<u>The end of the regional convergence in mortality in the European Union? Evidence from France and Germany</u>

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In this paper, we study the evolution of spatial inequalities in mortality in France and Germany over the last three decades. For this we calculate mortality rates in French departments (95 geographical units) and German RORs (96 units). This new dataset on regional mortality enables us: to rethink the study of the trend of spatial inequalities in mortality insofar as these tend to decrease when mortality at the national level decreases. In this context, the stagnation of inequalities observed in recent years should be all the more alarming since mortality continues to decline at the national level in France and Germany.

Introduction

Improving population health and reducing health disparities across population sub-groups are the main objectives of public health policy. Respectively, two different groups of indicators are used to monitor the achievement of these goals. The first group of indicators are indicators that reflect the mean, median or mode (called later “indicator of the mean”). The second group contains indicators of dispersion (called later “indicator of dispersion”). The question is whether the increase in life expectancy benefits everyone equitably. Two different fields of research have emerged to study this objective.

In the first field of research, studies focus on the analysis of mortality tables in the general population (univariate approach). For a long time, these studies have focused on the evolution of the average life span through indicators such as life expectancy or the standardized death rate (Oeppen and Vaupel, 2002; Vallin and Meslé, 2009).

More recently, researchers have been interested in the evolution of life span disparities within the population. Research was first conducted in the context of the debate concerning the compression of mortality at the extreme ages. Fries (1983) envisaged a world in which mortality at young ages would have disappeared and mortality at older ages would be centred around 85 years, the limit of human longevity. This hypothesis has since been surpassed, as mortality gains at older ages did not stop at 85 years (Rau et al. 2008).

Subsequently, this research focused on life span disparity, considering that it could provide additional information to that of average life span. Indeed, a priori, the indicator of the mean and the indicator of dispersion are very strongly correlated in the long run (Vaupel et al., 2011; Colchero et al., 2016). Thus, studying only one of the two types of indicators provides an account of the overall situation without much loss of information: an improvement in the indicator of the mean inevitably led to an improvement in the indicator of dispersion. Nevertheless, some studies have demonstrated the value of studying these two types of indicators in parallel and not separately for two main reasons.

First, Shkolnikov et al (2003), Smits and Monden (2009), Edwards (2011) or Timonin et al. (2016) have used this approach in an international comparison perspective. They highlight countries for which inequality in life expectancy for a given national life expectancy was higher. Thus, in the mid-2000s, the United States and France had a high inequality of female life expectancy over 15 years, while Sweden and England-Wales did not. Smits and Monden (2009) also showed that the first countries to reach a specific life expectancy did so with a higher level of inequality than those that reached this life expectancy later.

Second, other studies have shown the increasing importance of analyzing the two indicators jointly, as the strength of the correlation appears to be waning over time. Historically, the joint improvement in the two indicators was primarily explained by the concentration of mortality decline at young ages (Vaupel et al. 2011), due in part to declines in infectious disease deaths and women in childbirth (Seligman et al. 2016). Nonetheless, with near-zero infant mortality and the recent concentration of mortality decline at older ages, the decline in inter-individual inequality is no longer obvious. (Wilmoth and Horiuchi 1999). This is especially the case as increases in mortality among adults in midlife have been observed recently: during the AIDS epidemic of the 1990s, during the recent increase in mortality from suicide and poisoning in the USA (Case and Deaton, 2015), or in Eastern Europe in the 1990s. Thus, in some developed countries, there is a trend of improving average life span concomitant with stagnation or even increasing disparities in the general population (van Raalte et al., 2018).

In the second field of research, studies stratify the population by different dimensions of the socioeconomic status (SES) such as education level (Sasson, 2016), socio-professional category (van Raalte, 2014), or income (Chetty et al., 2016) ... etc. These studies shed light on the social mechanisms explaining differences in the general population. In other cases, the stratification can be done according to a geographical criterion. The subgroups are then made up of populations living in different regions of the same country (Gachter and Theurl, 2011; Janssen et al., 2016; van Raalte et al., 2020; Bonnet and d'Albis, 2020).

These studies generally emphasize the evolution of the indicator of dispersion: over the recent period, the continuous improvement of the indicator of the mean seems self-evident. However, interpreting the dynamics of inequality through the indicator of dispersion alone requires some caution for two reasons.

First, there seems to be a mathematical relationship between the indicator of dispersion expressed in relative terms and the indicator of the mean (Scanlan, 2006; Eikemo et al., 2009): in the long run, a low overall mortality rate would induce high relative inequality and vice versa. This theory has been put forward as an explanation for why inequality is higher in Nordic countries than elsewhere, despite their lower national mortality rates (Huijts & Eikemo, 2009; Mackenbach, 2012). Thus, an increase in inequality should not necessarily be interpreted as a negative outcome for society, but would be the mechanical result of a lower national mortality rate.

Second, the historical perspective reminds us that there have been periods of downward convergence that have combined an improvement in the indicator of dispersion with a deterioration in the indicator of the mean. In their study of the populations of the French *départements* since the beginning of the 19th century, Bonnet and d'Albis (2020) highlight a century of virtuous convergence (1880-1980) in which national life expectancy rose continuously and disparities between territories fell continuously. This virtuous convergence differs from the periods of downward convergence observed a few times between 1800 and 1880: epidemics led to a decrease in territorial disparities when they affected the most advanced territories. In the context of a pandemic as we know it today, this reminder has a particular resonance.

Thus, in this study, we follow the methods of analysis carried in the univariate approach by Shkolnikov et al. (2003), Smits and Monden (2009), or van Raalte et al. (2018) and show that the simultaneous analysis of a national indicator and a spatial indicator of dispersion is necessary to report in a more informative manner the objective of improving survival conditions. To illustrate this point, we rely on local mortality data by age and sex in France and Germany.

