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ORIGINAL ARTICLE

Spatial distribution of avoidable cancer deaths in Germany

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Abstract
Aim To investigate the spatial distribution of avoidable cancer mortality (ACM) rates in Germany and to identify small areas with exceptionally high rates using districts (*Landkreise/Kreise* and *kreisfreie Städte*) as a unit of analysis. Avoidable cancer mortality reflects deaths from cancer that should not occur in the presence of effective and timely health care.
Methods Age-standardised, average ACM rates were calculated for the period from 2000 through 2004 for each of the 439 districts in Germany using unit-record mortality data. The spatial distribution of ACM was subsequently analysed using country maps, interval estimates and regression analysis. Data on mortality and age distribution were obtained from the German Federal Statistical Office (DESTATIS) and the Federal Office for Building and Regional Planning (INKAR).
Results We found that in women under 70 years, the highest ACM rates were seen for cancer of the breast and for cancer of the trachea, bronchus and lung, whereas in men under 70 years, the highest ACM rates were seen for cancer of the trachea, bronchus and lung, and for cancer of the colon, rectosigmoid junction, rectum, anus and anal canal. The statistically lowest mean ACM rates could be found in the south of Germany for men and women. Although the mean ACM rates in men in former East Germany were significantly higher than elsewhere in the country, they were not substantially higher than those in the west and northwest. The mean ACM rates in women were even lower in the east than in the northwest and west.
Conclusion The spatial distribution of ACM rates in women in Germany showed a north-south gradient rather than the east-west gradient that often appears or, for sociohistorical reasons, is even assumed in the German context. When applying measures of ACM, we suggest using districts with statistically lower ACM rates than the nationwide average as a benchmark for the maximum number of excess deaths that should be considered preventable, whether within the current German context or beyond.

Keywords Avoidable cancer mortality · Spatial distribution · Germany · Health geography · Country maps

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Introduction

Cancer remains one of the leading causes of morbidity and mortality in the developed world. In Germany, 426,800 new cases and 210,930 deaths were registered in 2006 alone, with lung and colorectal cancer causing the most fatalities. Taken together, approximately 46% of all deaths in Germany that year could be attributed to some form of malignant neoplasm (Robert Koch Institute and Association of Population-based Cancer Registries in Germany 2010).

The World Health Organization has estimated that more than 40% of cancer deaths worldwide could be prevented by modifying or avoiding key risk factors (World Health Organization 2007). Implementing effective prevention strategies, however, requires identifying small areas burdened by exceptionally high mortality (Michelozzi et al. 1999; Chen et al. 2006; Nolasco et al. 2009; Borrell et al. 2010). Although a large number of studies to date have focused on spatial analysis in this field, most have relied upon conventional mortality rates (Mandelblatt et al. 1990; Rosenberg et al. 1999; Coleman et al. 2001; Ando et al. 2003; Cerhan et al. 2004; McNally et al. 2006; Albano et al. 2007; Sarfati et al. 2009; Bonneux et al. 2010). A disadvantage of such an approach is that these rates fail to capture information about life span and are thus influenced by a high number of deaths in old age, especially in developed countries. Measures of avoidable mortality attempt to address this shortcoming by incorporating the notion that deaths from certain causes should not occur given effective prevention or timely and appropriate access to health care (Nolte and McKee 2003). In addition, avoidable deaths are limited to those before a specified age, for example the age of 70, to reflect that the effectiveness of primary and secondary prevention and treatment substantially decreases after this age limit.

Rutstein et al. (1976) were the first to develop a list of causes considered to be preventable by primary or secondary prevention, or amenable to intervention or treatment by health services once the illness is manifest. Since then, various lists of this kind have been published, and each has differed depending on the definition of avoidable mortality applied by its authors (Nolte and McKee 2003; Charlton et al. 1983; Poikolainen and Eskola 1986; Holland 1988; Mackenbach et al. 1988; Treurniet et al. 2004; Sanchez et al. 1993; Song and Byeon 2000; Tobias and Jackson 2001; Levi et al. 2004; James et al. 2006; Ward et al. 2006; Korda et al. 2007; Chung et al. 2008). Cancer of the uterus, for example, was included by Holland (1988) in his list, but surprisingly did not appear again in any further studies of this nature until 1½ decades later, when Nolte and McKee (2004) published a comprehensive list based on an systematic review of the literature.

The concept of avoidable mortality has a number of limitations, chief among which is the choice of disease entities to be regarded as preventable or amenable to health care. As Nolte and McKee (2003) point out, "death is the final event in a complex chain of processes that involve issues related to underlying social and economic factors, lifestyles, and preventive and curative health care. Partitioning deaths among the categories is an inexact science." Thus, the choice of disease entities is always going to be arbitrary to a certain extent. In the present analysis, we will rely on the list of cancer types compiled by Nolte and McKee (2003), whose publication contains a detailed justification for their selection of disease entities.

