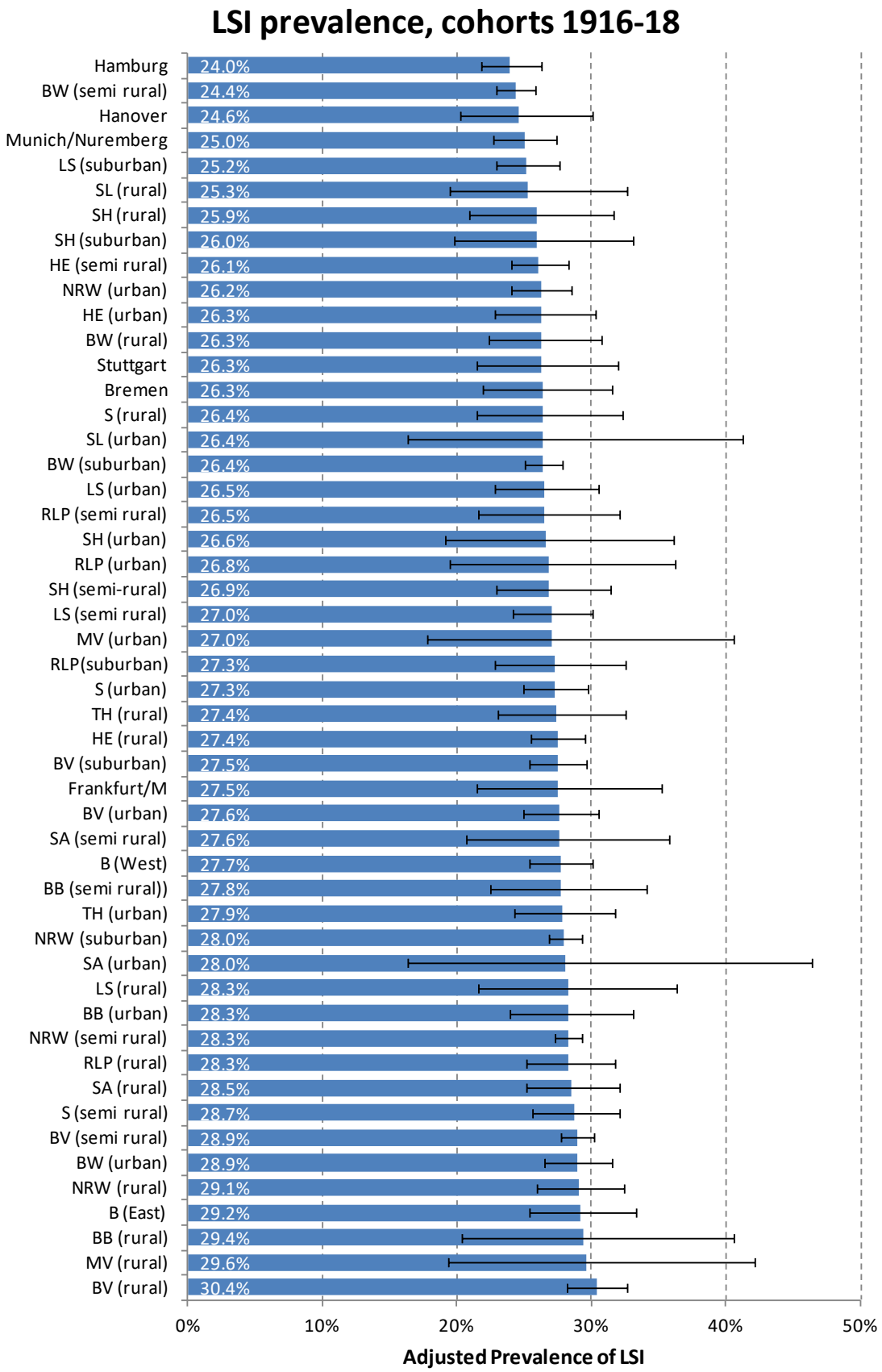

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 31: Adjusted prevalence of longstanding illness by regions, cohorts 1913-15, persons at age 65+, 2005-2009*



