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Quantifying the contribution of smoking to regional mortality disparities in Germany

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ABSTRACT

Understanding factors responsible for regional mortality differentials are crucial for developing adequate policy responses. The aim of this paper is to quantify the impact of smoking on regional mortality disparities in Germany and their changes over the last four decades. We use regional all-cause and cause-specific mortality data for the period 1980–2017, and perform our analysis across five geographical areas of Germany. We estimate smoking-attributable mortality using the *Preston-Glei-Wilmoth* method, which relies on mortality from lung cancer as a proxy of past smoking behavior. We measure the impact of smoking by computing complete life tables before and after eliminating smoking-attributable deaths. As expected, smoking-attributable mortality has been declining among males and increasing among females. This rise among females has been accompanied by rapidly growing regional divergence in lung cancer mortality determined by births cohorts 1940–1950. Our estimates suggest that in 2017, the elimination of smoking-attributable deaths would halve the female all-cause mortality gap with the vanguard region (*South*). East Germany with the lowest female smoking-attributable mortality stands out as a notable exception. However, soon the impact of smoking should grow in East Germany, which may eventually contribute to widening regional disparities in mortality.

Key words: Smoking-attributable mortality, regional differences, lung cancer, Germany

BACKGROUND AND AIM

Understanding factors responsible for regional mortality differentials are crucial for developing adequate policy responses. However, disentangling mortality determinants represent a complex task. First, there has been a long-standing debate concerning the relative importance of space and place on the one hand and individual characteristics on the other. Some researchers argue that processes operating at the individual level are crucial for understanding health inequalities while others suggest that these processes might operate differently in different places (Curtis and Jones 1998). Thus, spatial variation in mortality can be broadly interpreted in terms of *compositional* and *contextual* effects (Macintyre et al. 1993). Second, the observed regional disparities could be driven not only by contemporary socio-economic conditions and compositional effects but also by regional differences in long-term factors such as past smoking behavior.

Smoking is one of the leading mortality determinants responsible for international differences in mortality (Ezzati&Lopez 2000; Preston et al. 2010), the gender gap in mortality (Preston&Wang 2005), and mortality differences between socio-economic groups (Gregoraci et al. 2017; Long et al. 2021)). The impact of smoking on regional differences is less explored (Janssen&Spriensma 2012; Fenelon&Preston 2012; Muszyńska et al. 2014), partly because of the limited availability of regional long-term series by cause of death. Internationally, these kind of data, specifically mortality from lung cancer, are widely used to estimate smoking attributable mortality (Peto at al. 1992; Preston et al. 2010). The aim of this paper is to assess the contribution of smoking to mortality differentials in Germany. In particular, we intend to measure to what extent the long-standing East-West and North-West mortality divides (Kibele et al. 2015) are attributable to smoking, and how the role of smoking has changed over time.

DATA AND METHODS

Our analysis is based on official mortality data by German Federal States for the period 1980–2017. Those data include death counts by single year of age (all causes combined) as well as the death counts by 5-year age groups tabulated in accordance to 3-digit ICD–9 and ICD–10 codes. To estimate mortality rates we rely on official data on population counts (as on 31.12) for the periods 1979-1986 and 2012-2017. For the period 1987–2011, we use data on population exposures adjusted to the results of the 2011 Census (Klüsener et al. 2018).

The German Federal States are grouped into five macro regions: North, West-I, West-II, South, and East (Figure 1). This division captures the long-standing macro-regional differences in social and economic development as well as mortality differences in Germany reasonably well (Klüsener& Zagheni 2014). The *North* group consists of Schleswig-Holstein, Hamburg, Lower Saxony, and Bremen. *West-I* is formed by the most populated German State of North Rhine-Westphalia. *West-II* includes Hesse, Rhineland-Palatinate, and Saarland. The federal states Baden-Württemberg and Bavaria form the *South* group, while the territories of the former GDR (Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, and Thuringia) form the *East* group. Our analysis does not cover Berlin because this state was divided into an eastern and a western part between 1945 and 1990. As these parts exhibited quite distinct mortality patterns prior to and even after German reunification, the inclusion of whole Berlin into *East* would be inappropriate, at least for the period prior to 1990.

