Avoidable Mortality in the German Baltic Sea Region Since Reunification: Convergence or Persistent Disparities?

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Abstract

The consequences of political reunification for health and mortality have the unique character of a ‘natural experiment’. This is particularly true for the formerly divided German Baltic Sea region due to its cultural and geographic commonalities. This paper ascertains the changes and differences in premature mortality at ages 0–74 in urban and rural areas of the German states of Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH) since reunification and the contribution made by ‘avoidable’ mortality. Using official cause-of-death data, the effectiveness of health care and health policies was measured based on the concept of avoidable mortality in terms of both amenable and preventable conditions. Methods of decomposition and standardisation were employed in order to erase the compositional effect from the mortality trend. As a result, mortality differences relate primarily to men and the rural areas of the German Baltic Sea region. Whereas the mortality levels in the urban areas of MV and SH have converged, the rural areas of MV still show higher levels of preventable and amenable mortality. The results show that the accessibility and quality of medical care in the thinly populated areas of MV and the effectiveness of inter-sectoral health policies through primary prevention, particularly with regard to men, have room for improvement.

Keywords Avoidable mortality · Urban–rural differences · East and West Germany · Decomposition analysis · Direct standardisation · Natural experiment

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1 Background

Since the fall of the Iron Curtain, political transitions have taken place in Eastern Europe. However, measuring the contribution made by these transitions to improvements in health and life expectancy in country comparisons is difficult due to cultural differences which are barely quantifiable. Since these differences are assumed to be comparatively small between Western and Eastern Germany, the consequences of German reunification for mortality have the unique character of a ‘natural experiment’ in demographic research (Vaupel et al. 2003; Vogt and Vaupel 2015). Twenty-eight years after reunification, the average life expectancy is still lower in the eastern part of the country, at least among men. However, this east–west gap is partly a result of a north–south divide: life expectancy is highest in the south of Germany, which was part of West Germany, politically (Kibele 2012; Kibele et al. 2015; DESTATIS 2016).

Consequently, the ‘natural experiment’ attribution applies even more to the formerly divided German Baltic Sea region because of the geographic, cultural, historical and structural commonalities that cannot be found to the same extent in overall east–west comparisons. The two federal states that are located at the Baltic Sea—namely Mecklenburg–Vorpommern (MV) as part of the former German Democratic Republic (GDR) and Schleswig–Holstein (SH) as part of the former Federal Republic—are characterised by agriculture, tourism and lacking economic development and share a similar mentality, culture and language shaped by the Hanseatic era and centuries of Protestant tradition. These commonalities were among the driving factors for the long-time cooperation and, finally, the merger of the Evangelical Lutheran churches of Mecklenburg, Vorpommern and Schleswig–Holstein/Hamburg in 2012, which is the only east–west spanning church merger to date (Ahme et al. 2016). Today, the two states also share a common administrative unit within the framework of several federal institutions (Eltges 2014). From a historical perspective, the cooperation between the two regions in economic, cultural and political terms stretches back as far as the middle of the thirteenth century with the Wendish City League of Lübeck, Stralsund, Wismar, Kiel and Rostock marking an important milestone in the development of the Hanseatic League (Dollinger 1998).

In MV, Germany’s most north-easterly state, the average life expectancy is lower than in most other German states, including its western neighbour SH, even though it is a popular recreational and holiday destination and actually possesses a number of factors which are conducive to living a long life, e.g. good air quality, seaside location, many lakes and forests (LUNG 2017). Possible reasons for the lower life expectancy include socio-economic, structural and risk-relevant characteristics as well as selective migration following reunification and poorer living conditions during the GDR era.

As early life circumstances influence adult mortality (Doblhammer 2004), political, socio-economic and health conditions during the GDR are still likely to have an influence—albeit a decreasing one—on the mortality of people who grew up in MV in that time (Dinkel 2003; Gjonça et al. 2000). Generally,

socio-economic factors like employment, income, working conditions or education have a considerable impact on regional mortality differences in Germany, at least among men (Klein et al. 2001; Grobe and Schwartz 2003; von Gaudecker and Scholz 2007; Scholz and Schulz 2009; Scholz et al. 2010; Latzitis et al. 2011; Kibele 2012; Luy et al. 2015). The distribution of socio-economic characteristics, in turn, is influenced by selective migration. The emigration of ‘good risks’ has had a negative impact on average life expectancy in Eastern Germany (Luy and Caselli 2007). As concluded by Westphal (2016): “Leaving behind a population who has a greater susceptibility to chronic conditions, selective migration is likely to reinforce the consequences of population ageing and healthcare demand, in particular in regions characterised by outmigration”.

Structural factors involve, for instance, accessibility and quality of health care, which differ between regions. Aside from political, economic and social differences, two different health systems developed during the period of German partition (1949–1990), with the GDR’s system becoming increasingly antiquated in comparison with the FRG’s as far as medical technology was concerned (Dinkel 2003; Gjonça et al. 2000; Luy 2004a, b). As a consequence, the difference in life expectancy between East and West Germany grew until reunification, to the detriment of the east, but has been decreasing ever since. The remaining east–west gap is connected with causes of death that can be considered avoidable (Nolte et al. 2002; Kibele and Scholz 2009; Sundmacher et al. 2011; Kibele 2012). In addition, there are reverse urban–rural gaps in Eastern and Western Germany: in the west, overall mortality in urban districts is higher than in rural districts, but the opposite is true for the east (Kibele 2012). This contrast also applies to the German Baltic Sea region: In MV, the rural districts accordingly exhibit a higher level of mortality than the urban ones, especially in connection with cardiovascular diseases, whereas in SH the urban districts show a higher mortality level than the rural ones, particularly regarding neoplasms (Müller and Kück 1998; Heitmann et al. 2001; Kibele 2012; Mühlichen 2014). This contrast was implemented during the period of German partition. Whereas West Germany was committed to achieving regional equality of living conditions in accordance with its constitution, spatial planning in East Germany concentrated on the central cities, which consequently benefited from selective immigration (Werner 1985). Thus, the accessibility of medical care was, in comparison, limited in the neglected peripheral regions of the east (Bucher 2002; Mai 2004). As a long-term consequence, most urban districts in Eastern Germany still show better working and structural conditions and therefore attract internal migrants from the rural areas, which even further enhances the urban–rural contrast (Sander 2014).

Risk-relevant factors include smoking, alcohol abuse, unhealthy nutrition, low levels of physical activity and dangerous driving, for instance. Despite a considerable decline in traffic accident mortality in MV since 1990, it is still significantly higher here than in SH and most other German states. This is most likely a consequence of the many narrow tree-lined roads in the rural areas of MV which make dangerous driving even more dangerous (Dinkel 2003; DESTATIS 2017). Furthermore, according to a study by the Robert Koch Institute (RKI 2011), there is a high percentage of obesity among men and women in MV and a low level of sporting activity in comparison with other federal states. In this same study, men in MV also

exhibited considerably high rates of smoking and alcohol abuse and stated most often that they suffered from unhealthy working conditions. In SH and Hamburg, women showed relatively high percentages for smoking and alcohol abuse, whereas the values for men were below the German average. As a result, alcohol and tobacco-related mortality are relatively high among men in MV and among women in SH (Kibele 2012; Mons 2011).

