Supply of health care and amenable cancer-mortality in Germany

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Abstract

Aim: The aim of this study is to identify areas in Germany burdened by exceptionally high rates of amenable cancer-mortality (ACM) and to investigate the marginal contribution of health care on ACM using counties as the unit of analysis.

Methods: We use Poisson-regression with fixed effects and robust standard errors to investigate the impact of health care on cancer deaths over five years, within the framework of a health production function. To overcome shortcomings of conventional mortality measures, we follow Nolte et al (2004) and construct an indicator for amenable cancer-mortality (ACM) which captures deaths that should not occur given current medical knowledge and technology. In all models, we control for socio-economic status, environmental conditions and a comprehensive set of demographic variables. The sample is stratified by gender.

Data: We use individual-level data on mortality and county-level data on socio economic status and environmental conditions for the years 2000 to 2004. The data is taken from the causes-of-death statistics (provided by Destatis) and other statistics provided by the Federal Office for Building and Regional Planing (INKAR) and the German Hospital Foundation.

Results: ACM significantly differs between small areas within and between Bundeslaender. Country-maps of the spatial distribution of all amenable cancer-deaths in Germany show a north-south gradient in men and less in women. Our regression results suggest that the quantity of health care is not significantly associated with amenable cancer-mortality. However, regional differences in socio-economic and environmental factors influence the level of ACM.

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1. Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, being a major public health problem in both industrialized and developing countries. In 2004, 436,500 new cancer incidences and 208,824 cancer deaths were registered in Germany with malignant neoplasm of the lung (71/100,000 in men and 26/100,000 in women) and of colon and rectum (27/100,000 in men and 17/100,000) causing most cancer-related deaths. Taken together, approximately 46 percent of all deaths could be attributed to cancer in the same year (Population-based Cancer Registries 2008). The World Health Organization estimates that more than 30% of these deaths can be prevented by early detection, prevention and management of patients with cancer. Key in the reduction of cancer is 1) the modification or avoidance of risk factors (such as tobacco use, being overweight or obese, excessive alcohol consumption, low fruit and vegetable intake, physical inactivity, HPV-infections, urban air pollution), 2) implementation of prevention strategies (vaccination against HPV, reduction of exposure to the sunlight) 3) early detection of cancer and 4) effective treatment to cure and prolong life (World Health Organisation 2007).

Fundamental in the implementation of prevention strategies and monitoring of cancer-cases, is the identification of small areas burdened by exceptionally high mortality and the investigations into underlying causes of spatial variation in excess cancer-deaths. There is a vast literature on the determinants of cancer-mortality on population level (Albano et al 2007, Ando et al 2003, Cerhan et al 2004, Coleman et al 2001, Mandelblatt et al 1999, Sarfati et al 2009, Wilkinson and Pickett 2008) but only few studies use sensitive measures for excess cancer-deaths. A disadvantage of conventional mortality rates is that they do not capture information about the length of life and are therefore influenced by a high number of deaths at old-age, especially in industrialised countries. Moreover, mortality is a concave function with a (biological) limit so that improvements in the health system or lifestyle might not be accurately reflected in the variation of deaths (Or 2000). Measures of amenable or avoidable mortality (AM) incorporate the notion of excess mortality and define deaths that should not occur given effective prevention and timely and appropriate access to health care and health technologies as avoidable (Nolte and McKee 2003). The first list of AM indications was published by Rutstein et al (1976) and has since then been revised several times (Charlton et al 1983, Chung et al 2008, Holland et al 1988, James et al 2006, Mackenbach et al 1988, Korda et al 2007, Nolte and McKee 2003, Poikolainen and Eskola 1986, Holland et al 1988, Song and Byeon 2000, Tobias and Jackson 2000, Treuniet et al 1999, Ward et al 2006).

There is no gold standard of defining avoidable or amenable cancer cases. Testicular cancer was not included in the original list by Rutstein et al (1976) but was considered by Mackenbach et al (1988). Breast cancer was listed by Tobias and Jackson (2000) and investigated in several later studies (Chung et al 2008, Korda et al 2007, Nolte and McKee 2003). Cancer of the uterus was included by Holland (1988) but surprisingly disappeared from the list of AM for two decades. It was re-included in a comprehensive list compiled by Nolte and McKee (2003). In addition, the international Agency for Research on Cancer (IARC) linked the current trend of increasing overweight and reporting of a sedentary lifestyle to an increase in cancer of the upper digestive system in the US (Vainio and Bianchini 2002). The consumption of tobacco was identified as risk factor for cancer of the lip and esophagus (Levi et al 2004, Tobias and Jackson 2000) while the consumption of alcohol was found to abet cancer of the liver (Chung et al 2008). We use Nolte et al's list (2003) of amenable or avoidable cancer-types and extend it by cancer of the digestive and respiratory tract (lip, esophagus, liver, bladder and gallbladder).We also follow Ward et al (2006) and treat malignant neoplasm of the prostate in men as responsive to early detection and medical treatment. All amenable cancer deaths (ACMs) are subject to an age-threshold of 75. We prefer the term amenable over avoidable cancer deaths because some aggressive tumour-types from the list in Table 1 could not be avoided in strict sense of the word.