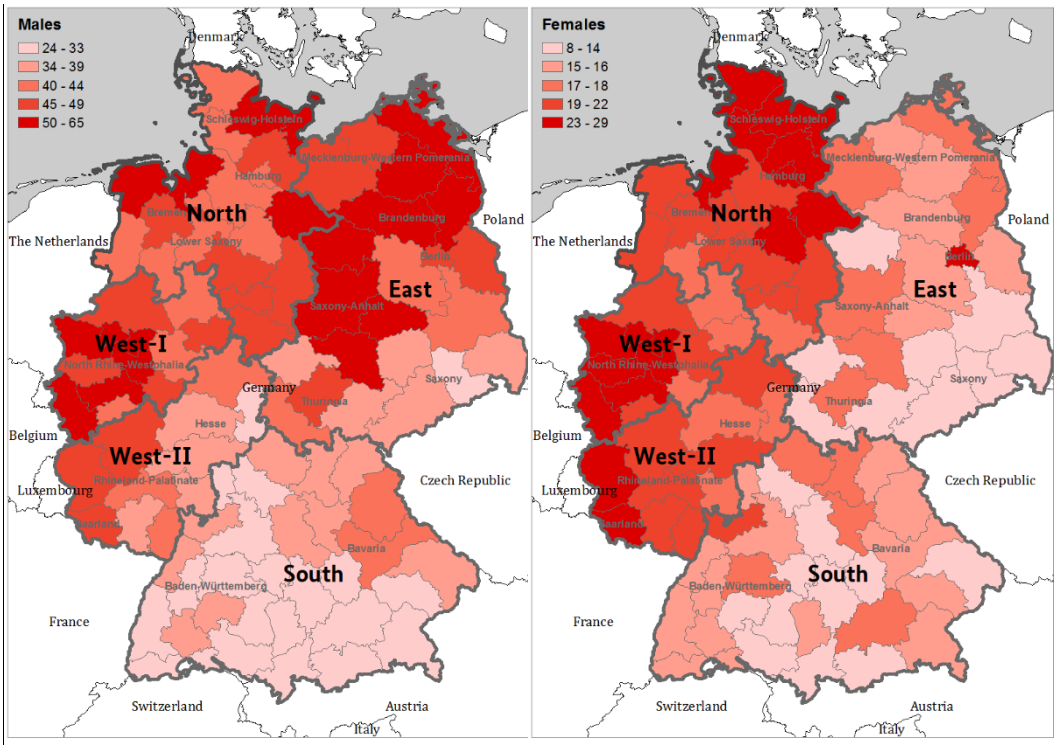

Figure 1. Our five German macro-regions and the spatial distribution of mortality from lung cancer in 2017
Note: Standardized death rates per 100 000 based on EPS-1976

For each macro-region we produce the complete set of HMD (Human Mortality Database) statistics according to the HMD Methods Protocol v5 (Wilmoth et al. 2007). These statistics include complete life tables and population exposures for ages up 110+. We estimate the smoothed rates of mortality improvements (ROMI), and visualize them using ROMI plots (Rau et al. 2018), with R-code modified from Acosta and van Raalte (2019). This allows us to identify i) cohorts exhibiting elevated mortality rates likely due to past smoking behavior and ii) major differences in the observed age-temporal patterns across our five regions.

We estimate smoking-attributable mortality using the PGW method (Preston, Glei, Wilmoth, 2010). Like another widely used method (Peto et al. 1992), the PGW method relies on mortality from lung cancer (items C32–C34 and 161–162 in the ICD–10 and the ICD–9, respectively) as the proxy of past smoking behavior. In order to quantify the effect of smoking on regional mortality differences we first removed the estimated age-specific smoking-attributable deaths from the respective number of deaths from all causes. Afterwards, we reproduce all life tables and compare the values of life expectancy at birth before and after the elimination of smoking-attributable deaths.