Since German mortality statistics offer no insight into socio-economic background, migration biography or early life circumstances, and given that linkages to other data sources are not possible to date, the influence of these variables at an individual level cannot be estimated.¹ Structural and risk-relevant factors can, however, be addressed in the official cause-of-death statistics by the concept of ‘avoidable mortality’, which encompasses causes of death that can be either avoided through timely and effective health care (‘amenable mortality’) or can be reduced through primary prevention by means of effective inter-sectoral health policies (‘preventable mortality’) (Nolte et al. 2002; ONS 2011). A comparatively high number of causes of death that are considered amenable to health care indicates unfavourable structural conditions with regard to the accessibility and quality of health care, whereas a high level of preventable mortality points to deficits in the effectiveness of health policies in reducing risk-relevant behaviour, e.g. smoking, alcohol abuse and dangerous driving. Studies examining avoidable mortality in Germany focused on east–west differences (Nolte et al. 2002; Kibele and Scholz 2009) or on cross-sectional differences at the district level (Sundmacher et al. 2011; Kibele 2012). Long-term trends have not been examined for Germany at a regional level yet, not to mention the German Baltic Sea region.

The objective of this paper is therefore to explore the development of the adaptation process in mortality for MV compared to SH since reunification, taking particular account of amenable and preventable mortality. Due to urban–rural gradients in cause-specific mortality, which are in some cases diametrically opposed in Eastern and Western Germany (Kibele 2012), both states were divided into urban and rural districts. Specifically, the following four hypotheses were examined:

1. On the one hand, trends in cause-specific death rates in MV and SH are influenced by compositional changes in the age structure. Selective migration accelerated population ageing in MV but slowed it in SH. On the other hand, the trends are influenced by the general decline in mortality. Exploring the extent of these two components, it is our expectation that the trends in death rates and their differ-

¹ The only study that tried to estimate the connection between selective migration and mortality in Germany used the Billeter index as an indicator of selective migration (Luy and Caselli 2007). Surveys that include other explanatory variables, e.g. the German Life Expectancy Survey (LES) and the Socio-Economic Panel (SOEP), do not offer a sufficient number of cases for regional mortality analyses, whereas the Study of Health in Pomerania (SHIP) focuses on a very limited regional context. Data of the German Statutory Pension Insurance Scheme (FDZ-RV) only work sufficiently for elderly men who were not employed as officials in the civil service. Moreover, these datasets do not only allow for cause-specific mortality analyses. Multi-level studies that combine individual and macro-data are problematic from a causality point of view, particularly when the number of regional units is low.

ences across the study regions are mainly driven by changes in the direct mortality component and that the extent of the compositional component differs between urban and rural regions and is of greater importance in the latter.

2. As is typical for Western Germany, an urban–rural divide in mortality to the detriment of the urban areas is expected for SH, whereas the opposite scenario, as is typical for Eastern Germany, is expected for MV.
3. The difference in age-standardised mortality between urban MV and urban SH is expected to have been widely eliminated since reunification, whereas mortality in rural MV is expected to be significantly higher than in the other regions.
4. The anticipated remaining difference between rural MV and rural SH is expected to be due mainly to higher amenable and preventable mortality rates in rural MV.

Decomposition analysis is used to explore the contribution of compositional changes and survival improvements to the changes in the regional mortality differentials in MV and SH. Direct standardisation is used to examine the trend in cause-specific mortality, adjusted for compositional distortions. To control for regional bias, the economically strong city of Hamburg, its surrounding districts in SH and the structurally weak Vorpommern region were studied separately as a sensitivity analysis (see supplementary material online).

2 Data and Methods

2.1 Data Sets and Aggregation

In the following analyses, we used the official German year-end population numbers by sex, age and district for the period 1989–2011, and the official cause-of-death statistics, including all deaths according to sex, age, district and cause of death from 1990–2011. Whereas the population statistics were obtained directly from the statistical offices of MV and SH/Hamburg on request, the cause-of-death statistics were accessed and prepared in the period from mid-2013 to mid-2016 at the Wiesbaden location for guest researchers of the *Forschungsdatenzentrum der Statistischen Ämter der Länder* (research data centre of the statistical offices of the federal states), since these data are not freely available for the district or municipal level. Pre-1990 data on causes of death were not used because they are barely available for small regions and are not suitable for east–west comparisons due to different coding practices (Dinkel 2003).

Whereas the annual population statistics are aggregated by age and sex at the district level, the annual cause-of-death statistics are individual data that first had to be merged into one data set and then aggregated by age, sex, region and cause of death. In the original data sets, cause of death is registered according to the International Classification of Diseases (ICD), with ICD-9 codes up to 1997 and ICD-10 codes from 1998 onwards.

Due to the data protection regulations of the research data centre, the data selection was limited to age groups instead of single years of age (except for infant deaths) and to three-digit ICD codes. In addition, any aggregated number of deaths

per region, sex, cause of death, age group and calendar year had to exceed the number of two to not be deleted. Thus, considering the number of cases, we merged age groups with a similar cause-of-death structure into the following seven age groups: 0–14, 15–34, 35–49, 50–59, 60–64, 65–69 and 70–74. We excluded the 75+ age group, and analysed it separately (see Figure S.6 in the supplementary material online) “as ‘avoidability’ of death and reliability of death certification become increasingly questionable at older ages” (Nolte and McKee 2004: 65). Because of the low numbers of cases in the first two age groups in particular, and in order to avoid random variation over time, we used 5-year values for all rates. Thus, the analyses refer to the period from 1992 to 2009.

The regional division is based on the administrative distinction between *kreisfreie Stadt* (urban district) and *Landkreis* (rural district) prior to 4 September 2011. The following four regions were therefore generated: urban districts of MV (Urban MV), rural districts of MV (Rural MV), urban districts of SH (Urban SH) and rural districts of SH (Rural SH). In the sensitivity analysis (see Figures S.2–S.5 in the supplementary material online), we added for comparison the neighbouring city of Hamburg and analysed separately the surrounding *Landkreise* of Hamburg in SH and the eastern *Landkreise* of MV due to structural and socio-economic differences. As some changes in the regional administrative structure of MV took place in the early 1990s and in 2011, the district borders as of 4 September 2011 had to be updated retrospectively for all years prior to 2011 using additional municipal-level data on population and causes of death. Table 1 and a map in Figure S.1 in the supplementary material online illustrate the composition of the chosen regions.

Table 1 Composition of the study regions

Region	Administrative districts (according to current territorial status as from 4 September 2011)	Population size on 31 December 2011
Urban MV	Urban districts of Rostock and Schwerin; former urban districts of Greifswald, Neubrandenburg, Stralsund and Wismar	521,525
Rural MV	Landkreis Rostock, Ludwigslust-Parchim, Mecklenburgische Seenplatte (excl. Neubrandenburg), Nordwestmecklenburg (excl. Wismar), Vorpommern-Greifswald (excl. Greifswald) and Vorpommern-Rügen (excl. Stralsund) ^a	1,113,209
Urban SH	All urban districts: Flensburg, Kiel, Lübeck and Neumünster	618,914
Rural SH	Dithmarschen, Nordfriesland, Ostholstein, Plön, Rendsburg-Eckernförde, Schleswig-Flensburg, Steinburg, Herzogtum Lauenburg, Pinneberg, Segeberg, Stormarn ^b	2,218,727

^aVorpommern-Greifswald (excl. Greifswald) and Vorpommern-Rügen (excl. Stralsund) were analysed separately as ‘Rural Vorpommern’ (360,634 inhabitants), the rest as ‘Rural Mecklenburg’ (752,575 inhabitants) in the online supplementary material

^bHerzogtum Lauenburg, Pinneberg, Segeberg and Stormarn are the surrounding districts of Hamburg and were analysed separately as ‘Rural Southern Schleswig-Holstein’ (983,709 inhabitants), the rest as ‘Rural Northern Schleswig-Holstein’ (1,235,018 inhabitants) in the online supplementary material

2.2 Selection of Causes of Death

We selected causes of death on the basis of the avoidable mortality concept, first developed by Rutstein et al. (1976).² ‘Avoidable’ deaths can be divided into causes amenable to medical or health care (amenable mortality) and causes avoidable through primary prevention (preventable mortality). Whereas amenable mortality can be considered as an indicator of the effectiveness of health care through secondary prevention or medical treatment, preventable mortality can be considered as an indicator of the effectiveness of inter-sectoral health policies in the broad sense and largely reflects risk-relevant behaviour of the population (Nolte et al. 2002).