Since 2003, however, several additional types of cancer have been identified as being largely preventable. The International Agency for Research on Cancer, for example, has linked the increasing prevalence of sedentary behaviour, overweight and obesity to a rise in the prevalence of cancer of the upper digestive system (IARC 2011; Vainio and Bianchini 2002), and the consumption of tobacco has been identified as a risk factor not only for cancer of the trachea, bronchus and lung, but also of the lip, mouth, pharynx, oesophagus and bladder (IARC 2011; Levi et al. 2004). In the present analysis, we therefore expand the list of avoidable forms of cancer compiled by Nolte and McKee (2003) to include these forms of malignant neoplasm. Table 1 presents an overview of all types of cancer regarded in this study as being preventable by primary or secondary prevention, or amenable to intervention by health services once the illness is manifest. Deaths due to skin cancer were identified using the International Classification of Diseases-10-GM (ICD-10-GM) codes C43–C44.[1]

Many studies on avoidable mortality have focused on cross-country comparisons (Holland 1998; Treurniet et al. 2004; Charlton and Velez 1986; Mackenbach et al. 1990; Weisz et al. 2008). Within-country differences, however, have been studied less extensively (Poikolainen and Eskola 1986; Mackenbach et al. 1988; Humblet et al. 2000; Andreev et al. 2003; Wiesner and Bittner 2004; Sundmacher et al. 2011). Wiesner and Bittner (2004) used the concept of avoidable mortality to explain differences in mortality rates and life expectancy between former East and West Germany after German reunification in 1990. They found that the higher rates of avoidable mortality initially observed in both men and women in former East Germany had decreased by more than half by 2001, almost reaching levels seen in the west of the country. More recently, Sundmacher et al. (2011) conducted a small-area spatial analysis of variation in avoidable mortality in Germany and found that rates of premature death due to cardiovascular disease were still considerably higher in the east than in the west.

The present study makes several contributions to the literature on avoidable mortality. First, we calculated age-standardised mortality rates at the district level (*Landkreise/Kreise* and *kreisfreie Städte*) for different types of avoidable cancer in order to illustrate small-area variations. To our knowledge, no study to date has focused on the spatial distribution of small-area avoidable cancer mortality

[1] Although we aimed to include Hodgkin's disease (for the age group 1 to 70 years) and leukemia (for the age group 1 to 44 years) as avoidable forms of cancer in accordance with the list published by Nolte and McKee (2003), mortality data on these two disease entities were incomplete and thus had to be left out of our analysis. Considering, however, that the cancer types account for a rather small proportion of overall cancer mortality in the relevant age groups (Deutsches Krebsforschungszentrum, 2011), it seems unlikely that the absence of these data has distorted our results in any substantial way.

Table 1 ICD-10-GM codes for causes of cancer mortality considered preventable or treatable in persons aged 1–70 years

Cancer type	ICD-10-GM code	Original source
Lip, oral cavity and pharynx	C00–C14	IARC (2011) and Levi et al. (2004)
Oesophagus	C15	
Colon, rectosigmoid junction, rectum, anus and anal canal	C18–C21	
Trachea, bronchus and lung	C33–C34	Nolte and McKee (2003)
Skin	C43–C44	
Breast	C50	
Cervix uteri, corpus uteri and uterus (part unspecified)	C53–C55	
Testis	C62	
Bladder	C67	IARC (2011) and Levi et al. (2004)

(ACM) in Germany broken down according to specific cancer types. Second, we computed interval estimates of ACM for each district in Germany based on data covering a 5-year period (2000–2004). We used this information to map the districts in which the confidence intervals for ACM rates diverged from the confidence interval for the nationwide average of ACM rates. This information may help policymakers and other researchers to identify regions with high and low rates of ACM in a reliable fashion. Lastly, we reexamined the literature on mortality rates in former East and in West Germany, and tested whether the frequent finding that mortality rates in the east are higher than in the west also applies to avoidable cancer mortality. To test regional differences, we used ordinary least squares regression with robust (Huber-White) standard errors.

Although our small-area analysis is primarily of interest to German public health professionals, it may also be useful in the European context by allowing neighbouring countries to compare their health burdens with those of nearby regions in Germany.

Methods

Data

Small-area mortality data in Germany have been maintained by the German Federal Statistical Office since 1991, but were not made available until 1998. These data are gathered at the level of individual districts and include information on age and region, as well as the complete ICD code (as reported on death certificates) for all individuals 1 year of age or older. Researchers can gain access to the cause of death statistics by demonstrating that they require the data for legitimate research purposes and by signing and adhering to the relevant data protection laws. We filed a formal application with the German Federal Statistical Office and received a positive reply.