SELECTED PRELIMINARY RESULTS

We begin with an overview of mortality trends from lung cancer by sex for our five macro-regions (Figure 2). The burden of past smoking has been declining among males and growing among females. This reflects a typical pattern: males experienced the smoking-epidemic much earlier than females. It is interesting to note that regional differences among males do not follow an East-West but a North-South divide (see also Figure 1). Compared to the other four regions, *South* has considerably lower lung cancer mortality. Among women, the rising mortality from lung cancer has been accompanied by rapidly growing regional divergence with *West-I* exhibiting the highest and *East* the lowest lung cancer mortality. These trends are consistent with the Lexis maps of the rates of female mortality

improvements for all-cause mortality depicted in Figure 3. Slow rates of mortality improvements (turquoise color) and more recently mortality increases (colors from yellow to red) among 1940–1950 (West-I) and 1945–1955 (East) birth cohorts point to the possible impact of smoking in both the worst and the best-performing regions.

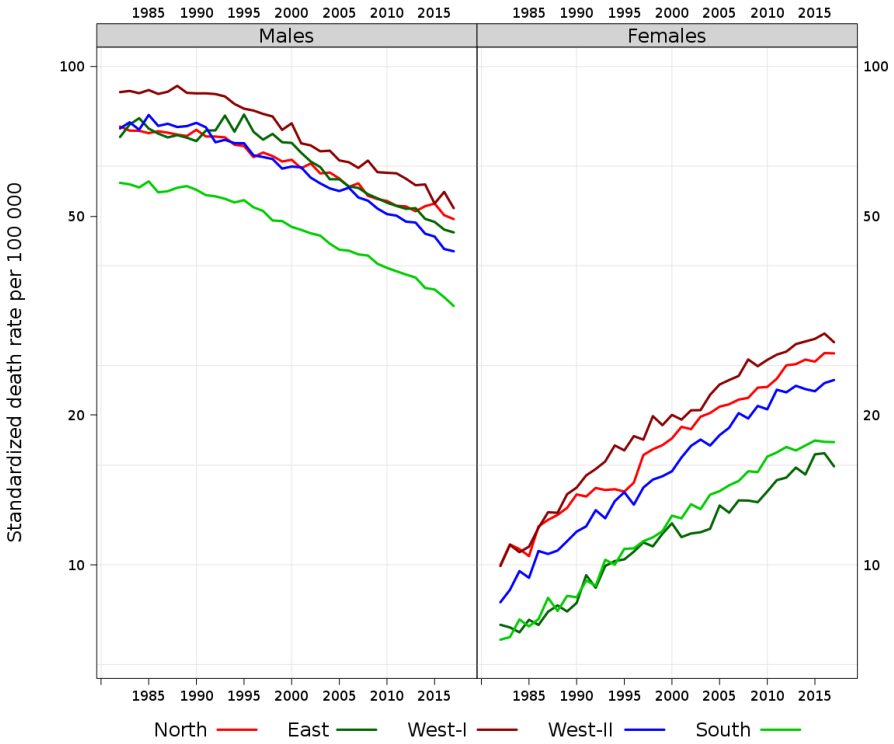

Figure 2. Mortality from lung cancer by our five macro-regions, 1982–2017
Note: As for Figure (1)

However, there are indeed notable differences between these regions. The observed patterns suggest that women of *West-I* were hit by the smoking epidemic the most. Compared to other regions women of *East* experienced the smoking epidemic with some time lag. This implies that in the near future the relative advantage of East German women should diminish. Not only the first post-war cohorts but also the 1980–1985 cohorts of "daughters" could contribute to this development. The strong period decline in lung cancer over the early 1990s in *East* is more likely related to the collapse of heavy industry and improved air quality, rather than smoking behavior.