Tab. 1: Amenable Cancer-Mortalities (ACM) by ICD-10 and age-group

Cause of Death	**ICD – 10**	**Age Group**
Malignant neoplasm of lip	C 00	0-75
Malignant neoplasm of esophagus	C 15	0-75
Malignant neoplasm of colon and rectum	C 18–C 21	0-75
Malignant neoplasm of liver	C 22	0-75
Malignant neoplasm of gallbladder	C 23	0-75
Malignant neoplasm of lung	C 33–C 34	0-75
Malignant neoplasm of female breast	C 50	0-75
Malignant neoplasm of cervix and and extended parts of the uteri	C 53	0-75
Malignant neoplasm of prostate	C 61	0-75
Malignant neoplasm of bladder	C 67	0-75

Tab. 1

Many authors have studied descriptive patterns of AM in industrialized countries. Nolte and McKee (2008) recently surveyed mortality data for 19 OECD countries including Germany and found a decline of more than 16 percent in AM in most countries within the last decade (with considerable variation in the gap between the decline in total mortality compared to amenable deaths between countries and gender). Based on age-standardized death rates Germany was ranked twelfth and therefore showed only a moderate improvement compared to other countries. While most AM-studies focused on cross-country comparison, within-country differences are poorly documented. The only exception for Germany is Wiesner and Bittner (2004) who used the concept of AM to explain variation in mortalities and life-expectancies between East and West Germany after the reunification. They found higher declines in mortalities amenable to health care in the East. These trends were similar in men and women.

Previous studies have also analyzed the relationship between supply of health care and mortality within the framework of a health production function (Auster et al 1969, Grubaugh and Santerre, 1994, Robst and Graham, 1997, Robst 2001, Or 2000, Or et al 2005, Aakvivk et al 2006, Crémieux et al 1999) but none of the studies employed amenable mortality as dependent variable. The evidence provided by the studies (using conventional mortality) remains inconclusive. Some studies reported a positive relationship (Crémieux et al 1999), some a negative (Grubaugh and Santerre , Robst and Graham, 1997, Robst, 2001, Or et al 2005) or none association (Aakvivk et al 2006).

We make two contributions to the literature: First we calculate age-standardized ACM-rates on county-level and plot small-area variation in amenable cancer deaths within Germany. Second, we analyse the impact of regional differences in the supply of health care on AM within the framework of a health production function. As discussed above, mortality is driven by deaths at old age and ACM is assumed to be more sensitive to changes in the health care system and lifestyle in the population. We use a Poisson regression model with fixed effects and robust standard errors in order to control for observed socio-economic and demographic and unobserved behavioural and environmental risk factors within and between counties. We use data from the causes-of-death statistics (provided by Destatis) and from the Federal Office for Building and Regional Planing (INKAR) and the German Hospital Foundation.

We find no statistical evidence that medical care operationalized as the number of physicians and the number of beds in all hospitals, teaching hospitals and relevant specialized hospital units impacts on ACM. However, our measure for rurality which might be associated with the quality of health infrastructure has a positive impact on amenable breast and prostate-cancer. From the broad range of socio-economic variables, low educational attainment and amenable breast-cancer mortality and high unemployment and lung-cancer are related. In addition, we find a moderate and strong decline in amenable breast and uterus cancer but a strong increase in amenable lung cancer in women over time. In men, amenable lung-cancer is significantly decreasing over time. The paper is organized as follows. Section one presents the statistical specification of the Poisson model with fixed effects and robust standard errors. In section two and three, we present the data and results that are discussed in section four. The last section concludes.

2. Statistical specification

We specify the following health production function:

$$\mathrm{AMC}_{\mathrm{it}} = \beta_0 + \beta_1 D_{it} + \beta_1 HB_{it} + \beta_1 X_{it} + \mathrm{a}_{\mathrm{i}} + \varepsilon_{\mathrm{it}}, \quad [1]$$

for i=1,...N; t=1,...T, where i is the county indicator and t is the time indicator. ACM is the number of amenable cancer-deaths in county i in year t. D is the quantity of doctors including GPs and doctors employed in hospitals. HB is a vector including the number of beds in teaching hospitals and speciality departments relevant to the respective type of ACM and X are other explanatory and control variables including socio-economic factors, environmental conditions and four dummies for the year of the death. a_{i} is the unobserved individual heterogeneity and $\varepsilon_{\mathrm{it}}$ is the error term.

Because the response variable is a count of events occurring to a particular unit of observation, divided by some measure of that unit's exposure, the Poisson distribution with a mean > 0 is appropriate in the estimation. Consequently, we assume cancer-deaths to be independent in the sense that the occurrence of one case will not make another more or less likely, but the probability of events within one year in one county is understood to be related to the explanatory factors.

Our observations vary over time and are not independent within counties and Bundeslaender. Moreover, we do not have observations on lifestyle and other risk factors (such as tobacco use, being overweight or obese, excessive alcohol consumption, low fruit and vegetable intake, physical inactivity, HPV-infections, urban air pollution, exposure to sunlight or radon-concentrations) on county-level (World Cancer Research Fund 2007). These unobserved factors are likely to be correlated with explanatory factors in our analysis and, unless controlled for lead to an omitted variable bias. Therefore including county-fixed effects seems to be particular important in this analysis. The models are estimated using fixed-effects-estimation and to obtain very reliable results, we also calculate robust standard errors for the Poisson-estimators.

Sampling issues and modelling strategy

The analysis is based on the German causes-of-death statistic 2000-2004 (provided by Destatis). The total number of deaths for the five years is 4,921,764. Deaths under 1 year of age are excluded from the statistic. In addition, we had to make all disease-specific deaths equal to or under three observations in a county within one age-group in the same year anonymous. This reduced the overall number by 99,743 cases to a total of 4,008,345 observations. For each year, we then calculated the total and age-standardized number of avoidable cancer deaths in the 439 German counties for men and women separately, arriving at a panel with 2195 observations for the dependent variable. We stratified by age and year in order to combine the individual and county-data on county level without losing information. We did not have information on number of beds in hospital units for four counties in men and five counties in women. This reduced the sample-size to 2170 and 2175 observations respectively. For men and women, we report six regressions, related to the three most common causes of amenable cancer deaths in women (breast, lung and uterus cancer) and men (lung, colon and rectum, prostate cancer). To allow for the possibility that the number of beds in specialized hospital units are not missing at random we include dummy variables interacted with the indicators for each year for the missing values in the equation. If the dummy variables are not significant then non responders are affected in the same way as responders and we estimate the conventional model. Moreover, it is possible that observations within Bundeslaender are not independent; we therefore control for clustering in Laender so that the robust standard errors in the regression models also account for this within-area correlation.