First, this approach allows us to make better international comparisons. Indeed, the greater or lesser spatial inequality observed between two countries is partly explained by their difference in national mortality. Thus, in the 1990s, the higher spatial inequality in Germany than in France was largely explained by a higher overall mortality rate. For a similar overall mortality rate, inequality was significantly lower in Germany. Similarly, this approach allows us to make better comparisons between age groups or between men and women. For example, in France, mortality at age 0 is similar to mortality among 45-54 year olds, but inequality for this age group is higher.

Second, this approach allows us to recall the strong correlation that exists between the national indicator and the spatial inequality indicator: over the long run, spatial inequality expressed in absolute value decreases when the national mortality rate decreases. Nevertheless, we go further by showing that the strength of this relationship varies according to age: for example, the decline in infant mortality since the 1980s in France has been accompanied by a small decline in spatial inequality, whereas the decline in mortality among 45-54 year-olds has been accompanied by a much larger decline in spatial inequality. Moreover, we show that the strength of this relationship also varies by time, in line with van Raalte et al. (2018): the slowdown in the rate of regional convergence observed recently for some age groups constitutes a huge historical break insofar as mortality at the national level has continued to decline at the same rate.

Third, this approach allows us to better understand specific increases in spatial inequalities. For example, in France in 2020, we show that the increase in spatial inequalities is partly explained by the increase in national mortality caused by the Covid-19 pandemic. Nevertheless, the greater increase in inequalities among women than among men, even though the increase in mortality was lower for women, raises questions about the difference in regional impact of the pandemic by gender.

Data and Methods

In this study, we use age- and sex-specific population and mortality data for German and French regions.

German data are available for 96 geographic units from 1992 to 2018.

French data are available for 95 departments in metropolitan France from 1968 to 2020 from the French Human Mortality Database (Bonnet, 2020). In this database, populations by sex and single age for the years 1968, 1975, 1982, 1990, 1999, 2008, 2013, 2014, and 2015 were collected from the censuses conducted by the *Institut National de la Statistique et des Etudes Economiques (INSEE)*; estimated populations by sex and five-year age groups are also made available by INSEE for the years 2016 to 2020. In addition, we use deaths by sex and single age published by INSEE from 1968 to 2020. Mortality rates are estimated according to a methodological protocol close to that of the Human Mortality Database (Wilmoth et al., 2020) and explained in a methodological document available on the dedicated website of the French Human Mortality Database.

For this study, we study two types of indicators. The first is an indicator of the mean, which describes the evolution of mortality for the whole population of the country: we use the mortality rate calculated at the national level. The second is an indicator of dispersion, which captures the evolution of inequalities between the populations living in each territory: we use the standard deviation (SD) of regional mortality rates. To calculate this standard deviation, we weight the regional mortality rates by the population of these regions so as not to give too much importance to regions with very low populations, in line with Timonin et al. (2016).

We study the evolution of overall mortality through standardized death rates, calculated using the 2013 European Standard Population. In addition, we use two different typologies to study age-specific mortality. The first is an aggregate classification with 5 age groups (0-14 years, 15-34 years, 35-64 years, 65-84 years, 85 years and over) that we apply to French and German regional data since 1992;

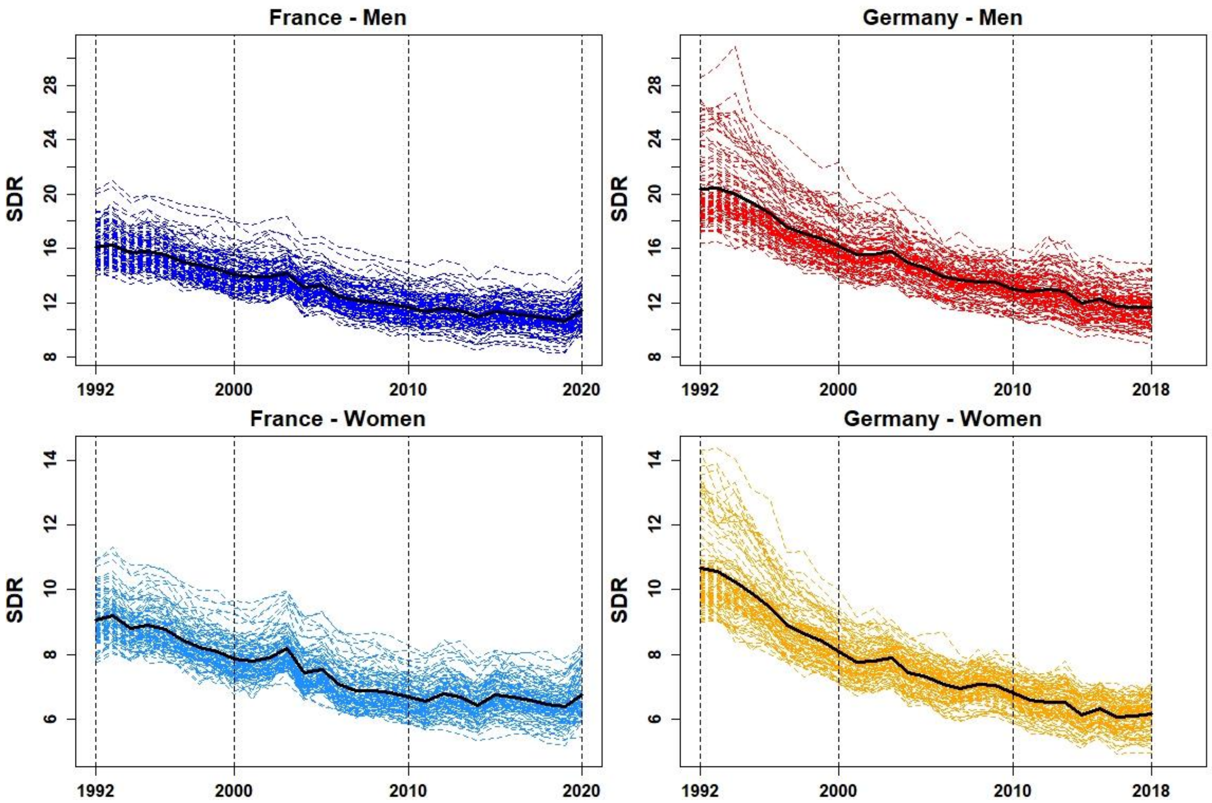
the second is an extended classification with 12 age groups (less than 1 year, 1-4 years, then decennial age groups up to 95 years and 95 years and over) that we apply to French regional data since 1968.