In the present study, we used the German modification (GM) of the 10th revision of the International Classification of Diseases (ICD-10) to identify deaths from cancer that took place from 2000 through 2004. We converted cases that had been inadvertently reported using ICD-9-GM to ICD-10-GM. In concordance with the great body of literature on avoidable mortality, we set an upper age limit beyond which deaths could no longer be considered preventable or amenable to health care. In doing so, however, we chose, in line with the German Robert Koch Institute (Gaber 2011), the conservative value of 70 years. Although cancer in younger age groups is more strongly associated with heritable factors, it is still amenable to health care.

For each year in our data set, we calculated the total and age-standardised number of avoidable cancer deaths separately for men and for women in each of the 439 districts that existed in Germany between 2000 and 2004 (i.e., prior to an administrative reform that slightly reduced the number of districts). The districts in Germany correspond to level 3 of the Nomenclature of Statistical Territorial Units system developed and used by the European Union for statistical and other purposes (European Commission 2011).

Age standardisation

To enable valid comparison between districts in our descriptive statistics, we used 5-year age brackets and calculated standardised mortality rates for all types of cancer we considered preventable or amenable to health care. To do so, we first calculated the age-specific mortality rates as follows:

$$MR_{act} = \frac{CD_{act}}{AP_{act}} \cdot 100,000$$

where MR is the mortality rate, CD the number of cancer deaths and AP the number of inhabitants in age group a in district c and year t. Second, we standardised MR_{act} using information from the overall population, as follows:

$$AMR_{ct} = \frac{\left(\sum N_{at} \cdot MR_{act}\right)}{\sum N_{at}}$$

where AMR is the age-standardised mortality rate and N the overall number of persons in age group a in year t in Germany. Stratified age data for each district were obtained from the Federal Office for Building and Regional Planning (*Bundesamt für Bauwesen und Raumordnung*).

Analysis of interval estimates

We calculated 95% confidence intervals for each district to show the range within which the average ACM rate fell between the years 2000 through 2004. The confidence intervals allowed us to determine whether the average ACM rate for 2000 through 2004 differed significantly between districts. If, for example, the ranges for two districts overlapped, the difference in the average scores might simply have been the result of variance within the population between the years. If the ranges did not overlap, however, it was possible to assert with 95% confidence that the difference between the districts was genuine. Using confidence interval plots, we compared the ACM rates for all 439 districts over 5 years to the average German ACM rate and subsequently illustrated on a country map which districts had ACM rates that were lower or higher than this average.

Ordinary least squares regression

To test the hypothesis that overall ACM rates among men and women in Germany follow a east-west gradient, we defined four binary variables for regions in Germany and regressed the former against the latter using an ordinary least squares method with robust (Huber-White) standard errors, as follows:

$$ACM_d = \alpha DR_d + \mu_d$$

where ACM_d is the mean ACM rate in district d for the years 2000 through 2004, DR_ds are the binary variables for the regions in Germany (dummy variables), μ_{dt} is an error term, and α is the coefficient to be estimated. The equation was estimated without constant term, with α representing the mean ACM rate in a given region.

Results

The mean age-standardised mortality rates for all types of cancer that we considered to be preventable or amenable to health care in women and men are shown in Figs. 1 and 2, respectively, for the years 2000 through 2004. In women, the most common cause of avoidable cancer death was breast cancer (11.46 deaths per 100,000 population), followed by cancer of the trachea, bronchus and lung (6.12 per 100,000), cancer of the colon, rectosigmoid junction, rectum, anus and anal canal (5.14 per 100,000), and cancer of the cervix uteri, corpus uteri and uterus (2.7 per 100,000). The rates for men were generally higher, with cancer of the trachea, bronchus and lung ranking as the leading cause of avoidable cancer death (21.4 per 100,000), followed by cancer of the colon, rectosigmoid junction, rectum, anus and anal canal (8.82 per 100,000), cancer of the lip, oral cavity and pharynx (4.03 per 100,000), and cancer of the oesophagus (3.19 per 100,000).

Figures 3 and 4 show the spatial distribution of all ACM rates and of the two highest ACM rates across the 439 districts for men and women separately. The three shades of colour represent the districts with the highest (dark), middle (light) and lowest (white) ACM rates. Out of all districts, 147 fell into the highest bracket and 146 into the middle and lowest brackets.

In Fig. 3, the map showing age-standardised mortality rates for all types of avoidable cancer (Map 1) reveals a north-south gradient, with higher rates in the geographic north and lower rates in the geographic south. Broken down according to gender, we see that the highest rates for women (Map 2) were generally in the states of North Rhine-Westphalia, Schleswig-Holstein and Lower Saxony, whereas the highest rates for men (Map 3) were primarily in Mecklenburg-West Pomerania and Brandenburg.

