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Determinants of Avoidable Deaths from Ischaemic Heart Diseases in East and West Germany

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Christoph Schwierz and Ansgar Wübker*

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Abstract
The objective of this paper is to identify selected forces of the decrease in the number of avoidable deaths from ischaemic heart diseases (IHD) in West and East Germany from 1996 to 2004. Our main result reveals that the number of intracardiac catheter facilities, which are an important diagnostic tool for IHD, do significantly account for decreases in avoidable mortality from IHD. This is important, as the modernization of the East German health sector included a considerable catch-up process in the number of IC facilities provided relative to West Germany.

JEL Classification: I12, I19

Keywords: Avoidable deaths, ischaemic heart disease, intracardiac catheters, Germany

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1. Introduction

Improving health system performance can save lives. As an example, Nolte and McKee (2008) estimate that a minimum of 75 000 deaths from treatable conditions for those aged under 75 would not have occurred in the USA in the year 2002, if the US health system performed on the average level of other industrialized countries. Consequently, identifying causes of and improving health system performance is of substantial interest to society. The objective of this paper is to identify selected forces of health system performance in Germany over the period 1996-2004.

To this aim, we measure health system performance by the number of avoidable deaths from ischaemic heart diseases (IHD) within the male population. IHD, such as angina pectoris or myocardial infarct, are characterized by reduced blood supply to the heart and can be mortal. The concept of avoidable deaths relies on the insight that deaths in younger ages are potentially avoidable if the given medical know-how is exploited (Rutstein et al. 1976; French and Jones 2006). Within the European Union, IHD account for 16 percent of all deaths and for 11 percent of deaths for those under the age of 65 (Eurostat 2006). In 2004, three out of the top ten most frequent causes of acute care hospitalization are assigned to this disease group and 167,681 people died from IHD in Germany.

Since 1991, German unification brought about a substantial progress of the East relative to the West German economy. As in other parts of the economy, large funds were aimed at the modernization of the health sector. As an example, average annual public investment per bed in East German acute care hospitals – which is the biggest health sector in terms of costs - is roughly 100 percent above the level of public investments in West German hospitals since reunification. The improvement in the health structure might have contributed to greater utilization of the health sector: Since reunification demand in terms of patients treated increased by 30 percent in East compared to 20 percent in West Germany.

There was also a considerable decrease in avoidable deaths, especially in East Germany whose health sector was heavily modernized. Table 1 shows standardized rates in avoidable mortality from IHD per 100,000 male inhabitants under the age of 65 in East and West Germany for the years 1996 and 2004. In 1996, the rate was 45.3 in West and 70.9 in East Germany. Until 2004, it dropped considerably and much faster in East than in West Germany. Still, mortality rates in 2004 were on average 11.8 percentage points higher in East than in West Germany. East German levels in 2004 were nearly at the same level as West German levels in 1996.

Table 1

Standardized rates in avoidable deaths from ischaemic heart diseases within the male population per 100,000 male inhabitants

	Total	West Germany	East Germany	East-West difference, in %-points
1996	49.8	45.3	70.9	25.6
2004	33.4	31.4	43.2	11.8
Change in %-points of 1996	-16.4	-13.9	-27.7	-13.8

Notes: Causes of Deaths Statistic 1996 and 2004, own calculations.

In Germany, the responsibility for the surveillance of public health and the financing of hospital infrastructure is on the level of the German Federal States (Busse and Riesberg 2005). Due to differences in health policies across Federal States and especially between East and West Germany, the density and provision of health services differ largely across them. We exploit these differences to measure how differences in health infrastructure between East and West Germany are related to decreases in avoidable mortality over time.