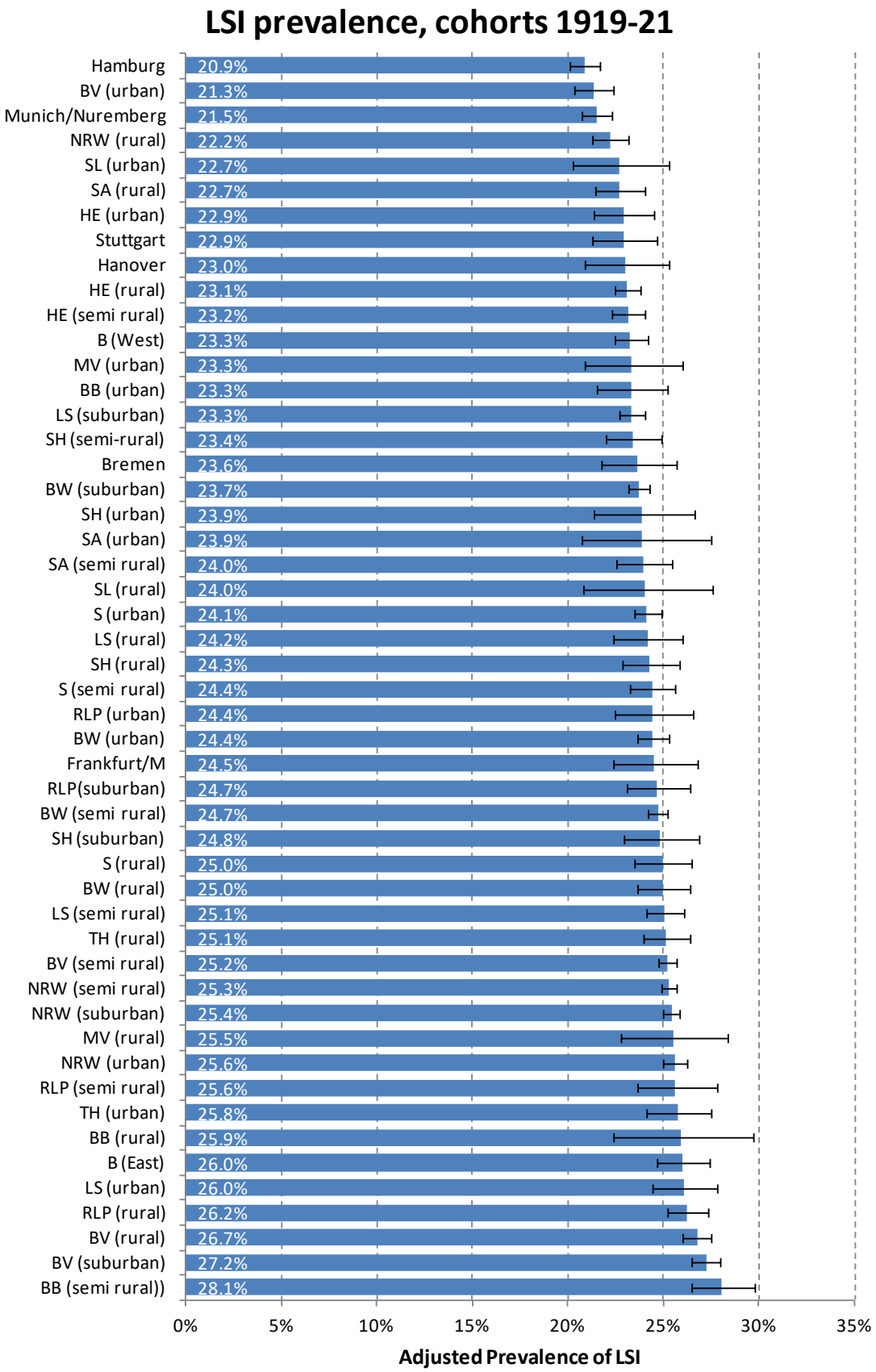

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 32: Adjusted prevalence of longstanding illness by regions, cohorts 1916-18, persons at age 65+, 2005-2009*