Figure 4 shows the two highest age-standardised mortality rates for avoidable cancer in women and men in Germany. ACM rates for breast cancer were low in former East Germany (Map 4). ACM rates cancer of the trachea, bronchus and lung were high in North Rhine-Westphalia, Saarland, Lower Saxony and Rhineland-Palatinate for both men and women; however, they were especially high for men in Mecklenburg-Pomerania, Saxony-Anhalt and Brandenburg and for women in North Rhine-Westphalia (Maps 5 and 6). Although a similar pattern could be seen for cancer of the colon, rectosigmoid junction, rectum, anus and anal canal in men, ACM rates for this type of cancer were also

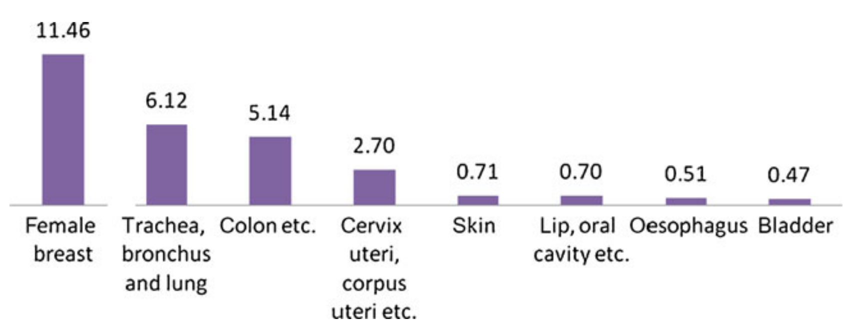


Fig. 1 Mean standardised ACM rates (per 100,000 population) for women from 2000–2004

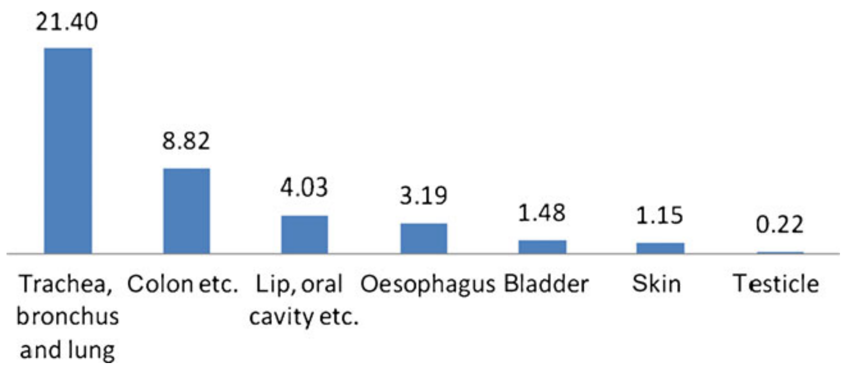


Fig. 2 Mean standardised ACM rates (per 100,000 population) for men from 2000–2004

high in the geographic south of Germany, especially in the Upper Palatinate region in northeast Bavaria (Map 7).

Figures 5 and 6 show variations in ACM rates for women and men, respectively, in each of the 439 districts in Germany. The ACM rates are plotted as confidence intervals with error bars for each district. The dots reflect the average ACM rate for each of the districts over the 5-year period (2000–2004), whereas the error bars indicate the statistical range within which these rates could fall because of population variance. The thick line in the middle of each figure represents the confidence interval for the nationwide average ACM rate for women (range: 27.37 to 28.25 deaths per 100,000 population) and for men (range: 39.84 to 41.08 deaths per 100,000 population).

Because it was impossible to determine which districts diverged from the nationwide average through a simple visual assessment, we determined which confidence intervals for the ACM rates in the individual districts did not overlap with the confidence interval for the average nationwide ACM rate. We subsequently used country maps to plot the districts with ACM rates that differed significantly from the nationwide average for women and men (Fig. 7).

Yellow represents districts with ACM rates that did not differ from the nationwide average at the 95% significance level. The map shows that the vast majority of districts fell within the confidence interval for the German average in women (393 of 439 districts) and in men (336 of 439 districts). The average ACM rate for the yellow districts was 28.30 deaths per 100,000 population for women and 41.35 deaths per 100,000 population for men. Green represents districts with ACM rates that were lower than the nationwide average. These districts were prominent in the geographic southwest for men and in the geographic south and parts of the geographic east for women. For women, the average ACM rate in green districts, of which there were 31, was 20.74 deaths per 100,000 population; for men, the average ACM rate in green districts, of which there were 67, was 29.21 deaths per 100,000 population. Finally, red represents the districts with the highest ACM