The parallel study these two indicators leads to the use of a concept called “elasticity”, largely used in the field of economics. We adapt this concept to our study of regional inequality. The elasticity is the variation of the standard deviation when the national death rate varies by 1%.

Results

Figure 1 shows the evolution of standardized death rates (SDRs) in France and Germany since 1992, by sex. The SDR for each geographical unit is represented by a dotted line, whereas the national SDR is represented by a black dotted line.

Figure 1: Trends in regional and national SDRs in France and Germany, 1992-2020



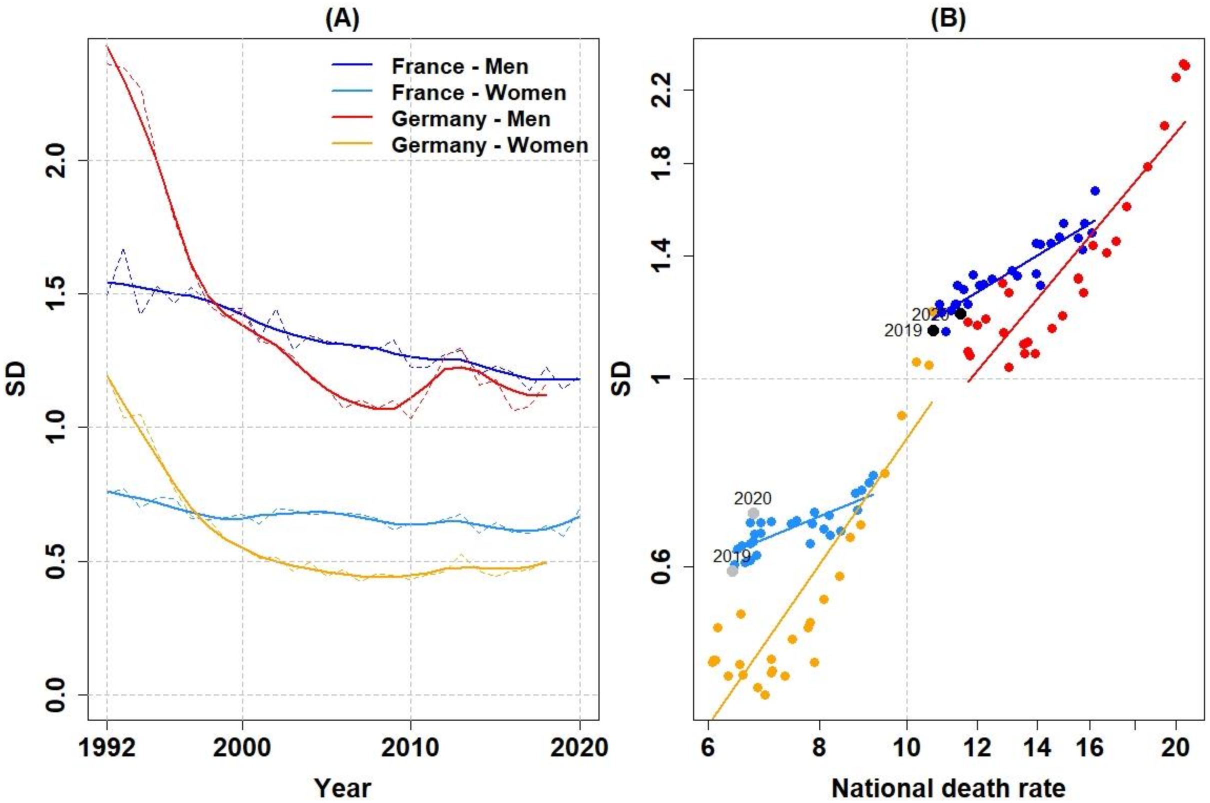
Notes: Regional SDRs represented by dotted lines. National SDR represented by a black line. Panel of 95 regions in France, 96 regions in Germany. Data from 1992 to 2020 for France, and from 1992 to 2018 for Germany.

The figure shows that the national SDR has improved over the entire period in all four groups. For men, it decreased from 16.1 per 1000 in 1992 to 11.5 per 1000 in 2020 in France, and from 20.3 per 1000 in 1992 to 11.7 per 1000 in 2018 in Germany. The trend is the same for women, with lower mortality rates. The figure reveals the years when mortality increased at the national level. This was the case in France and Germany in 2003 due to a severe heat wave (Robine et al. 2008). This was also the case in 2020 in France due to the COVID-19 pandemic (Pison and Meslé, 2021). The absence of data after 2018 for Germany does not yet allow to discuss the effect of COVID-19 for Germany.

Nevertheless, Figure 1 provides only insights on the evolution of territorial disparities in the two countries. This is particularly true in France, where the graph does not reveal a strong decrease in the disparity of regional situations. Conversely, in Germany there is a sharp decline in inequality up to the mid-2000s, due to the convergence of East German regions. The use of an inequality indicator is therefore necessary to assess quantitatively the evolution of territorial disparities.

To better understand the evolution of spatial inequalities in France and Germany, we have plotted in Figure 2 (A) the evolution of the SD of regional SDRs in France and Germany since 1992. The raw values of the SD are shown as dotted lines, whereas the values smoothed by local regression are shown as solid lines. Figure A2 (A) in appendix replicates this figure by depicting the developments for the West German and East German regions separately.

Figure 2: Trends of spatial inequality indicators in France and Germany (A); Spatial inequality indicators and national mortality rates in France and Germany (B).



Notes: "SD" means standard deviation of regional mortality rates. The values of the regional death rates are weighted by the regional population for the calculation of standard deviations. The national death rate is the death rate for all regions in each country. Panel of 95 regions in France, 96 regions in Germany. Data from 1992 to 2020 for France, and from 1992 to 2018 for Germany.