The list of amenable causes (Table 4 in the “Appendix”) is primarily based on Nolte and McKee (2003, 2004, 2008, 2012), which is the most widespread classification and suitable for international and regional comparisons as it is mostly based on three-digit codes and wider cause-of-death groups (instead of single 4-digit-code causes). Thus, it provides sufficient numbers and reduces incompatibilities because of different coding practices over time or across regions.³ The list of preventable causes (Table 5 in the “Appendix”) is primarily based on Page et al. (2006), which is the most comprehensive classification of causes avoidable through primary prevention. We added some conditions to both lists to keep in line with current research (see the notes of Tables 4 and 5 for detailed information) and made further minor adjustments to improve the compatibility between ICD-9 and ICD-10, especially when access is limited to three-digit codes. Moreover, we did not set an arbitrary threshold (i.e. a minimum number of cases or recent interventions) for excluding cases, as distinct from Tobias et al. (2010) and Plug et al. (2011). Apparently, an exclusion of rare causes like measles or whooping cough was unnecessary as all causes were aggregated into groups (amenable, preventable and other causes) and are not shown individually.

2.3 Methods

There are different ways of showing cause-specific mortality differences and dealing with compositional changes. The compositional component is particularly significant in this context because the composition of the population developed completely differently in the two federal states after reunification: while selective immigration had a rejuvenating effect on the age structure of SH, selective emigration accelerated population ageing in MV. To show cause-specific mortality differences over time and between regions and sex, without being distorted by compositional effects, the most suitable practice involves using standardised death rates. The direct standardisation of death rates was first introduced by Neison (1844) and has the advantage

² See Nolte and McKee (2004) for a detailed comparative description of all important works on the concept of avoidable mortality published prior to 2004.

³ See Mackenbach et al. (2013) for the limitations of amenable mortality analysis in international comparisons.

of being additive: “the sum of death rates by cause equals the death rate from all causes” (Meslé 2006: 36). Based on textbooks like Preston et al. (2000), we computed death rates with a directly standardised age and sex structure for each region according to sex and cause of death group. However, we adjusted the death rates for the use of 5-year periods and year-end population statistics:

$$\text{SDR}_t = \sum_x \left(\frac{D_{x,t-2} + D_{x,t-1} + D_{x,t} + D_{x,t+1} + D_{x,t+2}}{0,5 \cdot N_{x,t-3} + N_{x,t-2} + N_{x,t-1} + N_{x,t} + N_{x,t+1} + 0,5 \cdot N_{x,t+2}} \cdot C_x \right), \quad (1)$$

with SDR_t being the standardised death rate at time t (in years); D_x being the number of deaths at age x , N_x being the age-specific year-end population size and C_x being the age-specific standard population. In accordance with Preston et al. (2000: 26), the average of the age structures of MV and SH in 2000 was chosen as a standard population without disaggregation by sex (see Table S.1 in the supplementary material online). As a statistical test for the standardised death rates, we calculated 95% confidence intervals according to Chiang (1984), with the age-specific probability of death computed according to Farr (1859). If the confidence intervals of two regions did not overlap, the differences at the respective time t were interpreted as being statistically significant.

Another practice to measure mortality differences is the decomposition method, first introduced by Kitagawa (1955). Whereas the standardisation method eliminates the compositional impact on death rates by using an arbitrary standard population, the purpose of decomposition analysis is to measure the difference between the true, observed death rates both in terms of differences in mortality (direct component) and differences in age structure (compositional component).

We conducted two different decompositions. First, the difference in the (cause-specific or crude) death rate of each study region between 1990/1994 and 2007/2011 was decomposed into a direct and compositional component according to Kitagawa (1955). Second, we applied the ‘difference of differences’ approach of Rau et al. (2008) to the formula of Kitagawa to measure the direct and the compositional impact on the changes in mortality between regions over time:

1. the difference in mortality between 1990/1994 and 2007/2011 for urban districts in MV **minus** the difference in mortality between 1990/1994 and 2007/2011 for rural districts in MV,
2. the difference in mortality between 1990/1994 and 2007/2011 for rural districts in SH **minus** the difference in mortality between 1990/1994 and 2007/2011 for urban districts in SH,
3. the difference in mortality between 1990/1994 and 2007/2011 for urban districts in SH **minus** the difference in mortality between 1990/1994 and 2007/2011 for urban districts in MV and
4. the difference in mortality between 1990/1994 and 2007/2011 for rural districts in SH **minus** the difference in mortality between 1990/1994 and 2007/2011 for rural districts in MV.

This decomposition of the difference of the changes in the death rate Δd over time t_k (with $k = 1, 2$ for the periods of 1990/1994 and 2007/2011) between regions r_1 and r_2 was calculated in the following way⁴:

$$\begin{aligned} \Delta d(r_1, t_k) - \Delta d(r_2, t_k) = & \sum_x \frac{\frac{\bar{N}_x(r_1, t_2)}{\bar{N}(r_1, t_2)} + \frac{\bar{N}_x(r_1, t_1)}{\bar{N}(r_1, t_1)}}{2} \cdot (d_x(r_1, t_2) - d_x(r_1, t_1)) \\ & - \sum_x \frac{\frac{\bar{N}_x(r_2, t_2)}{\bar{N}(r_2, t_2)} + \frac{\bar{N}_x(r_2, t_1)}{\bar{N}(r_2, t_1)}}{2} \cdot (d_x(r_2, t_2) - d_x(r_2, t_1)) \\ & + \sum_x \frac{d_x(r_1, t_2) + d_x(r_1, t_1)}{2} \cdot \left(\frac{\bar{N}_x(r_1, t_2)}{\bar{N}(r_1, t_2)} - \frac{\bar{N}_x(r_1, t_1)}{\bar{N}(r_1, t_1)} \right) \\ & - \sum_x \frac{d_x(r_2, t_2) + d_x(r_2, t_1)}{2} \cdot \left(\frac{\bar{N}_x(r_2, t_2)}{\bar{N}(r_2, t_2)} - \frac{\bar{N}_x(r_2, t_1)}{\bar{N}(r_2, t_1)} \right), \end{aligned} \quad (2)$$

where the first two lines on the right side constitute the direct component, which shows the “contribution of survival improvement to the difference of differences of the death rates”, whereas the last two lines constitute the compositional component, which shows the “contribution of compositional changes over time on the difference of differences of the death rates” (Rau et al. 2008: 273). The annual average population size $\bar{N}$ was calculated based on the average of 2 year-end population numbers N . All statistical analyses were conducted in Excel.