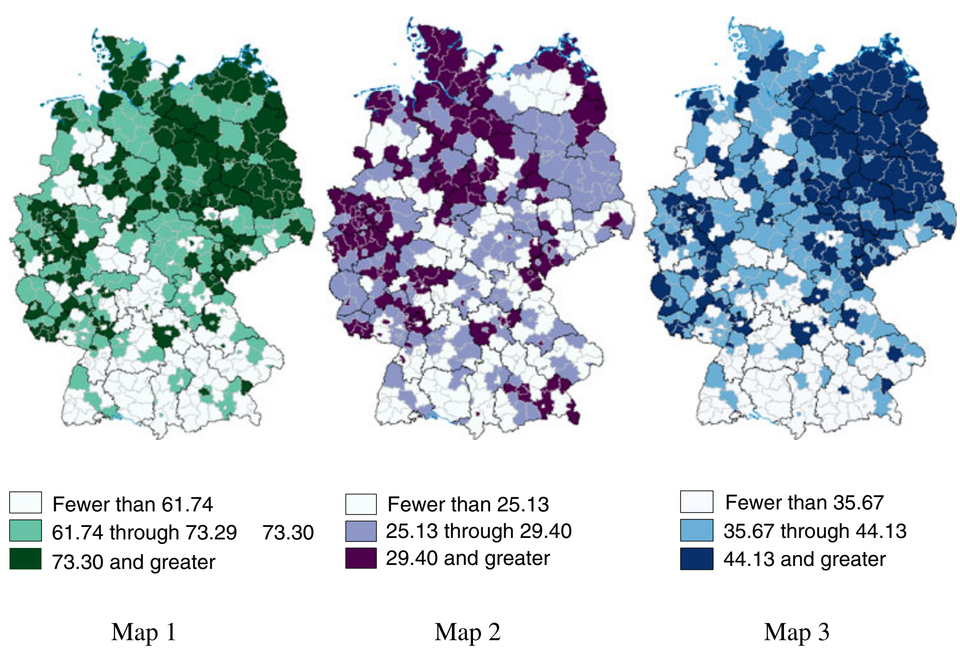


Fig. 3 Spatial distribution of mean standardised ACM rates (per 100,000 population) from 2000–2004. Map 1: ACM rates for both sexes. Map 2: ACM rates for women. Map 3: ACM rates for men

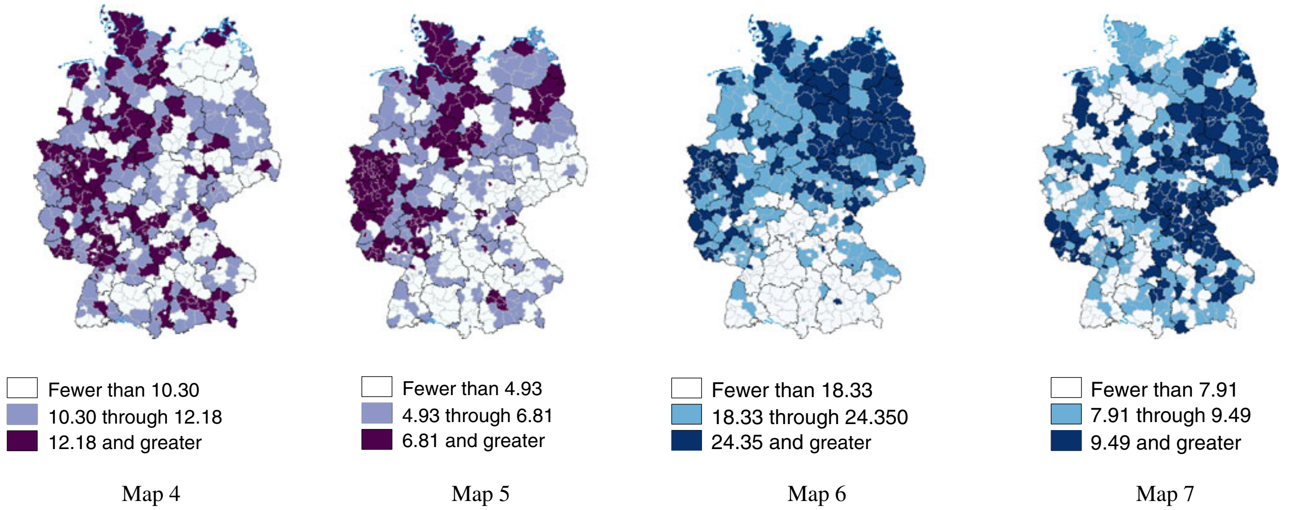


Fig. 4 Spatial distribution of different types of ACM rates (per 100,000 population) from 2000–2004. Map 4: ACM for female breast. Map 5: ACM for trachea, bronchus and lung in women. Map 6: ACM for trachea, bronchus and lung in men. Map 7: ACM for colon, rectosigmoid junction, rectum and anus in men

rates. For women, the majority of red districts, of which there were 13, were located in the geographic centre and north of Germany and in former West Germany. The average ACM rate in these districts was 33.42 deaths per 100,000 population. For men, the majority of red districts, of which there were 34, could be found in former East Germany. In these districts, the average ACM rate was 53.88 deaths per 100,000 population.