In view of this continuing East-West divide in health system performance, it is unclear to what extent policies improving the health structure have been successful or not. Received literature has identified numerous explanations for the regional variation in the occurrence of ischaemic heart diseases such as nutrition, physical activities, smoking and alcohol consumption, socioeconomic causes and differences in the medical health structure (Bobak and Marmot 1996, Kromhout 2001, Wübker 2007). Our focus is on the impact of specific indicators of health infrastructure. The identification strategy assumes that there are three sources of geographical variability in health system performance over time: differences in socioeconomic characteristics; random variability; and differences arising from the availability of local health structure. Once the model accounts for the first two sources, the variability in avoidable deaths can be attributed to differences in health structure such as the hospital market structure or specific structural indicators for the treatment of IHD. Further, unobservable differences across regions, such as lifestyle may impact upon health outcomes. Ignoring these factors may distort the estimated effects as obtained from a classical ordinary least squares estimator. Methodologically, we account for unobservable differences between regions by exploiting the panel structure of our data by the use of fixed-effect estimators.

The paper is organized as follows. Section 2 describes the data and descriptive results. Section 3 introduces the econometric model. Results are presented in section 4. Section 5 concludes.

2. Data

We analyze the mortality rate from IHD of the male population aged less than 65 on the regional level of German counties over the period 1996-2004.[2] Data before 1996 is unreliable or unavailable, such that it is not possible to retrace the modernization of health infrastructure back to German unification in 1991. Mortality rates are standardized by dividing actual values by the expected equivalent as defined by national average mortality rates in the age groups 1 to 4 years, 5 to 9 years, …, and 60 to 64 years. The data is extracted from the Causes of Deaths Statistic (*Todesursachenstatistik*), which provides the individual cause and year of death, age, sex and county of residence.

Explanatory variables, as described below, have been merged from the following sources: the annual German Hospital Statistic, which includes data of all hospital in-patients from all hospitals in Germany; the Regional Data Statistic providing information on socioeconomic variables; Bruckenberger (2007) giving information on structural indicators for the treatment of IHD. Because of missing data for some of the years for Mecklenburg-Vorpommern and Schleswig-Holstein, the analysis is based on 3853 observations from 439 counties in 16 Federal States, out of which 1006 observation from 118 counties in 5 States are for East Germany and 2847 observations from 321 counties in 11 States are for West Germany. Because of its strong similarity in health infrastructure, Berlin is counted to the West German subsample.

We use three broad categories of explanatory variables which are supposed to account for the variation in avoidable deaths: specific structural indicators for the treatment of IHD, the hospital market structure and socioeconomic variables.

First, we consider the number of intracardiac catheter (IC) facilities and the number of percutaneous transluminal coronary angioplasties (PTCA) as specific structural indicators for the diagnosis and treatment of IHD. IC facilities offer IC examinations. These are minimally invasive procedure involving the insertion of a catheter into a coronary artery to test for an abnormal narrowing of the coronary vessels. PTCA is a therapy used for the

[2] The group of ischaemic heart diseases is defined in the 10th revision of the International Classification of Diseases (ICD) by the codes I20 to I25. These cover angina pectoris (I20), initial (I21), subsequent (I22) and rezidivating myocardial infarctions (I23), and other acute (I24) and chronic ischaemic heart diseases (I25); Data in 1996 and 1997 was codified according to the 9th revision of ICD by the codes 410 to 414.

widening of a narrowed blood vessel with the means of balloons which are passed into the narrowed spaces and then inflated. Medical evidence points out the merits of these structural indicators for the success in the diagnosis and treatment of IHD (Bruckenberger 2007; Van de Werf et al. 2003).

Second, the treatment of IHD is closely linked to the acute care hospital sector, because of the emergent and initially high level of intensity of care required, which is provided by acute care hospitals. We approximate for the structural quality of acute hospital care by several measures. First, we measure the density of the provision of acute care services as approximated by the ratio of the number of beds to the number of residents on county level. Second, we consider the medical staff-to-patient ratio, which has been shown to be a potential determinant of the quality of care in hospitals.[3] We use the ratio of the number of patients to full-time doctoral staff as a proxy for the quality of the intensity of treatment. Third, we consider the number of large medical devices available in acute care hospitals per million inhabitants. The devices included are: Digital substraction-angiography devices, gamma cameras, heart-lung-machines and computer-tomographs.