3 Results

3.1 Decomposition of Trends in Death Rates

The results of the decomposition analysis are presented in Tables 2 and 3 for men and women, respectively. All in all, we find that the observed cause-specific death rates did not change drastically between 1990/1994 and 2007/2011 because of diametrically opposed developments in the direct and the compositional component. The direct component, without the compositional distortions, shows an immense decrease in amenable and preventable mortality, particularly in Mecklenburg–Vorpommern (MV). Survival improvements in other causes were comparatively small over time, especially in Schleswig–Holstein (SH). The direct effect was stronger than the compositional effect in the trend in amenable and preventable mortality rates in all regions and regarding both sexes. For women, this is also true for other causes, except for rural SH. Referring to the lower parts of both tables, the direct effect was stronger than the compositional one in terms of the change of the

⁴ The notation of the equations in this paper is based on Canudas-Romo (2003).

difference in observed death rates between urban and rural MV as well as between rural SH and rural MV. However, the change over time in the difference between rural and urban SH and between urban SH and urban MV was driven more by compositional changes. This is true for both sexes.

In more detail, with regard to men (Table 2), the observed cause-specific death rates decreased between 1990/1994 and 2007/2011, except for other causes of death, which increased in all regions. If the age structure had not changed between the two periods, however, all death rates would have fallen, as the direct component is negative in all regions. On the contrary, as a result of an ageing population, the compositional component is positive in all regions, especially in MV. In the urban areas of MV, the compositional impact in total premature mortality (33 per 10,000) is even stronger than the direct effect of mortality reduction (-32), which is, however, due to the impact of other causes of death. In all regions, the biggest improvements in terms of survival were found in preventable causes followed by amenable causes, whereas the reduction in other causes was comparatively small, especially in SH. Generally, the reduction in mortality was strongest in rural MV (-50 in total) followed by urban MV. Both urban and rural SH exhibited a decline in mortality of -21 per 10,000.

As shown in the lower half of Table 2, the regional differences in death rates decreased in most cases, except for the gap between urban SH and urban MV, where the direction changed to the detriment of the latter (from 3 to -5). This is primarily caused by the change in composition (-18.8), whereas the direct component points in the other direction (10.8). Thus, if the age structure had not changed, the death rates in the urban districts of MV would have improved to a greater extent than in the urban districts of SH, thereby narrowing the gap.⁵ Decreases in direct mortality differentials were remarkably high between the rural districts of SH and MV (29.4) and between the urban and rural areas of MV (18.3), which is largely attributable to preventable and amenable causes. By contrast, the decline in the difference between the rural and urban districts of SH (4.7) is mainly due to compositional changes (4.3), whereas the direct effect was relatively minor (0.3).

As shown in Table 3, the trend among women is almost identical. The main difference is that most values are substantially lower than those for men. In all regions, the observed death rates declined between 1990/1994 and 2007/2011, except for other causes in rural SH which increased slightly by 0.5 per 10,000. As was the case for men, the direct component shows a considerably higher decrease than the observed rates. In contrast to the trend among men, however, this decline was stronger in amenable mortality than in preventable mortality. Unlike the direct effect, the compositional component is positive in all regions, but has a lower impact on the observed mortality trend. Direct improvement in mortality was highest in rural MV (-26.4), followed by urban MV (-21.8), rural SH (-10.7) and urban SH (-10.5).

As far as the bottom part of Table 3 is concerned, the regional differences in observed mortality decreased between the two periods, with one exception: the

⁵ As the following chapter 3.2 will show, age-standardised mortality of men has never been significantly lower in urban MV than in urban SH since reunification.

Table 2 Decomposition of the difference in the cause-specific death rates of MV and SH (per 10,000) into direct and compositional components, men aged 0–74

Region	Cause of death	Death rate 1990/94	Death rate 2007/11	Δ	Direct	Compositional
Urban MV	Amenable causes	14.248	13.889	−0.359	−9.874	9.515
	Preventable causes	29.888	28.306	−1.582	−15.718	14.136
	Other causes	16.175	19.530	3.355	−6.050	9.404
	Total	60.312	61.725	1.414	−31.642	33.055
Rural MV	Amenable causes	19.309	15.590	−3.718	−13.940	10.222
	Preventable causes	42.586	30.709	−11.877	−28.507	16.630
	Other causes	17.927	19.668	1.741	−7.536	9.277
	Total	79.822	65.968	−13.854	−49.983	36.129
Urban SH	Amenable causes	15.757	12.898	−2.859	−6.792	3.933
	Preventable causes	30.065	22.713	−7.352	−13.097	5.745
	Other causes	17.500	21.056	3.556	−0.980	4.536
	Total	63.322	56.667	−6.655	−20.869	14.215
Rural SH	Amenable causes	13.662	11.917	−1.745	−7.039	5.294
	Preventable causes	25.638	20.375	−5.263	−12.619	7.356
	Other causes	14.590	19.595	5.005	−0.881	5.886
	Total	53.890	51.887	−2.003	−20.540	18.537
Urban MV minus rural MV	Amenable causes	−5.060	−1.701	3.359	4.066	−0.707
	Preventable causes	−12.698	−2.403	10.296	12.789	−2.494
	Other causes	−1.752	−0.138	1.613	1.486	0.127
	Total	−19.511	−4.243	15.268	18.341	−3.074
Rural SH minus urban SH	Amenable causes	−2.094	−0.981	1.114	−0.247	1.361
	Preventable causes	−4.427	−2.338	2.088	0.477	1.611
	Other causes	−2.910	−1.461	1.449	0.099	1.350
	Total	−9.431	−4.780	4.651	0.329	4.322
Urban SH minus urban MV	Amenable causes	1.509	−0.991	−2.500	3.082	−5.581
	Preventable causes	0.177	−5.593	−5.770	2.622	−8.392
	Other causes	1.324	1.526	0.202	5.069	−4.868
	Total	3.010	−5.058	−8.068	10.773	−18.841
Rural SH minus rural MV	Amenable causes	−5.646	−3.673	1.973	6.901	−4.927
	Preventable causes	−16.948	−10.334	6.614	15.888	−9.274
	Other causes	−3.338	−0.074	3.264	6.655	−3.391
	Total	−25.932	−14.081	11.851	29.443	−17.592

difference of observed mortality between urban SH and urban MV (−3.7) actually increased, not only among men but also among women. Whereas the direct effect (11.4) points towards a considerably greater improvement in terms of survival in urban MV, this was outweighed by the compositional effect (−15), i.e. the stronger population ageing of urban MV. The contribution of the direct component was strongest in terms of the difference between rural SH and rural MV

Table 3 Decomposition of the difference in the cause-specific death rates of MV and SH (per 10,000) into direct and compositional components, women aged 0–74