Age-standardization

To enable valid comparison between counties in the descriptive statistics, we directly standardize ACM using three age-brackets 0-18, 19-65 and 66-75. First, we directly calculate the age-specific death-rate $MR_{act} = \frac{CD_{act}}{AP_{act}} \cdot 100{,}000$, where MR is the mortality rate, CD the number of cancer deaths and AP the number of all inhabitants in one age-group a, in county c and year t. Secondly, the rates are standardized using information from the overall population: $AMR_{act} = \frac{\sum N_{at} \cdot MR_{cat}}{\sum N_{at}}$, where AMR is the age-standardized mortality rate and N the overall number of persons in each age group a in year t in Germany. The mortality rate gives the number of amenable cancer deaths per 100,000 inhabitants considering the age structure in each county for the years 2000-2004. To reduce the number of anonymous observations, we defined only three wide age-brackets. Most cancer cases fall in the 65-75 age-bracket and only a very small number of deaths occur in the youngest age group (0-18).

3. Data and Variables

Data sources for this analysis include the causes-of-death statistics (provided by Destatis), statistics from the Federal Office for Building and Regional Planning (INKAR), the German Hospital Foundation. The national causes-of-death statistics collects and reports all deaths including information on age, region and complete ICD-code (as reported by death certificates) in Germany. Information has been collected since 1991 but was only made available to the public in 2001. The 10th revision of the International Classification of Diseases (ICD-10) was used to select deaths from cancer for this analysis from 2000 onwards. Cases which were accidentally reported using ICD-9 were converted to ICD-10. The data on the density of hospital beds was provided by the German Hospital Foundation and the number of physicians and all other covariates taken from official regional statistics provided by INKAR.

Health care variables and covariates

To approximate the quality of the health care system on county-level, we include the number of beds per 100,000 inhabitants in all hospitals, teaching-hospitals and units that are relevant to treat the respective cancer type. In addition we include the number of all registered doctors per 100,000 within each of the 439 counties in our analysis.

In the literature, the development of cancer is linked to multiple risk factors such as smoking and environmental conditions (Ando et al 2003, Levi et al 2004, Vacchino 1999), diet (Calle and Thun 2004, Clapp et al 2007, Cummings and Bingham 1998, Lagergren et al 1999) and socio-economic status (Coleman et al 2001, Katz et al 2000, Marshall 1999, Song and Byoen 2000). Especially education is a strong determinant of mortality in some cancer-types (lung, breast, prostate) (Jemal et al 2009, Stirbu et al 2009, Vacchino 1999). For women, late labor and number of given births might affect breast and uterus cancer (Becker 2001, Hirte et al 2007).We control of differences in lifestyle using fixed effects and include a broad range of socio-economic and demographic variables and indicators for the year of the death in the equation. The covariates are described in Table 2.

Tab 2: Description of the dependent and independent variables (not including year-dummies)

Variable name	**Description**
Gynaecology beds	Number of hospital beds per 100,000 inhabitants, within gynaecology department
ENT-beds	Number of hospital beds per 100,000 inhabitants, within ear-nose-throat department
Gastroenterology-beds	Number of hospital beds per 100,000 inhabitants, within gastroenterology department
Thorax-surgery beds	Number of hospital beds per 100,000 inhabitants, within thorax-surgery department
Urology beds	Number of hospital beds per 100,000 inhabitants, within urology department
Hospital beds	Number of hospital beds per 100,000 inhabitants, total
University-hospital beds	Number of hospital beds per 100,000 inhabitants, university hospital
Doctors	Number of doctors/GPs per 100,000 inhabitants
Level of rurality	Density of inhabitants living in the county, inhabitants per 100 hectar
Hectares of county	Area-size of the county, in hectar
Fertility rate	Average number of child-births per women in the county
Private household income	Average income per private household in the county
Unemployment rate	Proportion of inhabitants in the county without employment
Social Benefit rate	Proportion of inhabitants in the county receiving social benefits
Without school qualification	Number of persons in the county without any school qualification per 100,000 inhabitants

With Abitur qualification	Number of persons in the county with A-level school qualification per 100,000 inhabitants
All inhabitants	Number of inhabitants in county, total
All men	Number of men in county, total
All women	Number of women in county, total
Men between 0 and 18	Proportion of men younger than 18 years
Men between 18 and 35	Proportion of men older than 17 years and younger than 35 years
Men between 35 and 50	Proportion of men older than 34 years and younger than 50 years
Men between 50 and 65	Proportion of men older than 49 years and younger than 65 years
Women between 0 and 18	Proportion of women younger than 18 years
Women between 18 and 35	Proportion of women older than 17 years and younger than 35 years
Women between 35 and 50	Proportion of women older than 34 years and younger than 50 years
Women between 50 and 65	Proportion of women older than 49 years and younger than 65 years

Tab. 2

4. Results

Descriptive results

The mean standardized ACM-rates for all cancer-types for the years 2000-2004 are shown in Fig. 1 and 2 for men and women separately. Lung cancer (25.6 ACMs per 100,000) is the leading cause of ACM in men followed by cancer of the colon and rectum (10.3 ACMs per 100,000) and the prostate (4.55 ACMs per 100,000). The ACM-rates for women are generally lower. Breast cancer deaths (12.5 ACMs per 100,000) are most common, followed by cancer of the uterus (6 ACMs per 100,000) and the lung (5.9 ACMs per 100,000).