Taken together, these results suggest that ACM rates were substantially higher in the geographic north, west and east of Germany than in the geographic south. At least among women, the territory of former East Germany, which has been shown in a range of studies to have higher general avoidable mortality rates (Wiesner and Bittner 2004; Sundmacher et al. 2011), does not appear in our maps to be characterised by higher rates of ACM than the northwest and west of the country. To assess the validity of these observations and to test formally the hypothesis that overall ACM rates in Germany follow an east-west gradient as suggested by the literature, we regressed the mean overall ACM rates for the years 2000 through 2004 on dummy variables that (1) served as rough proxies for the cardinal and ordinal directions (and are thus italicized to distinguish them as such) and (2) took both geographic and political considerations into account. We used the ordinary least squares method with robust (Huber-White) standard errors and without constant term.

More specifically, the dummy variable for the *northwest* included the states of Schleswig-Holstein, Lower Saxony

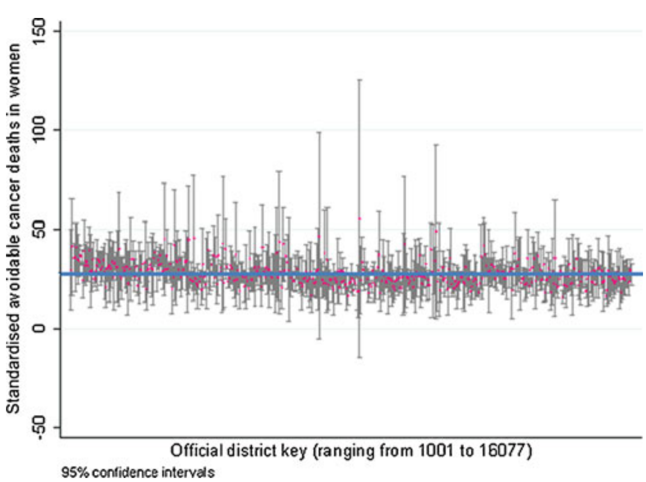


Fig. 5 Variation in ACM rates for each of the 439 districts in Germany and the nationwide average (plotted as confidence intervals) for women

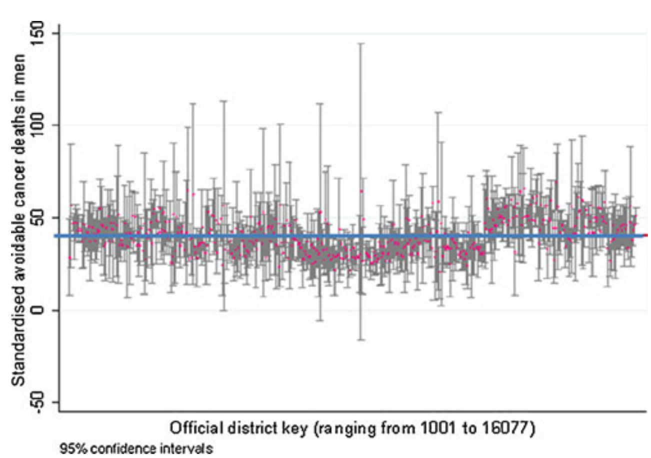
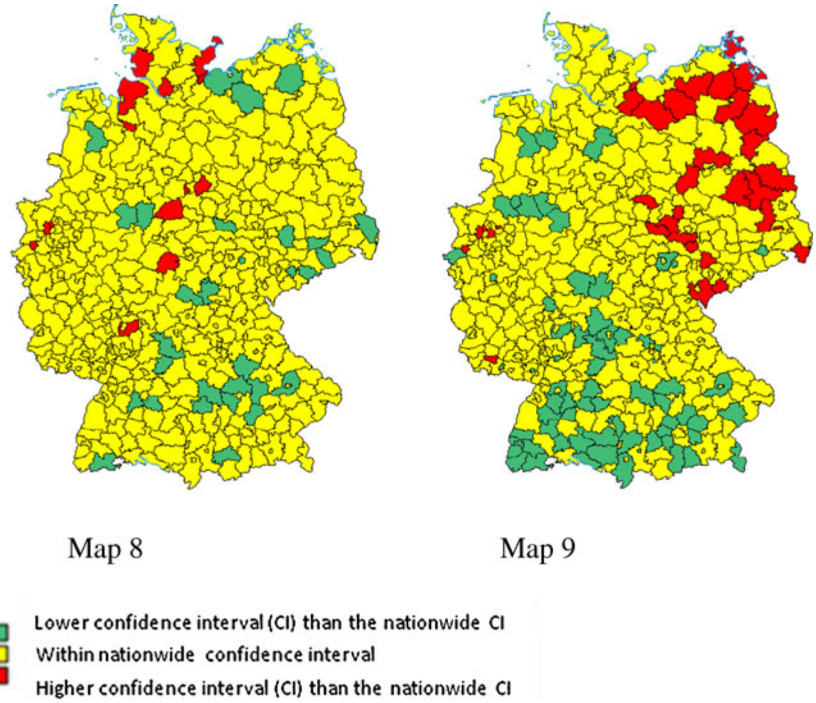