Spatial inequality in mortality has decreased significantly in Germany over the period. For men (red curve), the indicator fell from 2.36 in 1992 to 1.23 in 2018, a decrease of 48%. All this decline occurred between 1992 and the mid-2000s, before inequality stagnated. Spatial inequality in mortality has also declined in France, but at a much slower rate. For women (light blue curve), this decline is particularly small, since the standard deviation varies from 0.75 to 0.69, i.e., a decline of 8%. The year 2020 is marked by an increase in spatial inequalities in mortality among women in France: the indicator increases by 17% between 2019 and 2020 and returns to the values reached during the mid-2000s. It is interesting to note that this increase is less pronounced for men.

The figure also shows that the spatial inequality in mortality is greater for men than for women, regardless of the country and the period. Thus, in 1992, the male standard deviation in France was twice as high as the female standard deviation, a finding that is also valid in 2020.

Moreover, spatial inequality was greater in Germany than in France until the end of the 1990s. The gap was considerable in 1992 for both men and women: for example, the male standard deviation was 0.86 points higher in Germany than in France. Since the end of the 1990s, spatial inequality has been lower in Germany than in France: the gap has been stable since the mid-2000s, at about 0.15 points for women. For men, the gap has been close to zero since the mid-2010s. It is interesting to notice that if we consider West Germany and East Germany separately, spatial inequality has been lower in West Germany than in France since the beginning of the period.

Figure 2 (Panel B) shows, for each year represented by a point, the value of the spatial inequality indicator (standard deviation of regional SDRs) and the value of the synthetic mortality indicator (national SDR). Male and female values are shown in dark and light blue for France, and in red and orange for Germany. Values for 2019 and 2020 in France are represented by black dots for men and by grey dots for women. The lines represent the relationship between the two indicators, calculated by gender and age. The slope of this line gives us the calculated value of the elasticity. Figure A2 (B) in appendix replicates this figure by depicting the developments for the West German and East German regions separately

First, we notice the strong correlation that exists in our data between the synthetic mortality indicator and the spatial inequality indicator: a high national mortality rate is associated with a high value of the regional standard deviation. When we use all points, the elasticity is equal to 1.21. In other words, when mortality decreases by 1% at the national level, regional disparities decrease by 1.21%.

Second, the correlation between these two indicators is not the same for the two countries: in France, the decrease in mortality at the national level leads to a much smaller decrease in inequality than in Germany. For men, for example, over the entire period, the elasticity is 0.64, compared with 1.27 in Germany. The difference is even greater for women, with values of 0.43 and 1.53 respectively. Nevertheless, if we consider West Germany and East Germany separately, we can see that the elasticity is the same in France and West Germany but is much higher in East Germany.

Third, the decrease in the rate of spatial convergence observed in Germany from the 2000s onward in Figure 2 (Panel A) is not due to a smaller decline in mortality at the national level. The trend break is particularly clear: between 1992 and 2005, the elasticity for men was 2.12, compared with -0.15 between 2005 and 2018. In other words, between 2005 and 2018 in Germany, when male mortality decreased by 1%, regional disparities increased by 0.15%. This is also true if one considers East and West Germany separately, although the break is later for the East (late 2000s) than for the West (early 2000s).

Fourth, differences in the level of spatial inequality between France and Germany in the early 1990s were partly explained by differences in national mortality rates. Because of the very strong correlation observed between the spatial inequality indicator and the synthetic mortality indicator, German inequalities were higher than French inequalities because the mortality was also higher. This holds for sex differences too: male inequalities are higher than female inequalities because their mortality is also higher. Nevertheless, it is interesting to note that the extension of lines trends in France suggests that male inequality will probably be higher than female inequality at similar mortality rates.

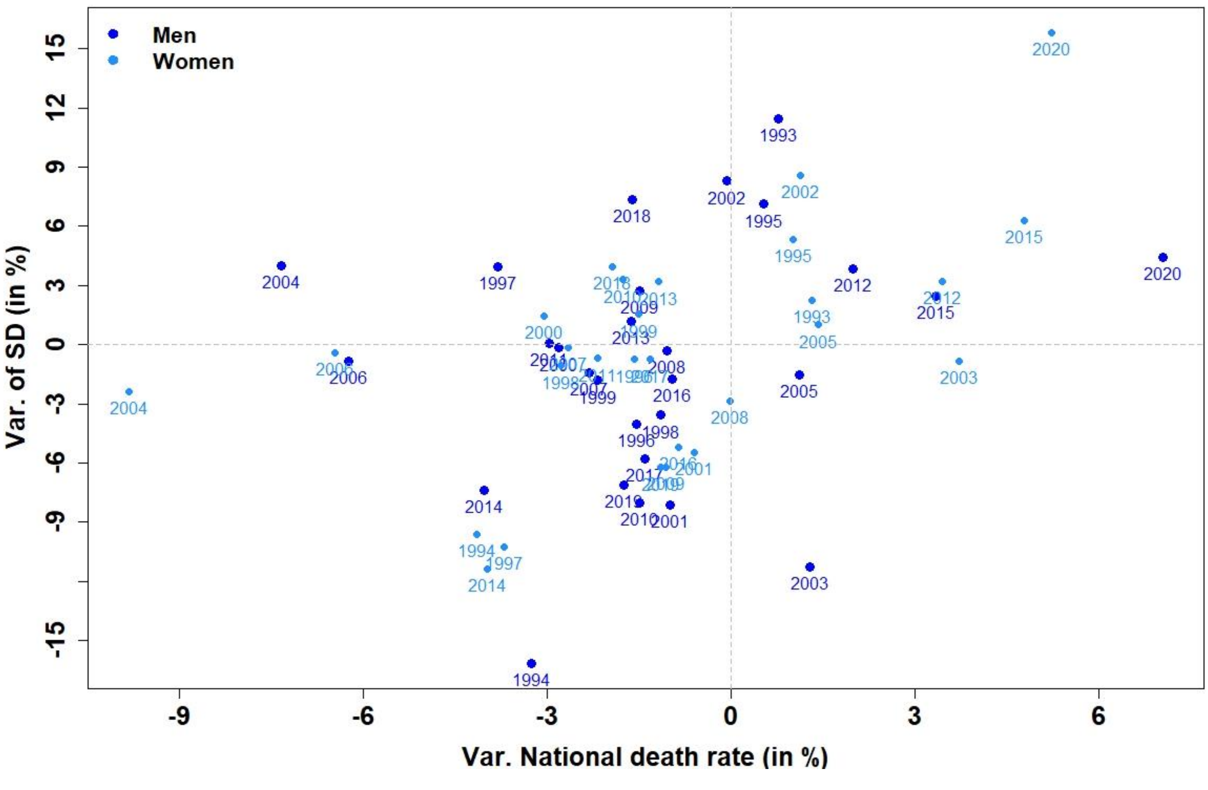
Finally, the increase in spatial inequality observed in France with the Covid-19 pandemic must be analysed with caution and differentiated by gender. For women, the increase in inequalities is much greater than would have been expected based on past trends: whereas inequalities in 2019 were the lowest of the analysis period, inequalities in 2020 are particularly high in relation to the national mortality rate. For men, the larger increase in national mortality led to a much smaller increase in spatial inequality.