Figure 1 and 2: Mean standardized ACM-rates per 100,000 for the years 2000-2004

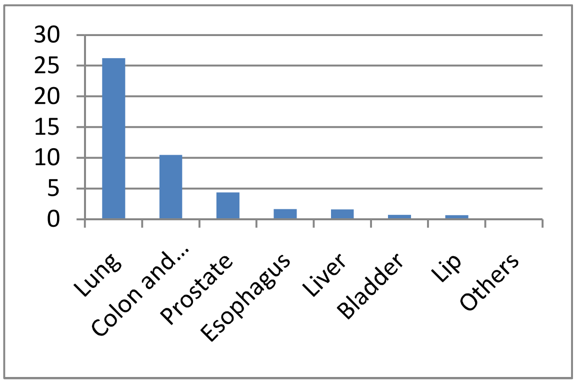


Fig.1 Mean standardized ACM in men

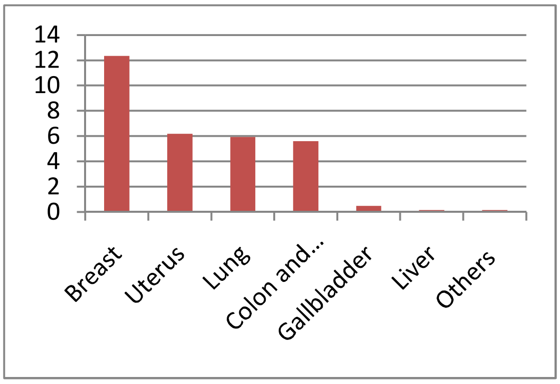
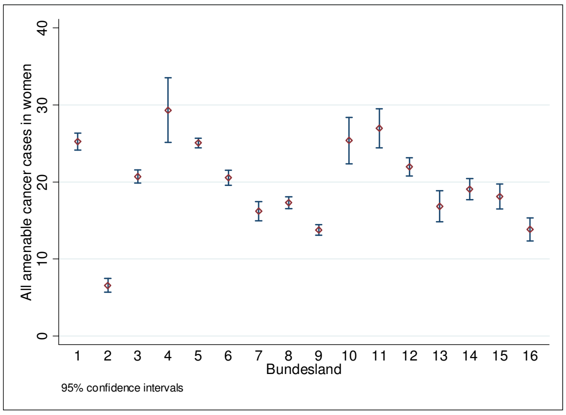


Fig. 2 Mean standardized ACM in women

Figure 3 shows the variation in overall ACM between the 16 German Bundeslaender with confidence intervals for the years 2000-2004 (the coding can be found in the Appendix). Hamburg (2) has the lowest ACM-rate in contrast to Bremen (4) with the highest mean-value. Figure 4 illustrates the high variation of ACM between counties within the largest Land Bavaria (9) in women. County-means go from approximately 3 amenable deaths up to about 28 per 100,000 population representing the full range of ACM-variation which can be found in the data. This implies that a small area-analysis is crucial to identify counties which are ridden by excess ACM. Consequently, we plotted the mean ACM of ten counties with the highest overall ACM-rates in women in Figure 5. Five of the counties can be found in Nordrhine-Westphalia, the others are situated in Saarland, North and East Germany. However, all confidence intervals overlap implying that there is no evidence for significant statistical differences between the counties. The respective graphs for men can be found in the appendix.

Figure 3 and 4: Mean ACM-rates with confidence Intervals



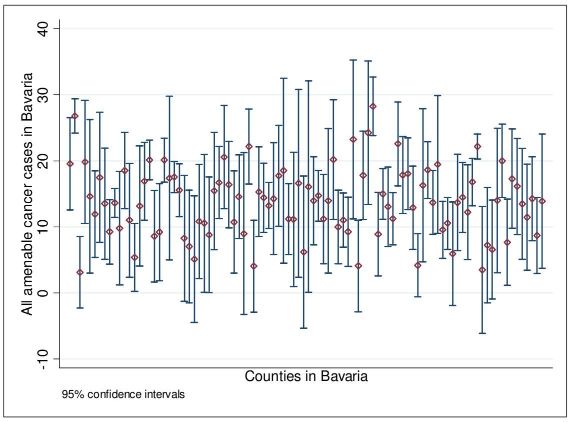


Fig.3 The 16 German Bundeslaender

Fig. 4 Counties within the Land Bavaria (9)

Figure 5: Mean ACM- rates with confidence Intervals for the ten counties with the highest ACM-rate

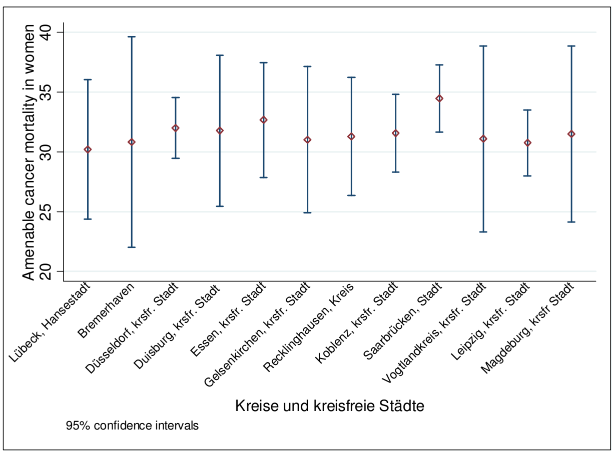


Fig. 5 Women

The country-maps below show the spatial distribution of overall ACM and of the three most common ACM-types for men and women separately. The three shades of grey represent the counties with the highest (dark), middle (light) and lowest (very light) proportion of ACM-rates. Of the 439 counties, 147 fall in the highest category and 146 in the middle and lowest bracket. Tables 3 and 4 provide the respective standardized ACM-rates for the maps.