Fourth, we condition on the level of market concentration, as measured by the Herfindahl-Hirschman-Index (HHI). The HHI is defined as the sum of the squared market shares of all hospitals in hospital's *i* market. The hospital's local market is defined as the sum of beds in maximum distance of 50 kilometres. High values of the index reflect high levels of market concentration. These have been shown theoretically and empirically to decrease the quality of care quality in markets with fixed prices such as the German hospital market (Gaynor 2006). Fifth, theoretical research predicts that quality of acute care hospital services may be related to the ownership type of the providers (Hansmann 1980, Weisbrod 1988).[4] However, in the US context these predictions have mostly not been fulfilled (Sloan et al. 2001). To test for the relevance of ownership in the German context, we control for the regional market shares in beds by the ownership type of hospitals, which is either public, private for-profit or private nonprofit. Finally, we also control for the market share of university hospitals, because of their specific role as centers of medical excellence.

The HHI, the market shares by ownership type, the market share of university hospitals and bed density are potentially endogenous to unobserved hospital quality and patient characteristics. Therefore, the estimated effects of these variables on avoidable deaths may be biased. As a possible solution, Kessler and McClellan (2000) propose an identification strategy which

[3] For a discussion of the topic and an application see Evans and Kim (2006).

[4] For a discussion of the distinguishing features of ownership types see Slown (2000).

bases the measures of hospital market structure on an exogenous source of variation: travel distances between hospitals and patients. In short, Kessler and McClellan specify patient-level hospital choice models and predict the number of patients admitted to each hospital based solely on exogenous characteristics of patients and hospitals. The predicted numbers of patients to each hospital are then used to calculate measures of hospital market shares and market concentration in each geographic region. The effects of these measures on the dependent variable are unbiased, because they do not depend on unobserved patient and hospital characteristics. For a detailed description of the model see Kessler and McClellan (2000). We adopt Kessler's and McClellan's approach to obtain unbiased effects of these variables on avoidable mortality.

Finally, regional variability in the socioeconomic structure is meant to account for differences in the risk factors which impact upon rates in avoidable mortality. Risk factors will determine the needs of the population to utilize health care services (Carr-Hill et al. 1994). Received literature on socioeconomic status and health has identified many determinants of health, although evidence on the relevance of each of the factors varies by each study (see Cutler 2008 for an overview). We use average levels of income per capita, the proportion of the population without educational attainment and the unemployment rate as an approximation for the socioeconomic structure on county level. Further, we include a measure of the degree of rurality of each county to account for unobserved heterogeneity across counties, which may reflect differences in household structures, lifestyle and health behavior (Hauck and Street 2006). Finally, we condition on the ratio of hospital visits to inhabitants from the same county of origin as a proxy for unobservable heterogeneity in health status. Health utilization and health status have been shown to be strongly correlated (van Doorslaer and Koolman 2002). However, this is at best only a partial indicator of health status, because we miss to observe the extent of ambulatory care. Table A1 in the Appendix presents the descriptive statistics.

As mentioned above, received literature reveals that the availability of heart catheterization technology is important to avoid premature deaths. Table 2 shows a considerable catch-up process in IC facilities and PTCA in East versus West Germany during the period considered. The difference in the number of IC facilities and PTCA per million inhabitants between East and West Germany shrank considerably despite a substantial increase in both IC facilities and PTCA in West Germany.

Table 2

Intracardiac catheter facilities and PTCA in East and West Germany per million inhabitants, 1996-2004

	Intracardiac catheter facilities			
	Total	**West Germany**	**East Germany**	**East-West difference, in %-points**
1996	4.46	5.33	2.53	-2.80
2004	7.55	8.21	6.09	-2.12
Change in %-points of 1996	3.09	2.88	3.56	0.68
	Percutaneous transluminal coronary angioplasties			
	Total	**West Germany**	**East Germany**	**East-West difference, in %-points**
1996	1446.9	1719.8	846.6	-873.2
2004	3263.1	3468.5	2811.2	-657.3
Change in %-points of 1996	1816.2	1748.7	1964.6	215.9

Notes: Own calculations.