Thus, our approach makes it possible to better analyse very short-term developments. Figure 3 repeats this analysis for each year in the case of France. It represents, for each year and each sex, the variation in the national SDR (in %) and the variation in the standard deviation or regional SDRs (in %). Men are represented by dark blue dots, and women by light blue dots.

Figure 3 shows the strong positive relation between the variation of the standard deviation and the variation of the national SDR. Beyond this reminder, we can analyse the annual changes and identify specific episodes. For example, the increase in national mortality observed in 1993, 1995, 2012, 2015, and 2020 led to an increase in spatial inequality (northeast quadrant), whereas the increase in mortality observed in 2003 led to a decrease in spatial inequality (southeast quadrant). This heat wave, which affected regions with lower mortality (notably Ile-de-France and Centre, see Robine et al., 2008), is in this sense exceptional. For 2020, the increase in male mortality is the highest of the period, but it does not coincide with the highest increase in spatial inequalities, observed in 1993. Conversely, the increase in female mortality was as large as the increase in 2015, but the increase in inequality was much higher.

On the other side, the years 2013 and 2018 are notable since they present a decline in mortality and an increase in spatial inequality (northwest quadrant). Thus, the decline in mortality in the most advanced regions was such that inequality increased. This is what Bonnet and d'Albis (2020) called the "Matthew effect" divergence: "To him who has will more be given" (Merton 1968)."

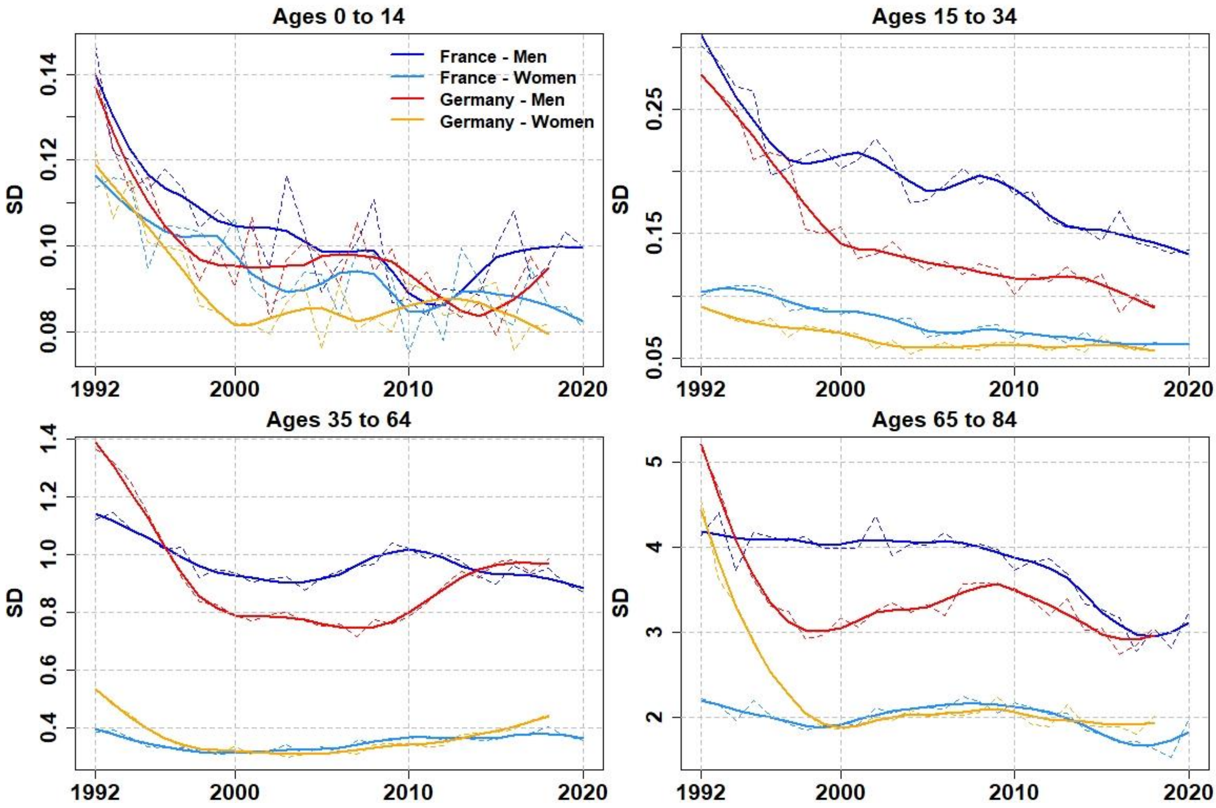
Figure 3 : Annual variations of the spatial inequality indicator and the national SDR by sex in France.