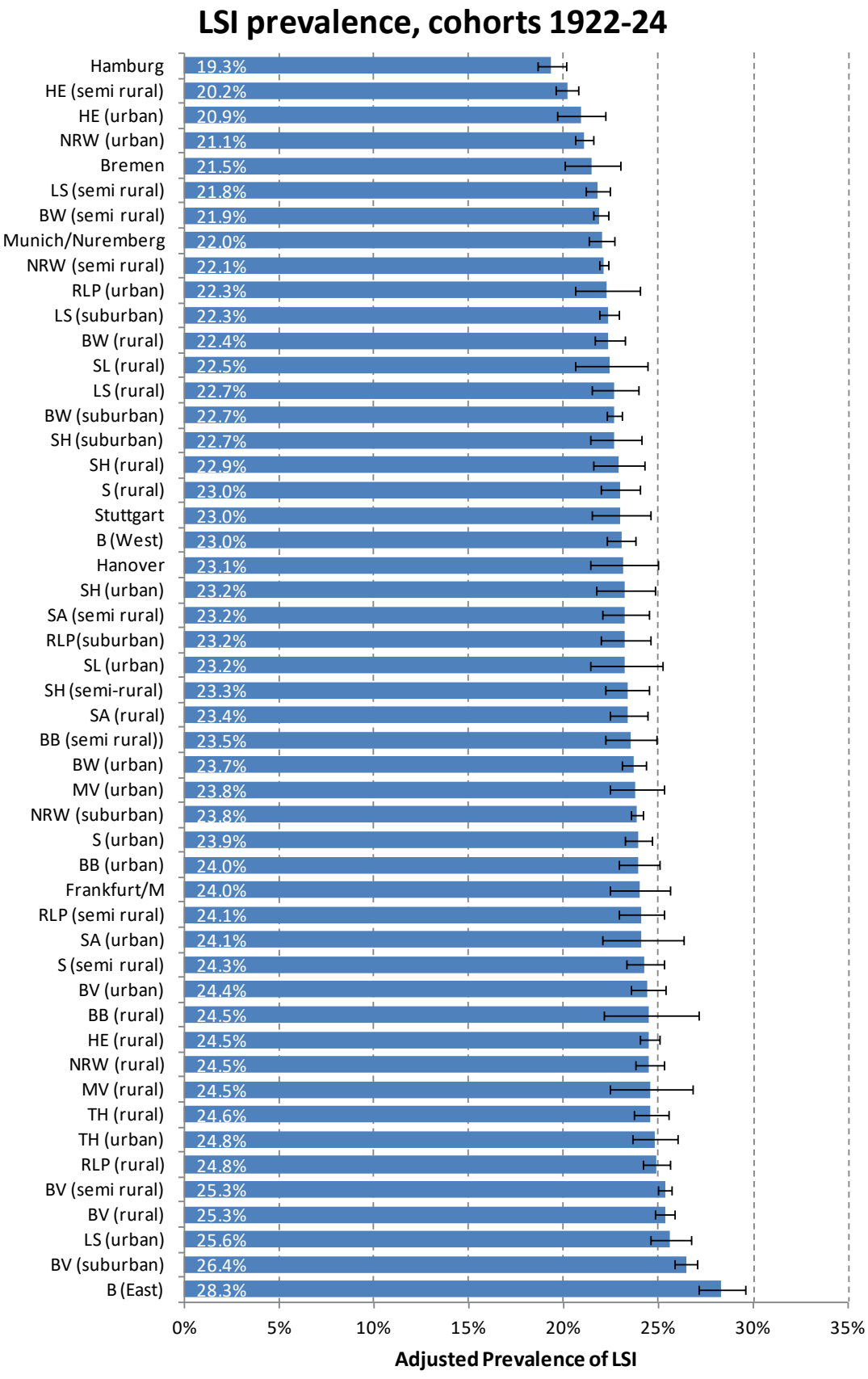

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 33: Adjusted prevalence of longstanding illness by regions, cohorts 1919-21, persons at age 65+, 2005-2009*