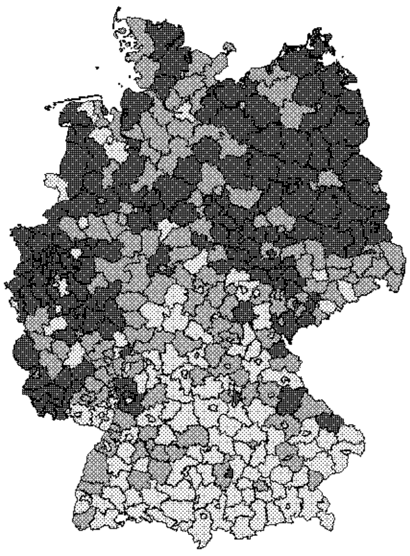


Fig. 6: All stand. amenable cancer deaths in men

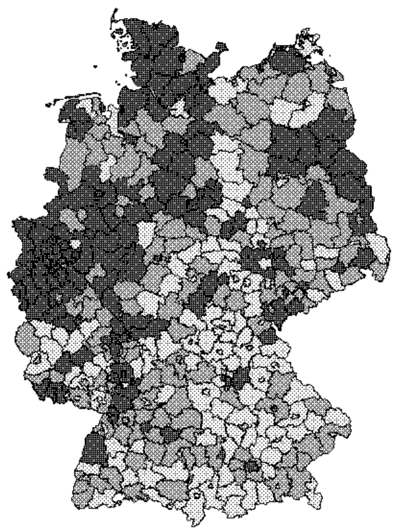


Fig.7: All stand. amenable cancer deaths in women

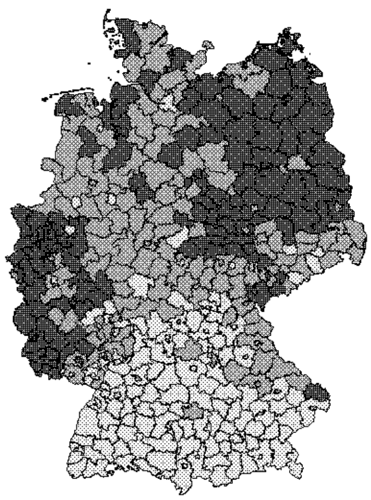


Fig. 8: AMC of the lung in men

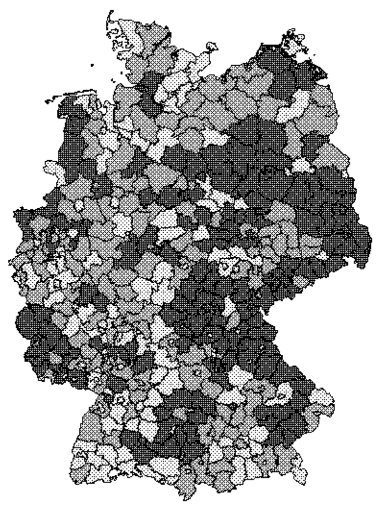


Fig. 9: AMC of colon and rectum in men

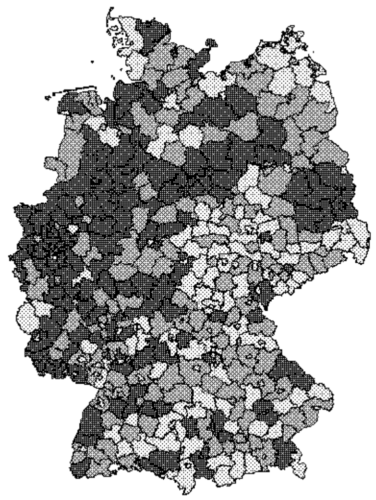


Fig. 10: AMC of prostate in men

	All	Lung	Colon	Prostate	Observations
(very light)	up to 41,99	up to 22,8	up to 9,67	up to 3,9	146
(light)	42 - 49,99	22, 81 - 28,57	9,68 - 11,34	4 - 5,17	146
(dark)	and more	and more	and more	and more	147

Tab.3

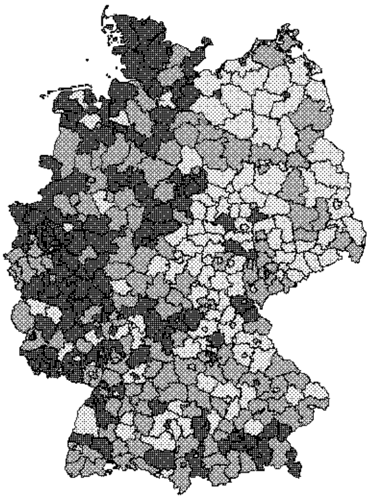


Fig. 11: AMC of the breast in women

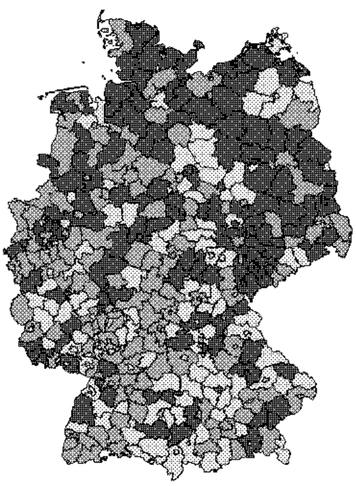


Fig. 12: AMC of the uterus in women

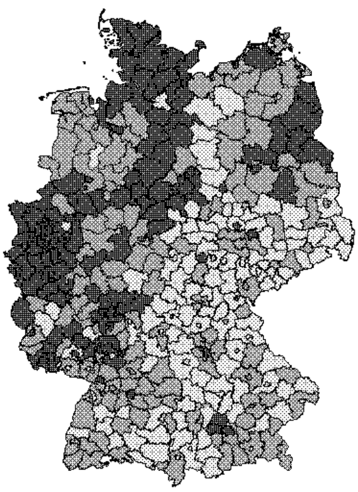


Fig. 13: AMC of the lung in women

All	Breast	Uterus	Lung	Observations
up to 16,09	up to 11,4	up to 5,64	up to 4,2	146
16,1 - 21,8	11,41 - 13,55	5,65 - 7,12	4,21 - 7,2	146
and more	and more	and more	and more	147