Notes: "SD" means standard deviation of regional mortality rates. The values of the regional mortality rates are weighted by the regional population for the calculation of standard deviations. The national mortality rate is the mortality rate for all regions in France. Panel of 95 regions. Data from 1992 to 2020.

We continue our analysis by presenting our results by age groups. Figure 4 replicates Figure 2 (Panel A) and presents the evolution of spatial mortality inequality in France and Germany since 1992, by four large age groups: 0-14 years, 15-34 years, 35-64 years, and 65-84 years. The raw values of the SD of the regional SDRs are shown as dotted lines, whereas the values smoothed by local regression are shown as solid lines.

Figure 4: Trends of spatial inequality indicators in France and Germany by age group, 1992-2020



Notes: "SD" means standard deviation of regional mortality rates. The values of the regional mortality rates are weighted by the regional population for the calculation of standard deviations. Panel of 95 regions in France, 96 regions in Germany. Data from 1992 to 2020 for France, and from 1992 to 2018 for Germany.

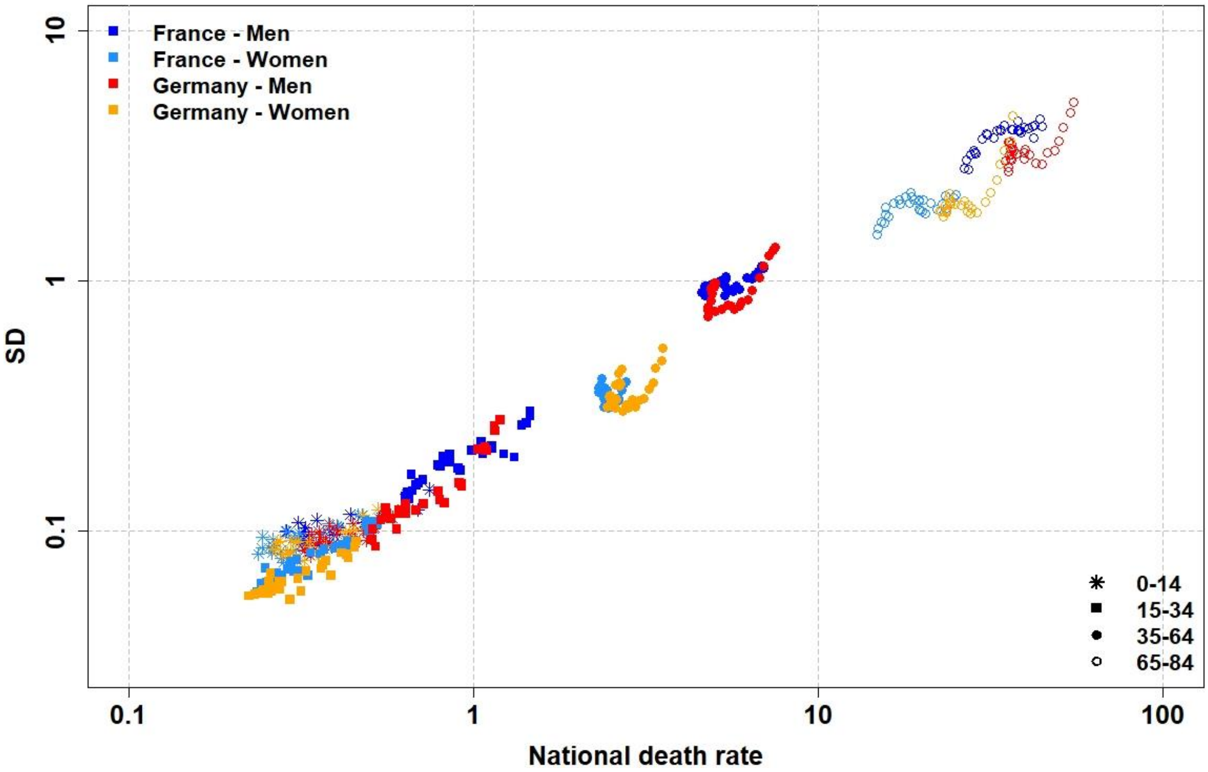
Spatial inequality in mortality has decreased overall over the entire period for each country, sex, and age group. The decrease was particularly strong among 15-34 year-olds, where it reached 55% for men in France and 68% in Germany. Nevertheless, this decrease in spatial inequality is not observed for all periods. For example, it has increased by nearly 25% for individuals aged 35-64 in Germany since 2000. It has also increased for individuals aged 65 to 84 from 1998 to 2008, except for French men. In the short term, we can also note the strong increase in spatial inequality in France for individuals aged 65 to 84 between 2019 and 2020: it reaches 15% for men and 30% for women.

This figure also compares the levels of inequality between men and women. Once again, we see that spatial inequality is much higher for men than for women for all age groups and all time periods. The only exception is for those under age 15 in Germany from 2012 to 2015.

Finally, Figure 4 compares the levels of inequality between France and Germany. Spatial inequality was much higher in Germany than in France at the beginning of the period for those over 35, while it was lower in Germany than in France for individuals under age 35. From the mid-1990s until the mid-2010s, inequality levels were lower in Germany than in France for all age groups. This situation was reversed again in the mid-2010s for those over age 35.

Figure 5 replicates Figure 2 (Panel B) for the same age groups as in Figure 4. It shows, for each year-age group pair represented by a point, the value of the spatial inequality indicator (standard deviation of regional SDRs) and the value of the synthetic mortality indicator (national SDR). Male and female values are shown in dark and light blue for France, and in red and orange for Germany.

Figure 5: Spatial inequality indicators and national SDR in France and Germany, by age group.



Notes: "SD" means standard deviation of regional mortality rates. The values of the regional mortality rates are weighted by the regional population for the calculation of standard deviations. The national mortality rate is the mortality rate for all regions in each country. Panel of 95 regions in France, 96 regions in Germany. Data from 1992 to 2020 for France, and from 1992 to 2018 for Germany.