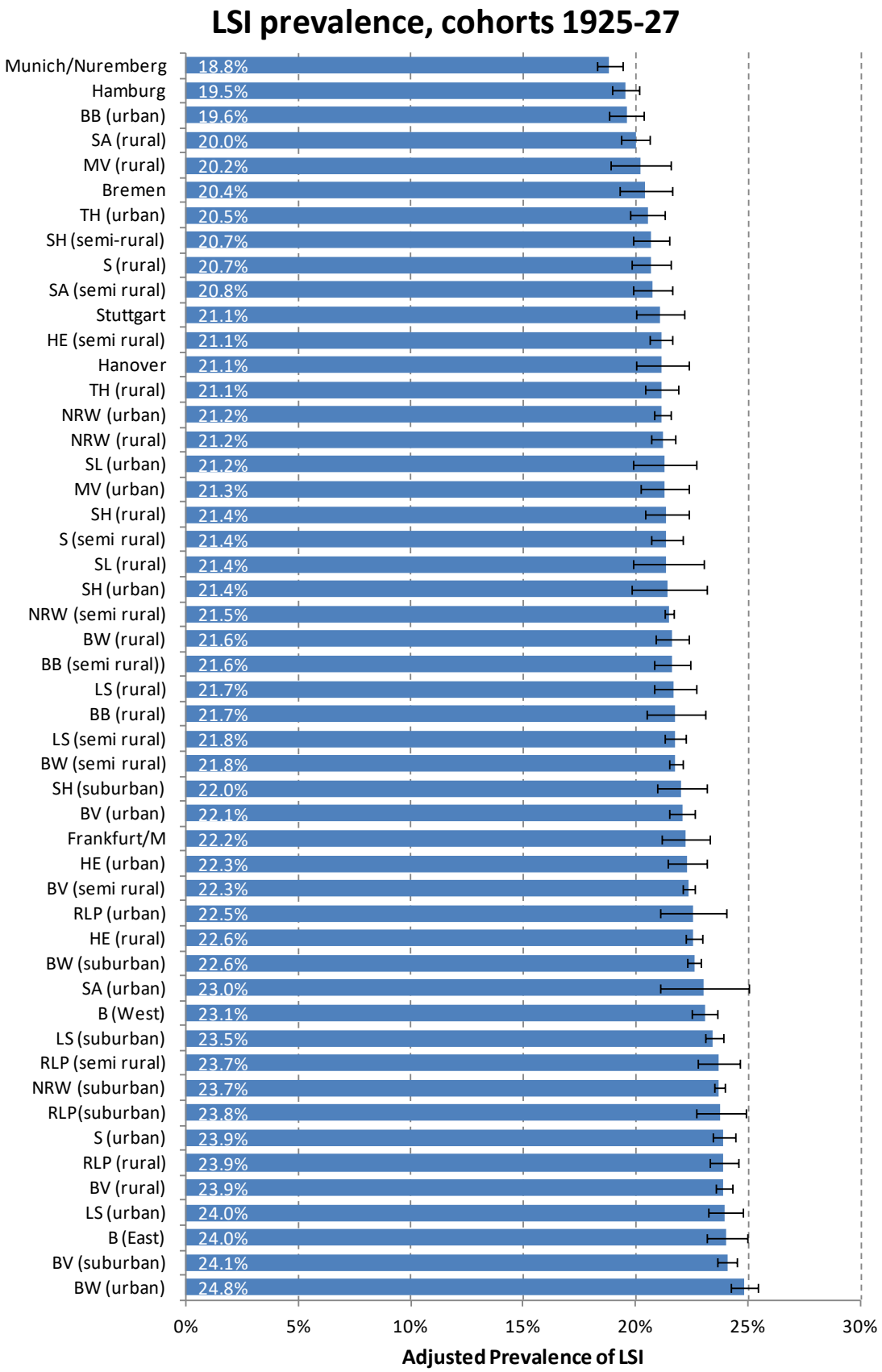

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 34: Adjusted prevalence of longstanding illness by regions, cohorts 1922-24, persons at age 65+, 2005-2009*