Fig. 6 Variation in ACM rates for each of the 439 districts in Germany and the nationwide average (plotted as confidence intervals) for men

Fig. 7 Confidence intervals for district-level ACM rates that are higher or lower than the nationwide confidence interval. Map 8: Confidence intervals for district-level ACM rates that are higher or lower than the nationwide confidence interval for women. Map 9: Confidence intervals for district-level ACM rates that are higher or lower than the nationwide confidence interval for men



and Hamburg; that for the *east* the states of Mecklenburg-West Pomerania, Brandenburg, Saxony-Anhalt, Thuringia and Berlin (i.e., the entire territory of former East Germany plus former West Berlin); that for the *south* the states of Bavaria and Baden-Württemberg; and that for the *west* the states of North Rhine-Westphalia, Hesse, Saarland and Rhineland-Palatinate. For obvious historical reasons and according to common usage in Germany, we employ these definitions of the terms *northwest*, *east*, *south* and *west* in the regression rather than using the cardinal and ordinal directions in a strictly geographic sense. Although it would naturally have been possible to regress the overall ACM rates on variables representing smaller areas, doing so would have made it difficult to compare average ACM rates in former East Germany (which, in a strict geographical sense, lies in the northeast of the country) with those in various states and regions in former West Germany.

The results of our regression show that the *northwest*, *east* and *west* of Germany had considerably higher mean ACM rates than the *south*, leading us to reject the hypothesis that overall ACM rates in Germany follow an east-west gradient. Although the overall ACM rates were highest in the *east* for men (47.7 deaths per 100,000 population), this result changed in the regression that used ACM rates among women as the dependent variable. The *south* clearly had the lowest ACM rates for both women and men. As expected, there was strong evidence that the differences in the regional ACM rates were statistically significant at a level of 1%. The regressions themselves were significant with an adjusted R^2 of more than 95%. The results are presented in Table 2.

Table 2 Results of the ordinary least squares regression with ACM as dependent variable

	Mean ACM rates in both genders		ACM rates in women		ACM rates in men	
	Coeff.	Huber-White SE	Coeff.	Huber-White SE	Coeff.	Huber-White SE
East	74.08	1.17***	26.61	0.52***	47.47	0.74***
West	70.49	1.12***	29.84	0.50***	40.65	0.71***
Northwest	71.84	1.55***	30.74	0.68***	41.10	0.97***
South	59.96	1.05***	25.83	0.46***	34.13	0.66***
Observations	439		439		439	
Adjusted R^2	0.97		0.96		0.96	

***Statistically significant at $P<0.01$

Discussion

In this paper, small-area mortality data from the German Federal Statistical Office and data on age distribution from the Federal Office for Building and Regional Planning (INKAR) were used to describe the spatial distribution of ACM rates in Germany at the level of individual districts. Our aims were (1) to illustrate the spatial distribution of age-standardised avoidable mortality rates for specific cancer types, (2) to map the districts for which the confidence intervals for ACM rates did not overlap with the confidence interval for the nationwide average, and (3) to investigate whether ACM rates were higher in former East Germany than in former West Germany as one might expect based on the existing literature on avoidable mortality focusing on Germany after reunificiation in 1990.

We found that in women under 70 years, the highest ACM rates were seen for cancer of the breast and for cancer of the trachea, bronchus and lung, whereas in men under 70 years, the highest ACM rates were seen for cancer of the trachea, bronchus and lung and for cancer of the colon, rectosigmoid junction, rectum, anus and anal canal. The results of our analysis of district-level confidence intervals suggest that the majority of regions with the lowest ACM rates are found in the geographic south of Germany for men and in the geographic east of Germany for women. For men, the majority of districts with ACM rates that were significantly higher than the German average were located in former East Germany. The few districts with significantly higher ACM rates for women were located in the geographic centre and in the geographic north of the country. The results of our ordinary least squares regression confirmed that the spatial distribution of ACM rates among women followed a north-south gradient, whereas ACM rates in men were highest in former East Germany.