Figure 5 reveals that the trends are perfectly reversed between France and Germany for individuals aged 65 to 84 years. In France, the decline in mortality at the national level was achieved with an unchanged level of inequality between 1992 and 2012, and then it was associated with a sharp decline in spatial inequality. Conversely, in Germany, the fall in mortality at the national level was first accompanied by a sharp decline in spatial inequalities between 1992 and 1998, and then it was associated with an unchanged level of spatial inequalities. The elasticity computed for France suggests that, for a given national mortality rate, spatial inequalities are greater for men than for women. This assertion does not hold in Germany.

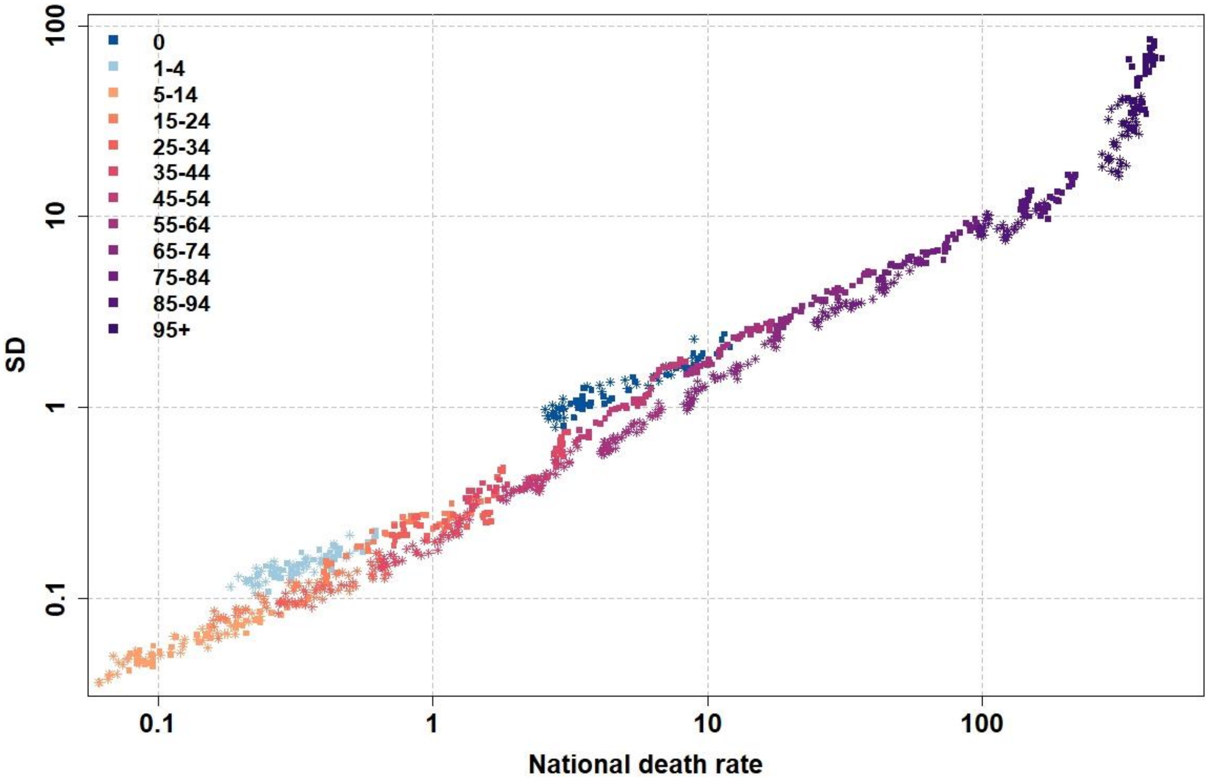
One can also see in Figure 5 a very specific evolution for individuals aged 35 to 64 in Germany. The decrease in mortality at the national level was accompanied by a strong decrease in spatial inequality between 1992 and 2008. Thereafter, the slight increase in mortality at the national level was accompanied by a very sharp increase in regional inequality, which put the country on a different path than previously observed: the national mortality rate observed in 2018 for women is similar to that observed in 2004, but the value of the standard deviation is 0.44 versus 0.30, a difference of 50%.

Finally, the profile observed for 0-14 year olds and 15-34 year olds does not show differences by sex and country. Nevertheless, we note that for a given mortality rate, spatial inequalities appear to be greater for the 15-34s (marked by stars) than for the under-15s (marked by squares). Moreover, the elasticity estimated from the data for both sexes and both countries is twice as large for individuals aged 15-34 (0.88) as for those under age 15 (0.4).

Finally, we finish our analysis by presenting our results by small age groups and for more than 50 years. Figure 6 uses local mortality data for France from 1968 to 2020. It replicates Figure 4 for decennial age groups, except for the youngest age groups (mortality under age 1 and for ages 1 to 4). Data for females are represented by a star, and data for males by a square.

Figure 6 reveals once again the strength of the correlation between the national mortality rate and regional inequality in the long term: the lower the national mortality rate, the lower the inequality indicator. This correlation appears clearly when data are available over a long period, as it is the case for France. Thus, when we use all these data by age groups, we see that the elasticity is 0.77. Interestingly, the strength of this correlation also increases with the mortality rate for those over age 5: for women, the elasticity is 0.53 for ages 5 to 14, 0.81 for ages 35 to 44 and 0.96 for ages 65 to 74.

Figure 6: Spatial inequality indicators and national SDR in France, by decennial age groups.



Notes: "SD" means standard deviation of regional mortality rates. Regional mortality rates are weighted by regional population for the calculation of standard deviations. The national mortality rate is the mortality rate for all regions in France. Panel of 95 regions. Data from 1979 to 2020.

Figure 6 also reveals a specificity for deaths of children under age 5. For children aged 1 to 4 years, national mortality over the period is as high as mortality for ages 15 to 24. However, regional inequality for these ages follows a higher path. Similarly, for children under age 1, mortality at the national level over the period is as high as mortality for women aged 55 to 64. Yet regional inequality follows a much higher path. Thus, mortality of children under age 5 is more unequal between French regions than mortality at other ages.