Region	Cause of death	Death rate 1990/94	Death rate 2007/11	Δ	Direct	Composi- tional
Urban MV	Amenable causes	12.386	10.123	– 2.263	– 8.073	5.809
	Preventable causes	11.689	9.572	– 2.117	– 7.006	4.890
	Other causes	12.341	11.575	– 0.766	– 6.760	5.994
	Total	36.415	31.269	– 5.146	– 21.839	16.693
Rural MV	Amenable causes	16.379	10.538	– 5.841	– 10.749	4.909
	Preventable causes	14.234	9.552	– 4.682	– 8.692	4.010
	Other causes	14.536	12.214	– 2.323	– 7.001	4.679
	Total	45.149	32.304	– 12.845	– 26.443	13.598
Urban SH	Amenable causes	14.319	9.527	– 4.793	– 5.366	0.573
	Preventable causes	12.544	9.755	– 2.789	– 3.299	0.510
	Other causes	13.302	12.055	– 1.247	– 1.810	0.562
	Total	40.165	31.337	– 8.828	– 10.474	1.646
Rural SH	Amenable causes	12.883	9.724	– 3.160	– 5.354	2.194
	Preventable causes	10.400	8.504	– 1.896	– 3.586	1.690
	Other causes	11.562	12.062	0.500	– 1.754	2.255
	Total	34.846	30.290	– 4.556	– 10.694	6.139
Urban MV minus rural MV	Amenable causes	– 3.993	– 0.416	3.577	2.676	0.901
	Preventable causes	– 2.545	0.020	2.565	1.686	0.879
	Other causes	– 2.195	– 0.639	1.556	0.241	1.316
	Total	– 8.733	– 1.034	7.699	4.603	3.096
Rural SH minus urban SH	Amenable causes	– 1.436	0.197	1.633	0.011	1.621
	Preventable causes	– 2.143	– 1.251	0.892	– 0.287	1.179
	Other causes	– 1.740	0.007	1.747	0.055	1.692
	Total	– 5.319	– 1.047	4.272	– 0.220	4.493
Urban SH minus urban MV	Amenable causes	1.934	– 0.596	– 2.529	2.707	– 5.236
	Preventable causes	0.855	0.183	– 0.672	3.707	– 4.379
	Other causes	0.961	0.480	– 0.481	4.951	– 5.432
	Total	3.749	0.067	– 3.682	11.365	– 15.047
Rural SH minus rural MV	Amenable causes	– 3.496	– 0.815	2.681	5.395	– 2.714
	Preventable causes	– 3.833	– 1.048	2.786	5.106	– 2.321
	Other causes	– 2.974	– 0.152	2.823	5.247	– 2.424
	Total	– 10.303	– 2.014	8.289	15.748	– 7.459

(15.7). Regarding the change in the difference between urban and rural MV, both the direct (4.6) and the compositional effect (3.1) showed the same direction, whereas the observed change between rural and urban SH is almost entirely attributable to changes in the age structure (4.5).

The direct component in other causes is relatively high for the change in the differences between urban SH and urban MV (about 5 per 10,000 for both men and

women) and between rural SH and rural MV (6.7 in men, 5.2 in women), compared to the inner-state regional differences in other causes. This is due to stronger decreases in other premature mortality in MV than in SH, even though these are still minor in comparison with the decreases in amenable and preventable causes.

3.2 Standardised Death Rates

To show the regional mortality trend over time, without distortions due to differences or changes in the age structure, we calculated standardised death rates. Figures 1, 2, 3, 4 display these rates, including confidence intervals (for measuring significance), broken down by causes of death for the population aged 0–74 in the urban and rural districts of MV and SH between 1990/1994 and 2007/2011, with men shown on the left and women on the right. For reasons of simplicity, the 5-year periods were named after the middle year in the figures (e.g. 1992 instead of 1990–1994). As already indicated in Sect. 3.1, the decrease in overall premature mortality (Fig. 1) was greater in MV than in SH, starting from a considerably higher level at the time of reunification. This process of equalisation was especially strong in the 1990s, but eventually slowed down. We find diametrically opposed urban–rural gradients in all-cause premature mortality in MV and SH, to the favour of urban MV and rural SH, respectively. The gap between the rural and urban areas of SH is significant and remained largely constant over time for both sexes. However, the gap between the urban and rural areas of MV decreased and is only still significant for men as it has become very small among women. Among both sexes, the difference in premature mortality between urban MV and urban SH had already been eliminated in the

Fig. 1 All-cause mortality in urban and rural regions of Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH), standardised death rate (deaths per 100,000), years 1992–2009, ages 0–74

Fig. 2 Amenable mortality in urban and rural regions of Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH), standardised death rate (deaths per 100,000), years 1992–2009, ages 0–74

mid-1990s. At the end of the observation period, rural MV still showed a significantly higher mortality level among men, although the difference has declined to a considerable extent. As for women, however, there is no longer any significant difference between rural MV on the one hand and rural SH and urban MV on the other, whereas urban SH lately displayed the highest level of premature mortality.

With regard to Figs. 2, 3, 4, preventable mortality is considerably higher than amenable mortality among men, whereas the opposite is the case for women, albeit to a lesser extent and with the exception of women in urban SH. Although the rate for other premature deaths was comparatively low in the early 1990s, the decrease in amenable and preventable mortality meant that it was higher at the end of the observation period, except for preventable mortality among men. In terms of amenable mortality (Fig. 2), the trend is very similar to overall premature mortality, albeit on a lower level. The main difference is that all significant regional differences have been completely eliminated for women. The preventable mortality trend, shown in Fig. 3, is also similar to that for overall premature mortality. However, the difference between urban MV and urban SH was not eliminated but actually increased in the final years of the observation period. With regard to other causes (Fig. 4), survival improvements were comparatively low, except for rural and urban MV in the early 1990s. In the final years of the observation period, the rate for both men and women was significantly higher in urban SH than in the other three regions, which showed no considerable differences at the end of the period; the only exception was the significantly higher rate for women in rural SH compared to urban MV.

Thus, among men, the remaining difference in premature mortality between MV and SH is primarily caused by higher levels of amenable and preventable mortality in rural MV. However, the urban districts of MV also show significantly higher

Fig. 3 Preventable mortality in urban and rural regions of Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH), standardised death rate (deaths per 100,000), years 1992–2009, ages 0–74

Fig. 4 Other mortality in urban and rural regions of Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH), standardised death rate (deaths per 100,000), years 1992–2009, ages 0–74

levels of preventable mortality in comparison with rural and urban SH. For women, the difference in amenable, preventable and other premature mortality between rural MV and both urban MV and rural SH has been completely eliminated, whereas

urban SH meanwhile exhibits the highest levels in all three categories. However, only in preventable mortality is the level significantly higher.

4 Discussion

The German Baltic Sea region is an east–west spanning region of two federal states in the north of Germany—Mecklenburg–Vorpommern (MV) and Schleswig–Holstein (SH)—that show strong commonalities in terms of geography, culture and economy and are not affected by the north–south divide of mortality in Germany. As a natural experiment, this paper shows for the first time the trend in premature mortality in MV and SH since reunification, focusing on the contribution made by avoidable mortality, based on a revised classification. Urban–rural differences were studied as well to demonstrate where the levels of mortality have already converged and where this has not been the case.

Methods of decomposition and standardisation were used to eliminate the compositional effect from premature mortality rates. Both methods reveal that premature mortality has decreased rapidly in the German Baltic Sea region since reunification. This is mainly due to a decline of avoidable mortality, i.e. causes considered avoidable through primary prevention or amenable to health care. In the 1990s in particular, survival improvements were stronger in MV than in SH, resulting in a balancing out in levels of mortality between the two neighbouring federal states. The huge difference between both states during the 1990–1994 period can largely be explained by the lack of medical technology in the former GDR (Dinkel 2003). The considerable decrease in amenable mortality in MV in the 1990s therefore reflects the massive improvements in the medical environment after reunification, whereas the decline in preventable mortality mirrors the improved effectiveness of inter-sectoral health policies in reducing risk-relevant behaviour. The regional differences that are still evident primarily concern men. For women, regional mortality differences have been largely eliminated, except in the urban districts of SH where mortality from preventable and other causes has turned to be significantly higher compared to the other three regions.