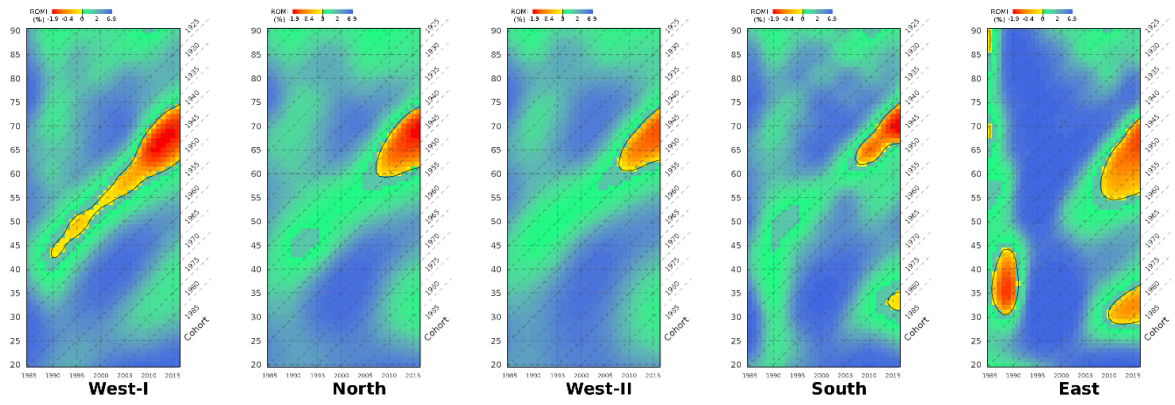

Figure 3. Rates of female all-cause mortality improvements by macro-regions of Germany, 1983–2017. Blue-green hues denote declining mortality from one year to the next, while orange-red hues denote mortality increase from one year to the next for the corresponding age on the y-axis

The trends presented in Figure 4 confirm that over the last four decades smoking was becoming an increasingly important factor for regional differences in female mortality. In 1982, the life expectancy gap with the best performing region (South) varied from 0.46 (North and West-II) to 2.41 (East) years. The hypothetical elimination of smoking-attributable deaths in all regions resulted only in incremental reductions of this gap.

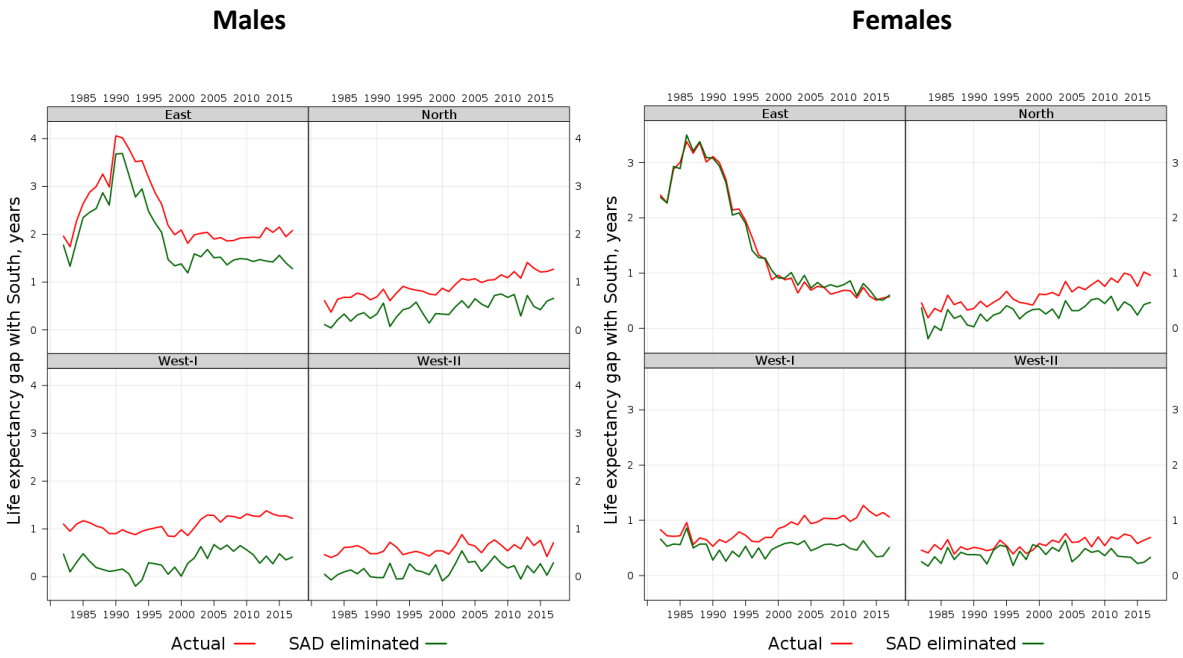

Figure 4. Mortality gap with the best performing region (South) before and after removal smoking-attributable deaths (SAD), 1982–2017

By contrast, in 2017, roughly a half of the regional gap was determined by smoking. This, however, does not concern *East* where the adjustment for smoking-attributable mortality did not have a notable impact on the difference with *South* throughout the whole observation period. Among males, smoking has remained a prominent determinant of regional mortality differentials throughout the analyzed period. Our results suggest that the second best-performing region (West-II) would have had mortality levels similar to the *South* in the 1980s-2000s, if differences in smoking-attributable deaths would have not existed. Despite rapidly declining smoking-attributable mortality, past smoking still explains a large proportion of the regional gap in male mortality. For example, in 2017, the gap in life expectancy between *North* and *South* would have reduced from 1.27 to 0.66 years in the absence of smoking.