Table 3 shows how our structural indicators have changed by quartiles of the regional changes in avoidable mortality over the period 1996-2004 and previews the results from the regression models. The quartiles are sorted by decreasing improvements in average mortality rates, i.e. the 1st (4th) quartile presents counties with the highest (lowest) decrease in mortality rates over 1996-2004. Higher increases in the number of PTCA and IC facilities are associated with higher decreases in avoidable mortality. This is consistent with the medical evidence of the importance of these indicators for a successful diagnosis and treatment of IHD. Contrary to the expectation, counties with an increasing market concentration have higher decreases in the mortality rate. Decreases in the shares of public hospitals and increases in the share of nonprofit hospitals go along with decreases in the mortality rate. There is no clear association between changes in the shares of for-profit and university hospitals and the mortality rate. The same is true for the relation of changes in bed density, doctor-to-patient ratios and large medical devices to changes in the mortality rate.

Table 3
Changes in explanatory variables by quartiles of decreases in average avoidable mortality in German counties, 1996-2004

	1st Quartile		2nd Quartile		3rd Quartile		4th Quartile	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Avoidable deaths	-45.1	13.8	-23.5	3.4	-11.7	3.3	4.6	8.5
Structural indicators for treatment of IHD								
PTCA	4382.2	1322.9	3870.5	1053.5	3616.2	975.9	3306.5	753.7
IC facilities	3.1	0.9	2.6	0.6	2.4	0.8	2.0	0.8
Hospital Market Characteristics								
Market concentration	108.2	2788.1	-351.7	1715.5	-267.2	2010.4	-326.0	1971.8
Share of hospitals, in percent								
Public	-2.7	3.1	-0.9	2.9	1.2	3.3	3.8	3.1
Nonprofit	2.2	16.7	1.8	16.4	-2.0	18.0	-2.5	22.6
University	0.5	15.1	-0.4	13.9	0.8	16.0	-1.3	13.1
For-profit	1.9	24.4	0.4	20.3	1.9	27.0	1.1	25.1
Bed density(*1000)	0.2	1.6	3.7	1.1	4.6	8.5	3.8	10.0
Doctor-to-patient ratio(*1000)	0.4	3.2	2.6	18.3	0.2	3.9	0.6	1.8
Large medical devices(*1000)	0.2	0.4	0.3	0.5	0.2	0.4	0.2	0.4

Notes: The number of available counties is 439.

3. Methods

The clustering of repeated annual observations within counties implies a panel structure of the data. To exploit this structure we define the following fixed-effect model:

$$y_{it} = \alpha_i + \beta' x_{it} + t_{1997} + \ldots + t_{2004} + \varepsilon_{it}, \qquad i = 1,\ldots, N,$$

where y_{it} is the ratio of avoidable deaths in the *t*th year within the *i*th county, α_i is a county-specific component capturing unobserved time-constant heterogeneity across counties, x_{it} is a set of observed variables associated with the counties' ratios of avoidable deaths, t_{1997} to t_{2004} are yearly dummies and ε_{it} is a time- and county-specific error term. Finally, β are coefficient estimates. All variables are centered around zero by subtracting their grand mean from the values of each region. After centering, the constant can be interpreted as the mean intercept across all years in all counties in all Federal States.

With the given panel structure of the data, it is possible to use either fixed-effect (FE) or random-effect (RE) estimation techniques in order to account for time-constant unobservable heterogeneity within counties. A merit of FE relative to RE estimation is the straightforward interpretation of the coefficients, which are solely based on within-individual variation over time. RE techniques exploit both within- and between-individual variation and are therefore more difficult to interpret.