4.1 Survival Improvements Versus Compositional Changes

The results of the decomposition analysis reveal immense distortions in the observed death rates caused by the compositional component, i.e. changes in the age structure. The direct component, i.e. survival improvements, and the compositional component had a diametrically opposed effect on the observed death rates. Consequently, if the age structure had not changed since 1990, the decrease in mortality rates would have been much greater in all regions, especially in MV. In fact, compared to SH, the population of MV was younger in the early 1990s, whereas it has now become older as a consequence of increasing life expectancy, low fertility and—in particular—selective migration (Dinkel 2004; Grünheid 2015).

Based on the given data, the first hypothesis, according to which the direct component had a stronger impact than the compositional one, has been confirmed in terms of the development of amenable and preventable mortality rates in all regions and both sexes. The direct effect was also stronger as regards the change in the difference in observed death rates between urban and rural MV and between rural SH and rural MV among both sexes. This feature of a strong direct effect is firstly because of the immense reduction in the level of avoidable mortality in rural MV which was, by comparison, high at the time of reunification. Secondly, urban and rural MV had similar age structures and suffered both from selective emigration particularly in the 1990s, albeit to a greater extent in rural MV (Lehmann 2008; Weiß 2006).

However, we established that the change over time in the difference between rural and urban SH and between urban SH and urban MV was driven more by compositional changes, which is also true for both sexes. In the first case, the mortality gap between urban and rural SH remained constant. Thus, the minor changes in the difference over time between these two regions were largely caused by changes in the age structure. In the second case, both effects were considerable, but the compositional one had an even greater impact because the average age in urban MV was lower than in urban SH in the early 1990s but higher in 2007/2011. In addition, the real mortality gap in 1990/1994 between these two regions was not as pronounced as between rural MV and rural SH.

Additional age-specific analyses of the data show that the direct component becomes stronger with growing age. The older age groups benefited to a greater extent from survival improvements than the younger ones. An exception is men in rural MV who showed the highest survival improvements in the 50–59 age group, particularly in connection with preventable mortality. In comparison with the compositional component, all four regions have in common that the direct component was more effective at ages 0–64, whereas the compositional component was more pronounced in the 65–69 and 70–74 age groups.

4.2 Urban–Rural Divides

By means of direct standardisation, we find diametrically opposed urban–rural gradients in all-cause premature mortality in MV and SH to the favour of urban MV and rural SH, thus confirming the second hypothesis, based on the given data. This regional divide in SH, with higher mortality rates in urban than in rural districts, is typical for all of Western Germany (Kibele 2012). This paper shows that the higher premature mortality level in urban SH is due in particular to causes of death that should be avoidable through primary prevention and—with reference to men only—causes that should be amenable to health care. This urban–rural gap is concentrated on men and women aged 35–74, particularly in connection with amenable and preventable neoplasms, whereas rural SH shows a higher mortality level in terms of traffic accidents in the 15–34 age group and cardiovascular diseases in the 75+ age group, as profound age- and cause-specific analyses of the data show. In SH, there is also an urban–rural divide in other premature deaths, though this divide is not significant for women. Aside from the varying effectiveness of health policies and

health care, different compositions of socio-economic status—as shown by macro-economic indicators (BBSR 2015)—and thus different compositions of risk-relevant behaviour may contribute to this divide.

By contrast, the rural–urban gap in MV has decreased and is only still significant for men as it has become very small among women. This decrease can be seen in the light of the shifting of mortality to older ages as a consequence of immense improvements in medical infrastructure following reunification, from which rural MV profited more since the need to catch up was greater there (Bucher 2002; Dinkel 2003; Mai 2004). Among men, the rural–urban gap in premature mortality in MV is closely linked to amenable mortality. Profound age- and cause-specific analyses show that cardiovascular diseases in particular play a more prominent role in rural MV than in urban MV, especially at ages 60 and older. Preventable mortality is also lower in urban MV than in rural MV, but to a decreasing extent, and can, for instance, be explained by excess road traffic mortality in rural MV. In the 75 and above age group, however, the rural–urban divide is still very pronounced in both sexes (see Fig. S.6) and applies in particular to cardiovascular diseases. Timely medical treatment of strokes and heart attacks is a challenge in the peripheral regions of the East (Kibele 2012).

4.3 Convergence and Persistent Disparities

With regard to the third hypothesis, we find confirmation for men that mortality differences between the two federal states relate only to the rural areas and no longer to the urban areas. However, this hypothesis does not apply to women as rural MV no longer differs significantly from rural SH and urban MV, whereas urban SH meanwhile exhibits the highest level of premature mortality. The equalisation between women in MV and SH is not only a consequence of the catching-up process in MV, but also of relatively small improvements in survival in SH compared to the rest of Germany.

With regard to men, the gap between rural MV and rural SH applies to all-cause mortality and amenable mortality. However, as far as preventable causes are concerned, mortality levels among men in both urban and rural MV are still significantly higher than in SH. The difference in amenable mortality points to comparatively worse accessibility to appropriate health care in rural MV, whereas the difference in preventable mortality for MV as a whole is related more to behavioural factors. Among the preventable conditions, levels of smoking- and alcohol-related causes are higher in MV among men, as in-depth analyses show. Moreover, in spite of a considerable decrease, traffic accident mortality is still relatively high in rural MV.

The convergence in life expectancy between women in Eastern and Western Germany can partly be explained by higher smoking rates among middle-aged Western German women (Myrskylä and Scholz 2013). The same is true for the German Baltic Sea region, as profound cause-specific analyses show: Tobacco-attributable mortality, e.g. lung cancer, is comparatively high among women in SH, particularly in urban SH. In MV, women show higher levels of alcohol-related mortality, but this feature is outweighed by the excess smoking-related mortality of women in SH.

In neighbouring Denmark, the high smoking rates (along with alcohol consumption and other factors) among women had a decisive influence on the stagnation in the development of female life expectancy between 1980 and the mid-1990s (Juel 2008; Christensen et al. 2010). But while in Denmark the female cohorts with the highest smoking rates are currently dying out and thus causing an increase in life expectancy (Lindahl-Jacobsen et al. 2016), this is not the case yet for the German Baltic Sea region. As additional analyses based on the German Microcensus show, the cohorts in SH with the highest smoking rates have already reached the mortality-relevant age, in particular with regard to cancer mortality, whereas the respective cohorts are younger in MV.⁶ As a result, the example of Denmark may possibly serve as an indicator of the future trend in mortality among women in the German Baltic Sea region. Vogt et al. (2017) forecast that the higher smoking rates of younger Eastern German women will reverse their contemporary mortality advantage in comparison with the West.

In summary, and with reference to the fourth hypothesis, the remaining difference among men in premature mortality between MV and SH is indeed caused by higher levels of amenable and preventable mortality in rural MV. However, also urban MV exhibits a higher preventable mortality rate compared to rural and urban SH. As far as women are concerned, however, the gap between MV (both urban and rural) and rural SH has completely disappeared in amenable, preventable and other premature mortality, whereas the highest rates in these three cause-of-death groups, significantly in preventable mortality, are recorded for urban SH.