OUTLOOK

Our preliminary results support the argument that past regional differences in smoking behavior are the single-most important determinant of contemporary regional mortality inequalities in Germany. The dominance of smoking is perhaps surprising given that German regions differ considerably on a host of other indicators such as socioeconomic conditions, family-formation patterns, health behavior, and religious observance. Between now and the EPC conference we intend to validate these results by incorporating in the analysis survey data on smoking prevalence. Another important item is our future research agenda is testing the sensitivity of our method to alternative model specifications, for instance, using the Vogt et al. 2017 regression coefficients.

REFERENCES

Acosta E, van Raalte (2019). APC curvature plots: Displaying nonlinear age-period-cohort patterns on Lexis plots. *Demographic Research* 41 (42), 1205–1234.

Curtis S, Jones IR (1998). Is there a place for geography in the analysis of health inequality? *Sociology of Health and Illness* (20), 645-672.

Ezzati M, Lopez AD. (2003). Estimates of global mortality attributable to smoking in 2000. *Lancet 362,* 847–852.

Fenelon A, Preston SH. (2012). Estimating Smoking-Attributable Mortality in the United States. *Demography* (49**),** 797–818

Gregoraci G, van Lenthe FJ, Artnik B for the DEMETRIQ consortium, et al. (2017). Contribution of smoking to socioeconomic inequalities in mortality: a study of 14 European countries, 1990–2004. *Tobacco Control* (26), 260–268.

Janssen F, Spriensma AS (2012). The contribution of smoking to regional mortality differences in the Netherlands. *Demographic Research* 27 (9), 233–260.

Kibele EU, Klüsener S, Scholz RD. (2015). Regional Mortality Disparities in Germany. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, *67*(1), 241-270.

Klüsener S, Zagheni E. (2014). The East-West gradient in spatial population development within Germany. Temporary GDR legacy versus longstanding spatial disparities. Historical Methods 47 (4), 167–169.

Klüsener S, Grigoriev P, Scholz RD, Jdanov DA (2018). Adjusting inter-censal population estimates for Germany 1987-2011. Approaches and impact on demographic indicators. *Comparative Population Studies* (43), 31–64.

Long D, Mackenbach J, Martikainen P. *et al.* (2021). Smoking and inequalities in mortality in 11 European countries: a birth cohort analysis. *Popul Health Metrics* (19) 3

Macintyre S, Maciver S, Sooman A. (1993). Area, class, and health: should we be focusing on places or people? *Journal of Social Policy* (22), 213–234.

Muszyńska MM, Fihel A, Janssen F. (2014). Role of smoking in regional variation in mortality in Poland. *Addiction* 109(11),1931-1941.

Peto R, Boreham J, Lopez AD, Thun MJ, and Heath C. (1992). Mortality from tobacco in developed countries: Indirect estimation from national vital statistics. *The Lancet* 339(8804), 268-278.

Preston S, Wang H. (2005). Sex Mortality Differentials in the United States: The Role of Cohort Smoking Patterns. PARC Working Paper Series 2-1-2005.

Preston SH, Glei DA, Wilmoth JR (2010). A new method for estimating smoking-attributable mortality in high-income countries. *International Journal of Epidemiology* 39(2), 430-438.

Rau R, Bohk-Ewald C, Muszyńska MM, Vaupel JW (2018). *Surface Plots of Rates of Mortality Improvement, in Visualizing Mortality Dynamics in the Lexis Diagram.* Springer.

Vogt T, van Raalte A, Grigoriev P, Myrskylä M (2017). The German East-West mortality difference: two crossovers driven by smoking. *Demography* 54(3), 1051–1071.

Wilmoth JR, Andreev K, Jdanov D, et al. (2007). Methods Protocol for the Human Mortality Database. University of California, Berkeley, and Max Planck Institute for Demographic Research, Rostock.