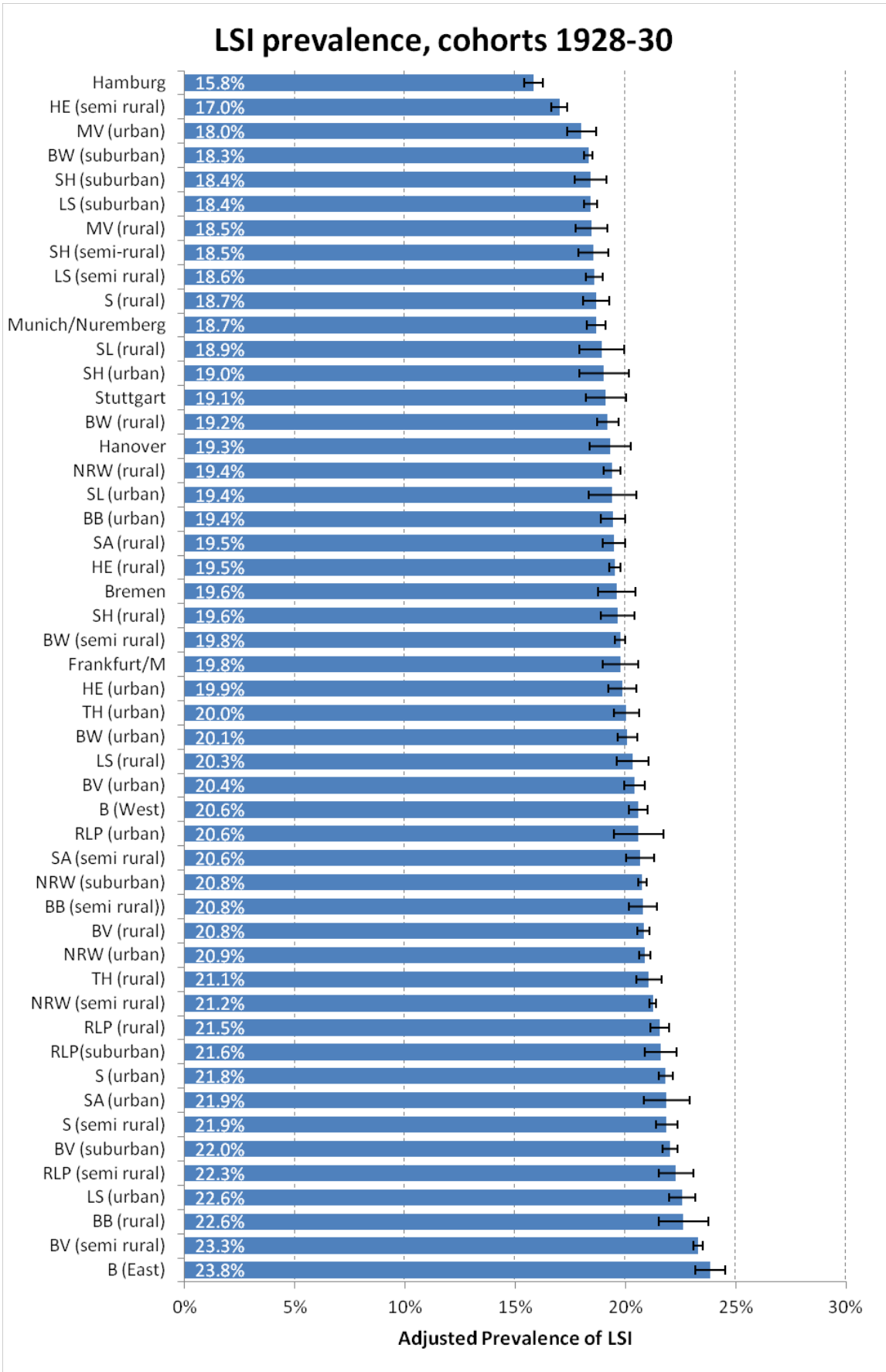

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 35: Adjusted prevalence of longstanding illness by regions, cohorts 1925-27, persons at age 65+, 2005-2009*