4.4 Sex Differences

The considerable differences between men and women justify conducting separate analyses for the two sexes. The sex gap in mortality in favour of women is a typical result for industrial countries (Trovato 2005). It can be explained by biological and non-biological factors, with the latter in turn being influenced by the former: on the one hand, women are biologically/genetically more ‘robust’, whereas, on the other hand, non-biological factors such as unhealthier working conditions and a riskier lifestyle of men compared to women have a decisive impact as well (Luy 2003, 2009; Luy and Gast 2014; RKI 2014). Especially the higher smoking rates of men compared to women were found to be an important explanatory factor in several industrial countries (Valkonen and van Poppel 1997; Trovato 2005). In MV, the sex gap is higher than in any other German federal state (DESTATIS 2016). Health policies and advances in health care applied to both sexes but were obviously less effective among men. “Overall, women are more likely than men to engage in health behaviours associated with primary prevention”, as concluded by Hiller et al. (2017: 348). In comparison with the other federal states, men in MV show relatively high rates of obesity, smoking and alcohol abuse (RKI 2011, 2014; Baumeister et al.

⁶ The regional smoking rates as surveyed in the 2005, 2009 and 2013 waves of the German Microcensus were provided by the Federal Statistical Office (DESTATIS) on request.

2005). Salzmann (2012) concluded that an adoption of a less risky lifestyle has only taken place slowly among men in MV.

4.5 Potential Bias and Limitations

The decline in premature mortality is closely linked to a decline in avoidable mortality, which points to the suitability of the used cause-of-death classification. There was a decrease in other ‘non-avoidable’ premature mortality in MV during the early 1990s, though, that might seem counterintuitive but can be explained by the immense general improvements in living conditions in Eastern Germany following reunification and the consequent shifting of mortality to older ages (Vogt 2013). In both SH and MV, the aggregation of amenable causes of death is dominated by cardiovascular diseases among men, but with decreasing weight and followed by neoplasms. Among women, however, neoplasms were more frequent than cardiovascular diseases. This is mainly due to the fact that women-specific neoplasms like breast, uterine and cervical cancer are outnumbering testicular cancer. In the aggregation of preventable causes of death, neoplasms play the most important part, followed by cardiovascular diseases.

With regard to the different age groups, in-depth analyses of the used data show that the differences among men were rather consistent over age, whereas differences among women mirror different cohort-specific smoking rates. Thus, preventable mortality among women aged 15–49 is higher in MV, especially in urban MV, but among women aged 50–69 it is higher in SH, particularly in urban SH. Among both men and women, excess mortality of rural MV in comparison with the other three regions is strongest in the 15–34 age group, which is linked to fatal traffic accidents, and in the 70–74 age group, which is due mainly to excess cardiovascular mortality.

The regional distinction proved appropriate to show where convergence has already taken place and where it has not. As a common feature, all urban districts in MV and SH are classified as an *Oberzentrum* (high-level urban centre) in regional planning, with the exception of Wismar, which nevertheless does partly fulfil functions of an *Oberzentrum*. Regarding the rural areas, however, population density is considerably higher in rural SH (about 145 inhabitants per square kilometre) than in rural MV (ca. 50). Consequently, there are structural advantages in rural SH which most likely benefit the accessibility of health care. We conducted a sensitivity analysis (see Figures S.2–S.5 in the supplementary material online) that further divides the rural parts of MV and SH to control if the chosen regional division overlays other regional differences in the study area. The analysis shows that there are indeed inner-regional differences to the advantage of the southern districts in SH and of the western districts (Mecklenburg) in MV but they are rather small in comparison with the chosen urban–rural distinction.⁷ Furthermore, the urban–rural distinction

⁷ Additional district-level analyses confirm that the main gap in rural mortality is between Mecklenburg and Vorpommern in MV and between the south and the north in SH.

delivers a clearer view of where differences still exist (between the rural areas of both states) and where they have widely disappeared (between the urban districts). In comparison with SH and MV, the neighbouring metropolitan city of Hamburg shows a lower level of amenable mortality, thus indicating a comparatively good accessibility of health care. However, the preventable mortality level in Hamburg is very similar to urban SH, which is not surprising since its smoking rates are also very similar to urban SH, as additional analyses of the German Microcensuses 2005, 2009 and 2013 show.

An inclusion of important individual-level variables like socioeconomic conditions and migration biography in a multivariate model would help improve the understanding of the observed differences. However, these variables are not available in this context up to now. Different outcomes of preventable mortality imply that health policies are not equally effective among all population groups, especially in connection with socio-economic conditions. Salzmann (2012) identified unemployment as one of the major drivers of male excess mortality in MV. In fact, MV has been one of Germany's federal states with the highest levels of unemployment since reunification. In January 2018, the unemployment rate in MV stood at 9.3%, compared to 6.3% in SH and 5.8% nationwide (BA 2018). Moreover, the level of education among young men, especially in the eastern peripheral regions of Germany, has much room for improvement compared to young women (Sievert and Kröhnert 2015).

Socioeconomic compositions are influenced by selective migration. Whereas MV has exhibited large losses in net migration since reunification, SH has reported migration gains, particularly from MV (Bucher and Heins 2001a; Dinkel 2004; Fischer and Kück 2004; Heiland 2004; Sander 2014). Furthermore, among young and highly-qualified people, emigration from MV is greater than immigration to MV, especially in its rural areas (Bucher and Heins 2001b; Lehmann 2008; Schultz 2006; Weiß 2006). The metropolitan region of Hamburg plays a special role in this context as the southern districts of SH benefit from suburbanisation-related immigration from Hamburg, whereas only a small number of municipalities in western MV are located close enough to Hamburg (and Lübeck) to benefit from migration gains (Dinkel 2004; Sander 2014). Consequently, it is highly probable that the higher mortality levels in rural MV are influenced to a considerable degree by the outmigration of young and better-educated people, while average life expectancy is highest in the university city of Rostock that has profited from migration gains since the early 2000s (BBSR 2015).

5 Conclusions

In an east–west spanning region that is not affected by the German north–south divide in mortality and where cultural and geographic differences are relatively small, are there still east–west differences that can be considered avoidable? The results of this natural experiment reveal that the accessibility and quality of medical care in the thinly populated rural areas of the east (MV) can still be improved

in comparison with the rural areas of the west (SH), whereas this is no longer the case for the urban areas. Furthermore, inter-sectoral health policies aiming at primary prevention also need to become more effective, especially among men in MV (focussing in particular on smoking, alcohol abuse and dangerous driving), but also—to a lesser extent—women in urban SH whose high rate of smoking becomes visible in the rate of preventable mortality.

All in all, the data reveal that the remaining difference in premature mortality between MV and SH is largely linked to excess avoidable mortality of men in the rural areas of MV. Therefore, German health policies should focus more on the accessibility of medical care in the thinly populated areas of Eastern Germany and men-specific measures of primary prevention in particular. This involves educational policies as well to reduce the educational disadvantage of men since the level of education influences not only the occupational status later in life but also the health-related lifestyle (Klein et al. 2001). Moreover, the creation of adequate opportunities in the labour market, especially for the highly-educated young people, is one of the major current and future challenges for MV.

Further research should focus on the long-term consequences of selective migration and socio-economic differences in this context. But as long as there is no German mortality register that allows for linkages to other data sources, this connection will remain a research gap on the individual level. On the other hand, the analyses of other east–west spanning regions in Germany would be a fruitful addition to research. Since the German reunification is the only worldwide contemporary example of a political unification of a formerly divided nation, an adaptation to other countries could focus on other ‘natural experiments’ like the contribution of different health care systems on mortality differences between politically divided but ethnically homogenous populations over time.

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Compliance with Ethical Standards

Conflict of interest The author declares that he has no conflict of interest.

Appendix

Tables 4 and 5.