4. Results

The random effects specification was rejected by the conventional Hausman test. We therefore present the results of the fixed-effects model including all explanatory variables. Table 4 shows estimates for the whole of Germany as well as separate results for West and East Germany.

Increases in the number of IC facilities are highly statistically significant and related to a decrease in regional mortality rates. An additional IC facility per million inhabitants contributes to a reduction in avoidable mortality by 1.43 years. The effect is higher in East than West Germany, although it is significant in the East only on a low significance level. In contrast, PTCA is not significantly related to changes in mortality on conventional statistical levels.

Table 4
Coefficient estimates

	Germany		West Germany		East Germany	
	Coeff.	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Structural indicators for treatment of IHD						
IC facilities	-1.43***	(0.15)	-1.95***	(0.67)	-2.50*	(1.48)
PTCA	-4 E-03	(3 E-03)	-2 E-03	(2 E-03)	-1 E-03	(2 E-03)
Structure of acute care hospital market						
Market Concentration*1000	-1.02	(2.03)	2.02	(2.13)	2.14	(4.21)
Share of hospital beds						
For-profit	-0.06	(2.01)	-2.02	(2.43)	-0.45	(4.10)
Public	0.69	(1.62)	-0.11	(1.85)	-1.62	(3.62)
University	2.65	(2.27)	1.54	(2.81)	2.62	(4.43)
Bed density (*100)	4.11	(2.78)	-0.64	(3.69)	6.89	(4.66)
Doctor-to-patient ratio	-18.19	(30.93)	28.96	(39.62)	-39.74	(53.26)
Large medical Devices (*1000)	-8.29	(8.42)	-5.70	(4.09)	0.97	(2.23)
Socioeconomic variables						
Increasing rurality	2.20	(1.68)	-1.75	(1.84)	13.42***	(3.45)
Income per capita	5 E-04	(1 E-03)	-1 E-04	(1 E-03)	3 E-03	(2 E-03)
Unemployment rate	-0.23	(0.37)	-0.32	(0.48)	-0.48	(0.377)
No school graduation	-14.83	(12.79)	7.59	(15.82)	-2.19	(25.68)
Hospitalization rate	-20.96	(19.52)	-68.26***	(22.67)	48.06	(39.12)
Year						
1997	1.06	(0.90)	0.29	(0.98)	-7.14***	(2.41)
1998	0.95	(1.13)	-1.03	(1.15)	-13.18***	(3.29)
1999	9 E-03	(1.36)	-2.71*	(1.47)	-17.68***	(4.35)
2000	-1.88	(1.56)	-4.37**	(1.96)	-24.12***	(4.77)
2001	-1.94	(1.75)	-4.91**	(2.36)	-25.24***	(5.26)
2002	-3.85**	(1.87)	-6.20***	(2.35)	-30.87***	(5.82)
2003	-2.84	(1.99)	-6.04**	(2.43)	-28.48***	(6.66)
2004	-2.75	(2.36)	-6.50**	(2.88)	-30.67***	(8.17)
Constant	55.52***	(2.79)	52.63***	(2.63)	80.33***	(4.92)

Notes: Number of observations is 3853.

Within-county changes of the measures of the structure of the acute care hospital market are not significantly related to changes in avoidable deaths.

Similarly, within-county changes in most of the socioeconomic variables are not significantly associated with changes in the dependent variable. Only the increasing degree of rurality is negatively associated with mortality in West Germany, but positively in East Germany. This may reflect pronounced changes in the rural socioeconomic structure in East versus West Germany. Further, increases in the hospitalization rate in West Germany are related to decreases in mortality, whereas there is no significant effect for East Germany.

The yearly dummies are highly statistically significant in the separate West and East regressions, signaling a clear pattern of decreasing mortality over time with from IHD in the male population. These decreases are stronger in East than West Germany and capture nearly all of the reduction in avoidable deaths in the given time period. The time trends may be related to pronounced changes in lifestyle, socioeconomic environment and other coronary risk factor in East Germany.[5] However, unfortunately we are not able to test these hypotheses with the current data set.