Tab. 4

For men and women, we find a north-south gradient with higher ACM-rates in the north, especially in North-West and East Germany. One exception is breast cancer that is rare in the east which might also reflect the low number of young females living there. Uterus cancer is in contrast prevalent in the New Laender and also in the west. Amenable lung cancer deaths accumulate in the east, Saarland and Nordrhine-Westphalia in men and women. A similar pattern can be recognized for prostate cancer. Cancer of the colon in men is the only type which also accumulates in the healthy south of Germany – it dominates the east including North Bavaria.

However, all descriptive results should be interpreted on a note of caution. There are two sources from which potential biases can result: First, the required anonymization especially affects counties with a small number of inhabitants – with fewer events, the probability that observations are fully dropped from the sample is considerably higher. Secondly, we could only use three age-brackets (0-18, 19-65, 65-75) for the standardization so that a high variation in age within the groups (especially 19-65) between counties can bias the results.

The results of the Poisson-regression are presented in Table 5 for women and in Table 6 for men. The fixed effects control for unobserved heterogeneity assumed to result from differences in lifestyle and environmental conditions between counties. We chose fixed over random effects because the unobserved part is assumed to correlate with the explanatory variables in our model. We tested systematic differences between random and fixed effects models using a Hausman test and failed to reject the hypothesis of no difference for all models. Depending on the model, 2-10 counties with zero ACMs in each year dropped from the Poisson models with fixed effects. However, we argue that the remaining sample is representative because only counties with a low number of inhabitants were excluded. The coefficients are reported as incidence rate ratios (IRR) and therefore give the percentage change in ACMs per county for an explanatory factor. In all models, we do not find statistical evidence that medical care supply influences ACM. However, our measure of rurality (inhabitants per 100 hectar) which might also reflect the quality of health infrastructure is positively associated with amenable breast and prostate cancer. From the broad range of socio-economic variables, only low educational attainment and amenable breast cancer mortality and high unemployment and amenable lung cancer deaths are related. In addition we find a moderate and strong decline in amenable cancer of breast and uterus but a strong increase in amenable lung cancer in women over time. The opposite is true for men: amenable lung cancer is significantly decreasing over time. Overall, the magnitude of coefficients is small. Exceptions are the change in the unemployment-rate in men which increases the number of amenable lung cancer deaths by about 2.3 percent and the change in rurality that increases the number of amenable deaths from prostate cancer by approximately 2.4 percent. The summary statistics of the covariates can be found in the appendix.

Tab. 5: Fixed-effects Poisson regression results with robust standard errors for women

Variables	**Amenable breast cancer**			**Amenable uterus cancer**			**Amenable lung cancer**	
	Parameters	S.E		Parameters	S.E		Parameters	S.E
Gynecology beds per 100,000	0.99955	(0.00046)		0.99939	(0.00118)		x	
ENT-beds per 100,000	x			x			1.00228	(0.00252)
Thorax-surgery beds per 100,000	x			x			1.00022	(0.00036)
Urology beds per 100,000	x			x			x	x
Hospital beds per 100,000	1.00008	(0.00006)		1.00015	(0.00013)		0.99992	(0.00007)
University-hospital beds per 100,000	0.99957	(0.00034)		0.99911	(0.00064)		0.99989	(0.00052)
Doctors per 100,000	1.00061	(0.00603)		1.00122	(0.00347)		0.99716	(0.00408)
Level of rurality	1.00983	(0.00548)	**	1.00275	(0.00768)		0.99355	(0.01549)
Hectares of county	1.00000	(0.00002)		0.99998	(0.00001)	***	1.00002	(0.00001)
Fertility rate	1.59047	(0.48120)		1.04671	(0.69290)		x	x
Private household income	1.00000	(0.00000)		1.00000	(0.00000)		1.00000	(0.00000)
Unemployment rate	0.99794	(0.02183)		1.00494	(0.01760)		0.97864	(0.02169)
Social Benefit rate	1.00002	(0.00002)		1.00001	(0.00004)		1.00000	(0.00003)
Without school qualification per 100,000	1.00093	(0.00028)	***	1.00030	(0.00060)		0.99980	(0.00047)
With Abitur qualification per 100,000	0.99986	(0.00020)		1.00010	(0.00021)		0.99978	(0.00031)

Year 2001	0.96860	(0.02389)		0.95792	(0.02514)		1.01048	(0.03528)	
Year 2002	0.96266	(0.01868)	**	0.94967	(0.01901)	**	1.06707	(0.04728)	
Year 2003	0.93837	(0.02851)	**	0.89872	(0.03568)	**	1.14347	(0.05594)	
Year 2004	0.96194	(0.02911)		0.84599	(0.05181)	**	1.22371	(0.09208)	**
All inhabitants	1.00001	(0.00001)		0.99999	(0.00001)		0.99997	(0.00001)	**
All women	1.00000	(0.00002)		1.00003	(0.00003)		1.00007	(0.00003)	**
Women between 0 and 18	0.99999	(0.00002)		1.00000	(0.00002)		1.00003	(0.00002)	**
Women between 18 and 35	0.99998	(0.00001)		1.00001	(0.00003)		0.99998	(0.00002)	
WomMen between 35 and 50	0.99998	(0.00003)		1.00001	(0.00004)		0.99998	(0.00004)	
Women between 50 and 65	1.00000	(0.00002)		1.00003	(0.00002)		0.99998	(0.00003)	
Log Likelihood	-4981.64			-4827.60			-4875.60		
Number of observations	2150			2150			2120		