Table 4 Causes considered amenable to health care^a, ages 0–74^b (unless otherwise stated)

Disease group	Cause of death	Age	ICD-9 code	ICD-10 code
Infectious	Intestinal infections	0–14	001-9	A00-9
	Tuberculosis		010-8, 137	A15-9, B90
	Whooping cough	0–14	033	A37
	Measles	1–14	055	B05
	Other infections		032, 034-8, 045, 084, 381-3, 681-2, 730	A35-6, A38-41, A46, A80, B50-4, H65-70, L03, M86, M89-90
Neoplasm	Colorectal cancer		153-4	C18-21
	Bone cancer		170	C40-1
	Skin cancer		172-3	C43-4
	Breast cancer		174	C50
	Cancer of cervix uteri		180	C53
	Uterus cancer	0–44	179, 182	C54, C55
	Testis cancer		186	C62
	Bladder cancer		188	C67
	Eye cancer		190	C69
	Thyroid cancer		193	C73
	Hodgkin's disease		201	C81
	Leukaemia	0–44	204-8	C91-5
	Benign neoplasm		210-29	D10-36
Endocrine	Diseases of the thyroid		240-6	E00-7
	Diabetes mellitus (50% of deaths)	0–49	250	E10-4
Neurological	Bacterial meningitis		320	G00
	Epilepsy		345	G40-1
Cardiovascular	Rheumatic heart disease		390-8	I00-9
	Hypertensive disease		401-5	I10-3, I15
	Ischemic heart disease (50%)		410-4	I20-5
	Heart failure		428-9	I50-1
	Cerebrovascular disease (50%)		430-8	I60-9
Respiratory	Influenza		487	J10-1
	Pneumonia ^c		480-6	J12-8, A48.1
	Asthma ^d	0–44	493	J45-6
	Other respiratory diseases	1–14	460-79, 488-9, 494-5, 497-519	J00-9, J20-39, J47-99
Digestive	Peptic ulcer disease		531-4	K25-8
	Appendicitis		540-3	K35-8
	Abdominal hernia		550-3	K40-6
	Cholelithiasis and cholecystitis		574-5	K80-2
Genitourinary	Nephritis and nephrosis		580-9	N00-7, N17-9, N25-7
	Hyperplasia of prostate		600	N40

Table 4 (continued)

Disease group	Cause of death	Age	ICD-9 code	ICD-10 code
Maternal/infant	Maternal death		630-76	O00-99
	Perinatal deaths (excl. stillbirths)		760-79	P00-96, A33
	Congenital anomalies		740-59	Q00-99
External	Treatment complications		E870-9	Y60-84

^aThe list for amenable causes of death is primarily based on Nolte and McKee (2003, 2004, 2008, 2012) but was extended by selected infections for which “early detection and effective intensive support coupled with appropriate antibiotic therapy can massively reduce case fatality rates” (Page et al. 2006: 205). Heart failure was added due to effective treatment (Tobias et al. 2010; Plug et al. 2011), malignant melanoma (listed as part of skin cancer) due to advances in early detection and adjuvant therapy (Page et al. 2006; Tobias et al. 2010). Bladder cancer—although highly connected with smoking—shows moderately effective treatment, “with good 5-year relative survival for early stage disease” (Page et al. 2006: 208) and is thus considered amenable. Bone cancer was added due to advances in adjuvant therapy (Tobias et al. 2010), thyroid cancer because of advances in diagnosis and adjuvant therapy (Page et al. 2006; Tobias et al. 2010). Benign neoplasms and eye cancer were considered amenable due to effective medical and surgical treatment (Tobias and Jackson 2001; Page et al. 2006). In accordance with Page et al. (2006), ischemic heart disease, cerebrovascular disease and diabetes were split equally on a 50:50 basis into amenable and preventable causes (according to age, sex, region and year) as survival improvement in these conditions is about equally split between incidence reduction and improved treatment effectiveness

^bThe general upper age limit is 75 years. Deviating age limits were set for childhood infections, leukaemia, uterus cancer and diabetes in accordance with Nolte and McKee (2004: 64–67). The age limit for asthma was widened in compliance with Tobias et al. (2010: 14)

^cIn ICD-9, the pneumonia group includes Legionnaires’ disease (482.84). This condition was shifted, however, to the bacterial diseases group (A48.1) in ICD-10. Due to the limitation to three-digit codes, A48.1 could not be considered for the period from 1998 onwards. However, this is statistically negligible

^dIn the clinical modification of ICD-9, chronic obstructive asthma is listed as 493.2 in the asthma group. Since the introduction of ICD-10, this condition has been registered in the COPD group (chronic obstructive pulmonary disease) under J44.8. This shifting problem is, however, statistically negligible and additionally does not affect this study, as in Germany, chronic obstructive asthma has presumably been registered in the COPD group before (there has never been a 493.2 code in the German modification of ICD-9)

Table 5 Causes considered avoidable through primary prevention^a; ages 0–74^b (unless otherwise stated)

Disease group	Cause of death	Age	ICD-9 code	ICD-10 code
Infectious	Hepatitis		070	B15-9
	HIV/AIDS ^c		042-4	B20-4
	Sexually transmitted diseases		090-9	A50-64
Neoplasm	Cancer of lip, oral cavity, pharynx		140-9	C00-14
	Cancer of oesophagus		150	C15
	Cancer of stomach		151	C16
	Cancer of liver		155	C22
	Cancer of larynx		161	C32
	Cancer of trachea, bronchus, lung		162	C33-4
Endocrine/nutritional	Nutritional deficiency anaemia		280-1	D50-3
	Diabetes mellitus (50% of deaths)	0–49	250	E10-4
	Alcohol and drug related diseases		291-2, 303-5	F10-6, F18-9
Cardiovascular	Ischemic heart disease (50%)		410-4	I20-5
	Cerebrovascular disease (50%)		430-8	I60-9
	Aortic aneurysm		441	I71
Respiratory	Chronic obstructive pulmonary disease		490-2, 496	J40-4
Digestive	Cirrhosis of liver		571	K70, K73-4
External	Land transport accidents		E810-29, E846-8	V01-4, V06, V09-80, V82-9, V98-9
	Falls		E880-6, E888	W00-19
	Fires, burns		E890-9	X00-9
	Accidental poisonings		E850-69	X40-9
	Drowning		E910	W65-74
	Suicide		E950-9	X60-84
	Violence		E960-9	X85-Y09

^aThe list for preventable causes of death is primarily based on Page et al. (2006) but was extended by laryngeal cancer as it is highly associated with tobacco and alcohol consumption (Ahrens et al. 1991; Simonato et al. 1998; Tobias and Jackson 2001; Phelan et al. 2004). Both alcohol and tobacco consumption are problematic in the eastern part of the German Baltic region. In accordance with Tobias et al. (2010), self-inflicted injuries were excluded from the suicide group since cause and motivation are not clear and the group of land transport accidents was extended by motor vehicle non-traffic accidents, other road vehicle accidents and vehicle accidents not elsewhere classifiable to avoid differences due to different coding practices

^bThe general upper age limit is 75 years. In accordance with Nolte and McKee (2004: 64–67), the age range for diabetes is shorter. Compared to Page et al. (2006), the age limit for chronic obstructive pulmonary disease was widened in compliance with Tobias et al. (2010: 14)

^cSince the introduction of HAART (highly active antiretroviral therapy) in 1996, HIV has increasingly become amenable to health care. Studies that focus on amenable mortality only (without preventable conditions) should consider HIV as an amenable condition (Tobias et al. 2010; Plug et al. 2011)

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