These findings contrast with the results of previous studies, which have found a distinct difference between avoidable mortality rates in former East and West Germany, with considerably higher rates in men and women in the east (Wiesner and Bittner 2004; Sundmacher et al. 2011). We suggest that the results of these earlier studies can be attributed to a high rate of cardiovascular deaths in the east in both men and women. Indeed, Sundmacher et al. (2011) showed that more than 30% percent of all avoidable deaths in Germany between 2000 and 2004 could be attributed to ischemic heart and cerebrovascular disease—a percentage so high that it most certainly masked the very different distribution of ACM rates throughout Germany as a whole.

In both genders, the high rates of avoidable mortality attributable to cancer of the trachea, bronchus and lung in North Rhine-Westphalia, Saarland, Lower Saxony and Rhineland-Palatinate (Maps 5 and 6) are congruent with historically high levels of tobacco consumption in these states (Deutsches Krebsforschungszentrum 2009). An exception is former East Germany, where the level of tobacco consumption was generally lower than in West Germany before 1989, but higher in the 1990s and the decade following the year 2000. However, whereas the percentage of male smokers has increased steadily in former East Germany since German reunification, the percentage of female smokers there increased only until 1998, declining each year thereafter (Lampert and Burger 2004; Maschewsky-Schneider et al. 2006). This may explain the predominance of low ACM rates in former East Germany, especially considering that the percentage of female smokers has risen steadily in former West Germany since 1984.

The ACM rates for cancer of the colon, rectosigmoid junction, rectum, anus and anal canal in men were high both in former East Germany and in northeast Bavaria (Map 7). Interestingly, both areas have been linked historically to a high consumption of smoked meat and a low intake of fruit and vegetables (Becker and Wahrendorf 1998). In our study, ACM rates for cancer of the colon, rectosigmoid junction, rectum, anus and anal canal appeared to be higher in rural areas. Although faecal occult blood testing and colonoscopy, which have been shown to be effective in preventing deaths from colorectal cancer, are covered by statutory health insurance for certain age groups, the high rate of colorectal cancer deaths in our data may be an indication that the use of these tests in these regions is lower than elsewhere in Germany.

Breast cancer is the type of cancer in Germany with the highest rate of avoidable mortality rate in women (Sundmacher et al. 2011), and the results of the present study show that mortality rates due to this cause are considerably higher in former West Germany than in former East Germany. Research has shown that women who have their first child in their 30s are 63% more likely to develop breast cancer before menopause and 35% more likely to develop the disease after menopause than their counterparts who give birth to their first child before the age of 22. Women who remain childless have an even higher risk (Simpson et al. 2002). The potential for a link between ACM rates for breast cancer and differences in family planning between former East and West Germany is therefore worthy of future analysis. Before German reunification in 1990, women gave birth to their first child at the age of 22 years in East Germany and 27 years in West Germany on average (Becker 2001; Dobritz 1997; DESTATIS 2007). Moreover, childlessness today is significantly lower in former East Germany; in former West Germany, 16% of women between 40 and 75 years of age were childless in 2006 compared to 8% of women in this age group in the east.

Although the concept of avoidable mortality necessarily implies a theoretical maximum in the number of preventable deaths, achieving this maximum is unrealistic from a public health perspective. For avoidable cancer mortality, we identified districts with statistically lower and higher ACM rates compared to the average nationwide ACM rate using interval estimates to achieve an additional degree of robustness. We suggest that the districts with statistically lower ACM rates could be used as benchmarks, defining a maximum number of excess deaths that could be prevented within the current German context. The concept of benchmarking was most famously used by the WHO in its ranking of the worlds' health systems as part of the World Health Report 2000, which sparked a debate about approaches for benchmarking both within Germany and internationally. We hope to contribute to this ongoing discussion by providing health professionals with an approach that allows for the creation of realistic benchmarks that are based not on the comparison of countries, which can differ radically in terms of geographic conditions, cultural backgrounds and political systems, but rather on within-country comparisons of small areas to a national average. In line with Nolte et al. (2006), however, we believe that if benchmarking is to guide prevention policies, it will be essential to move beyond purely descriptive comparisons and analyse and address the determinants of ACM rates, such as differences in lifestyle, socioeconomic and environmental conditions, or in the quality and quantity of health care services—and to do so using not only aggregated data, but also data obtained at a micro level. The results of such evaluations can help researchers and public health officials design preventive measures that systematically reduce the number of avoidable cancer deaths.

Conclusion

The spatial distribution of ACM rates for women in Germany showed a north-south gradient rather than the east-west gradient that often appears or, for sociohistorical reasons, is even assumed in the German context. In former East Germany, the ACM rates for men were higher compared to other regions, but were not substantially higher than those seen in the geographic west or north of the country. Our interval estimates confirmed these findings. Finally, when applying measures of ACM, we suggest using districts with statistically lower ACM rates as a benchmark for the maximum number of excess deaths that should be considered preventable, whether within the current German context or beyond.

Conflicts of interest The authors declare that they have no conflicts of interest.

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