5. Discussion and conclusion

The objective of this paper was to identify selected forces of health system performance in Germany over the period 1996-2004 as measured by the reduction of number of avoidable deaths from ischaemic heart diseases (IHD) within the male population. Methodologically, after adjusting for the socioeconomic structure of each region and yearly time trends in avoidable mortality, we have accounted for unobservable differences between regions by the use of a fixed-effect estimator.

Our main result reveals that the number of intracardiac catheter facilities, which are an important diagnostic tool for IHD, do account for decreases in avoidable mortality from IHD. This is important, as the modernization of the East German health sector included a considerable catch-up process in the number of IC facilities provided in East as compared to West Germany. Our results suggest that this modernization may have contributed to save people from premature deaths. However, except this parameter we could not identify any structural factors of health system performance which would relate significantly to reductions in avoidable deaths.

Further, decreases in both West and East German mortality rates are "explainable" to a large degree by unobservable factors such as yearly dummies. It is therefore probable that other factors, not accounted for in this

[5] See Müller-Nordhorn et al. (2004) for a good overview into the literature.

study, might be more important for reductions in mortality. Unfortunately, this hypothesis was not testable with our data set.

Moreover, the time trends clearly show a stronger decrease in avoidable deaths in East than in West Germany. The initial level in avoidable deaths was much higher in the East than in the West in 1996. A reduction from this high level may be less costly with a given medical knowledge which was already available in West Germany at this time. Still, the decrease was not high enough in order to close the gap between West and East German levels in avoidable deaths. It may be that the impact of health infrastructure on reductions in avoidable deaths is age specific. Before the modernization of the health system, older age groups in East Germany had probably a high risk to die before the age of 65. This risk can not be totally reduced by better access to medical care, because convalescence in advanced age is more difficult. Also, older age groups have a higher share in avoidable deaths than younger age groups. This divergence in the relative responsiveness of age groups to the modernization of the infrastructure in East Germany might explain why the divide in East-West rates of avoidable deaths still persists. An age-specific analysis in avoidable deaths in future research should be able to shed light on this hypothesis.

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Appendix

Table A1

Descriptive Statistics, averages over 1996-2004

Variables	Definition	Mean	SD
Outcome			
Avoidable deaths from IHD	Ratio of deaths from ischaemic heart diseases of the male population with age lower than 65 years to the expected equivalent of 100 000 inhabitants given the age/sex profiles and national averages	41.26	23.12
Hospital market structure			
Share of nonprofit hospitals	Market share of the number of beds of private non-profit hospitals	0.31	0.27
Share of for-profit hospitals	Market share of the number of beds of for-profit hospitals	0.08	0.19
Share of university hospitals	Market share of the number of beds of university hospitals	0.16	0.21
Market concentration	Herfindahl-Hirschman-Index of market concentration	3686.71	2759.77
Bed density	Ratio of the number of beds to the number of residents	2.46 E-03	2.11 E-03
Doctor-to-patient ratio	Ratio of the number of in-hospital patients to full-time doctoral staff	2.35 E-03	0.01
Large medical devices	Ratio of the number of large medical devices including digital substraction-angiography devices, gamma cameras, heart-lung-machines and computer-tomographs to 1 Mio. residents	66.12	52.31
Specific indicators for the treatment of ischaemic heart diseases			
IC	Ratio of intracardiac catheters facilities to 1 Mio. residents	5.75	2.10
PTCA	Ratio of the number of percutaneous transluminal coronary angioplasties (PTCA) to 1 Mio. residents	2011.02	746.59
Socioeconomic structure			
Rurality	Degree of rurality from 0 to 1	0.27	0.26
Income	Real per capital income in €	15223.28	1987.64
Education	Share of population without school graduation	0.09	0.03
Unemployment	Unemployment rate	11.29	4.55
Hospitalization	Ratio of the number of patients to the number of residents within the same county	0.21	0.03

Notes: Own calculations.