Tab 5
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Tab. 6: Fixed-effects Poisson regression with robust standard errors for men

	Amenable lung cancer			**Amenable colon cancer**			**Amenable prostate cancer**		
Variables	Parameters	S.E		Parameters	S.E		Parameters	S.E	
ENT-beds per 100,000	1.00066	(0.00112)		x	x		x	x	
Thorax-surgery beds per 100,000	0.99970	(0.00026)		x	x		x	x	
Gastroentorlogy-beds per 100,000	x	x		0.99976	(0.00054)		x	x	
Urology beds per 100,000	x	x		x	x		1.00111	(0.00385)	
Hospital beds per 100,000	1.00004	(0.00006)		1.00002	(0.00003)		0.99997	(0.00018)	
University-hospital beds per 100,000	1.00033	(0.00037)		0.99926	(0.00064)		0.99943	(0.00079)	
Doctors per 100,000	1.00134	(0.00143)		1.00217	(0.00400)		1.00000	(0.00512)	
Level of rurality	0.99709	(0.00450)		0.99717	(0.00444)		1.02239	(0.00731)	**
Hectares of county	0.99999	(0.00000)	**	1.00002	(0.00001)	**	1.00004	(0.00002)	**
Private household income	1.00000	(0.00000)		1.00000	(0.00000)		1.00000	(0.00000)	
Unemployment rate	1.02289	(0.01054)	**	0.99738	(0.02214)		1.01670	(0.02532)	
Social Benefit rate	1.00000	(0.00002)		1.00004	(0.00002)		1.00001	(0.00004)	
Without school qualification per 100,000	0.99971	(0.00024)		1.00028	(0.00047)		1.00012	(0.00098)	
With Abitur qualification per 100,000	1.00000	(0.00013)		0.99994	(0.00016)		0.99980	(0.00020)	
Year 2001	0.99454	(0.01813)		0.97824	(0.02244)		1.01361	(0.04163)	
Year 2002	0.98507	(0.02093)		1.00814	(0.01615)		1.06874	(0.03433)	**
Year 2003	0.95878	(0.01496)	**	0.98425	(0.02186)		1.02371	(0.03899)	
Year 2004	0.95497	(0.01635)	**	0.92952	(0.03018)	**	0.98878	(0.04709)	
All inhabitants	1.00003	(0.00001)	***	1.00001	(0.00001)		1.00003	(0.00002)	
All men	0.99998	(0.00002)		1.00002	(0.00002)		0.99993	(0.00008)	
Men between 0 and 18	1.00002	(0.00001)		0.99997	(0.00002)		0.99997	(0.00004)	
Men between 18 and 35	0.99998	(0.00001)		0.99998	(0.00002)		1.00005	(0.00005)	
Men between 35 and 50	0.99997	(0.00002)	*	0.99996	(0.00003)		1.00004	(0.00006)	

Men between 50 and 65	0.99999	(0.00001)	0.99998	(0.00003)	1.00002	(0.00004)
Log Likelihood	-5293.69		-4927.52		-4538.46	
Number of observations	2155		2135		2125	

Tab. 6

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

5. Discussion

In this paper, we used the causes-of-death statistics, official regional statistics (INKAR) and statistics provided by the German Hospital Foundation to describe spatial variation of age-standardized amenable cancer-deaths between counties in Germany and to investigate the contribution of health care to a reduction in ACM. We used Poisson regressions with fixed effects and robust standard errors to control for observed and unobserved heterogeneity between counties. The quality and quantity of health care was approximated based on the number of physicians and beds in all hospitals, teaching hospitals and in relevant units.

Cancer of the breast, uterus and lung are the most common causes of ACM in women under 75. On a considerably higher level, lung, colon and rectum and prostate cancer take the largest share of ACM in men. Overall, we recognize a north-south rather than the often discussed east-west gradient. This suggests that the often found distinct difference between East and West Germany (Nolte et al 2002, Wiesner and Bittner 2004) was driven by a high number of deaths from ischemic heart diseases in the New Laender. The ACM-rates are even lower in East compared to West Germany.

However, the specific distribution depends on the cancer type. Amenable cancer-deaths that are thought to be brought forward by tobacco-consumption (lung and breast cancer) are prevalent in the Saarland and Nordrhine-Westphalia in both genders and in the east in men and in the north in women. ACM-rates that depend on early detection (uterus, breast, prostate cancer) are higher in rural areas. Amenable cancer of the colon and rectum in men is accumulated in the east and north Bavaria, areas which were often linked to a high consumption of smoked meat (Becker and Wahrendorf 1998). The low rate of cancer and especially breast cancer in East Germany might to some extent be a statistical artifact: A low proportion of young females live in Germany’s east-part. Furthermore, Becker (2001) used data on breast cancer in women stratified by six age groups (30-85+) over five decades (50-00) to show that breast cancer-rates varied between age groups, but were notably similar between East and West Germany. In addition, he showed that system inherent differences in registering and coding mortalities after reunification occurred in the older age groups.