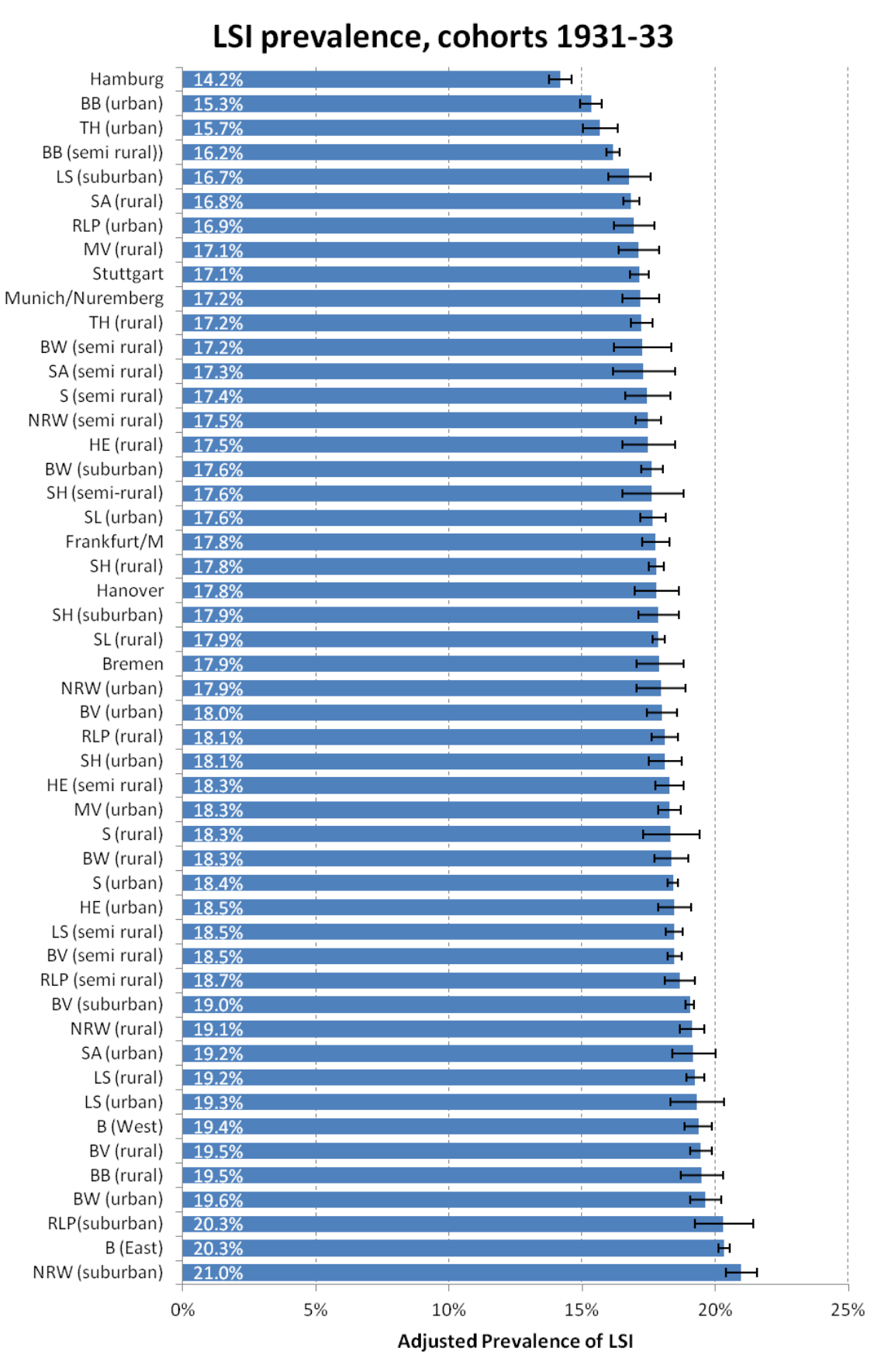

(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 36: Adjusted prevalence of longstanding illness by regions, cohorts 1928-30, persons at age 65+, 2005-2009*




(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)

*Figure 37: Adjusted prevalence of longstanding illness by regions, cohorts 1931-33, persons at age 65+, 2005-2009*




(Statistical Offices of the Federation and the Länder, Microcensus 2005, 2009)