The regression results show that the set of our health care variables is not significantly associated with a reduction in ACM. When we estimate the models using random-effects regression, we find a negative relationship between doctor supply and ACM for most cancer types. However, the Poisson model with fixed effects eliminates these effects suggesting that unobserved heterogeneity resulting from behavioural and environmental differences between counties is a crucial factor in the spatial distribution of amenable cancer-deaths. However, it should be taken into account that the set of health care variables only approximates differences in the quality health care based on the quantitative distribution of doctors and hospital beds. It does not incorporate direct information on the quality of care. From the range of socio-economic variables, low educational attainment increases amenable breast cancer-mortality and high unemployment is associated with lung cancer deaths. Both low educational attainment and unemployment associated with economic and social hardship might 1) constraint access to timely and effective health care although available in the respective county, 2) reduce the ability to recognize and to cope with early warning signals of cancer, and/or 3) be related with high stress that is conducive to the development of some cancer types (Becker 2001, Clapp et al 2007, Marshall et al 1999).

6. Conclusion

In summary, our paper suggests that AMC significantly differs between small areas within and between Bundeslaender. The map of all amenable cancer-deaths shows a north-south gradient. Our regression results suggest that the quantity of health care does not significantly reduce amenable cancer-mortality. However, the unemployment rate and low educational attainment play a significant role in lung and breast cancer respectively.

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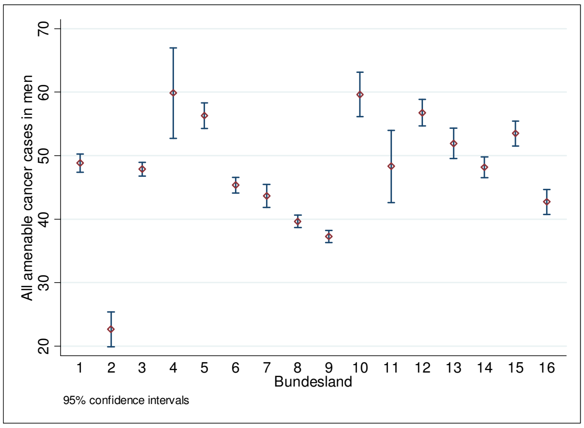
Appendix

Fig. 1 and 2: Mean ACM-rates with confidence Intervals for all Laender and Bavaria for men



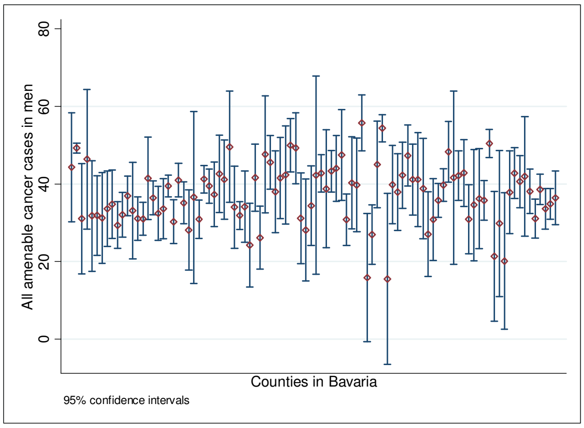


Fig.1 The 16 German Bundeslaender

Fig.2 Variation of ACM.means between ounties within Land Bavaria (9)

Tab 2: Codes for Bundeslaender

Official numbers of Bundeslaender	
01 Schleswig-Holstein	09 Freistaat Bayern
02 Freie und Hansestadt Hamburg	10 Saarland
03 Niedersachsen	11 Berlin
04 Freie Hansestadt Bremen	12 Brandenburg
05 Nordrhein-Westfalen	13 Mecklenburg-Vorpommern
06 Hessen	14 Freistaat Sachsen
07 Rheinland-Pfalz	15 Sachsen-Anhalt
08 Baden-Württemberg	16 Freistaat Thüringen

Tab. 1

Tab. 1.: Summary statistics of independent variables 2000-2004 on county-level, for both genders

Description	**Mean**	**S.E.**
Number of hospital beds per 100,000 inhabitants, within gynecology department	101.0198	98.44224
Number of hospital beds per 100,000 inhabitants, within ear-nose-throat department	29.85207	42.8648
	21.33088	49.66536
Number of hospital beds per 100,000 inhabitants, within thorax-surgery department	9.637788	30.25356
Number of hospital beds per 100,000 inhabitants, within urology department	35.70691	43.10501
Number of hospital beds per 100,000 inhabitants, total	1170.334	1180.689
Number of hospital beds per 100,000 inhabitants, university hospital	92.60276	362.7431
Number of doctors/GPs per 100,000 inhabitants	151.6599	52.08099
Density of inhabitants living in the county, inhabitants per 100 hectar	26.78241	26.2539
Area-size of the county, in hectar	81325.18	59669.61
Average number of child-births per women in the county	1.374433	0.13739
Average income per private household in the county	16250.78	2152.306
Proportion of inhabitants in the county without employment	10.56583	5.448461
Inhabitants in the county receiving social benefits per 100,000	2848.472	1557.101
Number of persons in the county without any school qualification per 100,000 inhabitants	115.3872	45.30913
Number of inhabitants in county, total	187821.9	217931.4
Number of men in county, total	91793.04	105913.4
Number of women in county, total	96028.85	112033.9
Proportion of men younger than 18 years	17769.83	18649.01

Proportion of men older than 17 years and younger than 35 years	20308.74	25768.21
Proportion of men older than 34 years and younger than 50 years	23097.09	27366.61
Proportion of men older than 49 years and younger than 65 years	17498.44	20838.39
Proportion of women younger than 18 years	16855.19	17692.95
Proportion of women older than 17 years and younger than 35 years	19469.04	25448.89
Proportion of women older than 34 years and younger than 50 years	22101.5	25892.85
Proportion of women older than 49 years and younger than 65 years	17726.16	21494.85

Tab. 1