Finally, Figure 6 shows a different pathway by sex for individuals aged 45 to 74. For these specific age groups, Figure 6 is replicated in Appendix (Figure A1). At similar mortality rates, spatial inequality is greater for men than for women starting at age 45. The paths converge again from age 75 onwards.

Discussion and conclusion

The almost continuous decrease of mortality observed since the beginning of the 20th century in France as well as in Germany hides disparities within the population. To account for this, we have seen in this article that it was relevant to adopt an approach based on the parallel analysis of a indicator of the mean calculated at the national level and an indicator of dispersion.

Since 1992, the analysis of spatial inequalities shows that disparities between territories have decreased in France and Germany. This very optimistic observation must be qualified with regard to the correlation between the spatial inequalities indicator and the national indicator: when national mortality decreases, territorial disparities computed in an absolute manner also decrease. Thanks to the data collected, we have seen that territorial disparities decreased on average by 1.21% when national mortality decreased by 1%. The breaks in the trend must therefore be analysed in relation to this average correlation. For example, this elasticity collapsed in Germany, from 2.12 between 1992 and 2005 to -0.15 between 2005 and 2018 for men. The country has thus undergone a major regime change. This article provides a way to assess quantitatively the convergence and divergence phases as theorized by Vallin and Meslé (2004). An analysis of the spatial inequality indicator alone in Germany does not suggest that we have entered a new phase of spatial divergence, since it is stagnating. However, our approach, which uses the difference between the value of the long-period elasticity and the value of the short-period elasticity as an indicator to describe the succession of these phases, shows that this is indeed the case.

This approach also makes it possible to better analyse very short-term developments. For example, we have seen that the increase in spatial inequalities in France between 2019 and 2020 was partly explained by the increase in national mortality due to the Covid-19 pandemic. As such, the differences between men and women were interesting to study: the increase in mortality was much larger for men than for women, but the increase in spatial inequalities was much more contained for men. This result calls for further research on this issue. The very high mortality observed in nursing homes (Hardy et al., 2021), which have a predominantly female population, could be a possible explanation if they are highly concentrated spatially.

This approach also allows isolating certain specific age groups for which the evolution of spatial disparities would merit a more in-depth study. In this respect, spatial inequalities among children are greater than spatial inequalities among older age groups, even though their mortality levels are comparable. This suggests that mortality at these ages is much more strongly concentrated in specific territories, even though it is a strong issue for national cohesion. The lower elasticity calculated for children aged 1 to 5 years also suggests that mortality gains are less well distributed over the national territory than mortality gains among adults.

Similarly, this approach isolated a different pathway between men and women aged 45-74: for a given mortality rate, spatial inequality is greater for men than for women. One possible explanation lies in differences in epidemiological profile: it is likely that men causes of death are more unevenly distributed over the national territory than women causes of death at these ages. An analysis of local mortality by cause of death may help to explain this difference in pathways.

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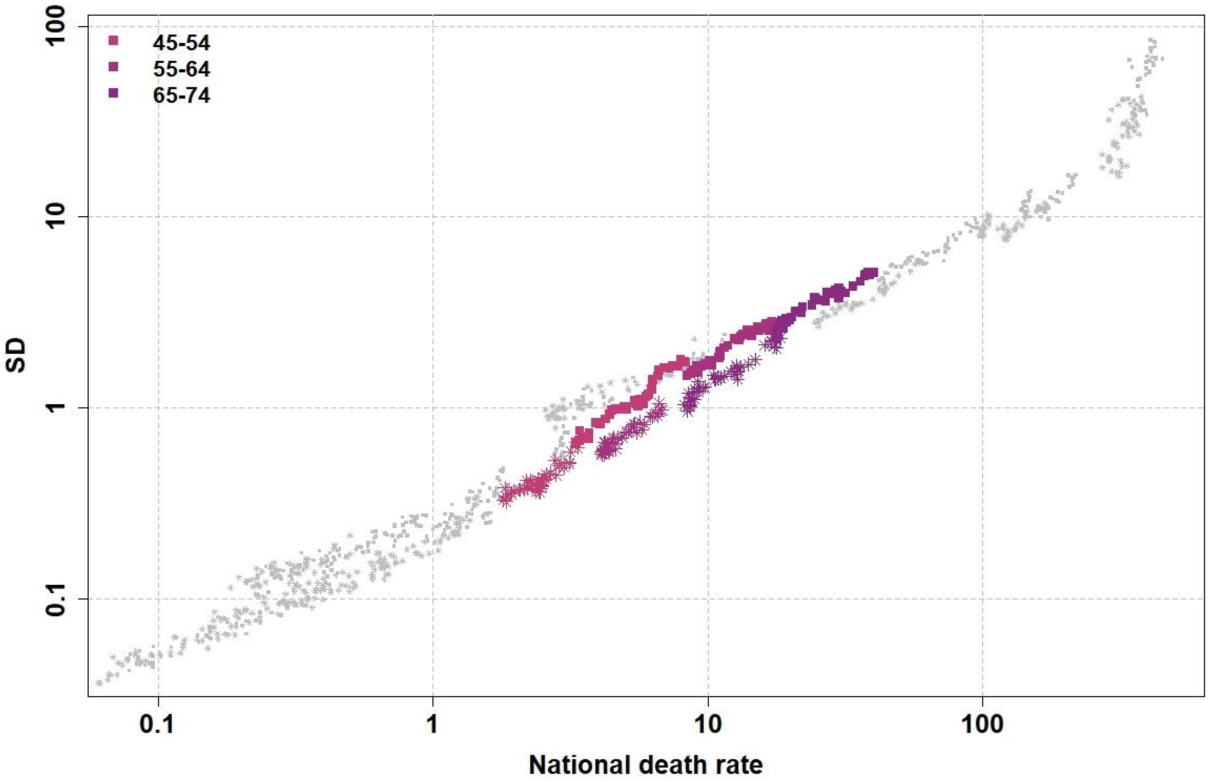
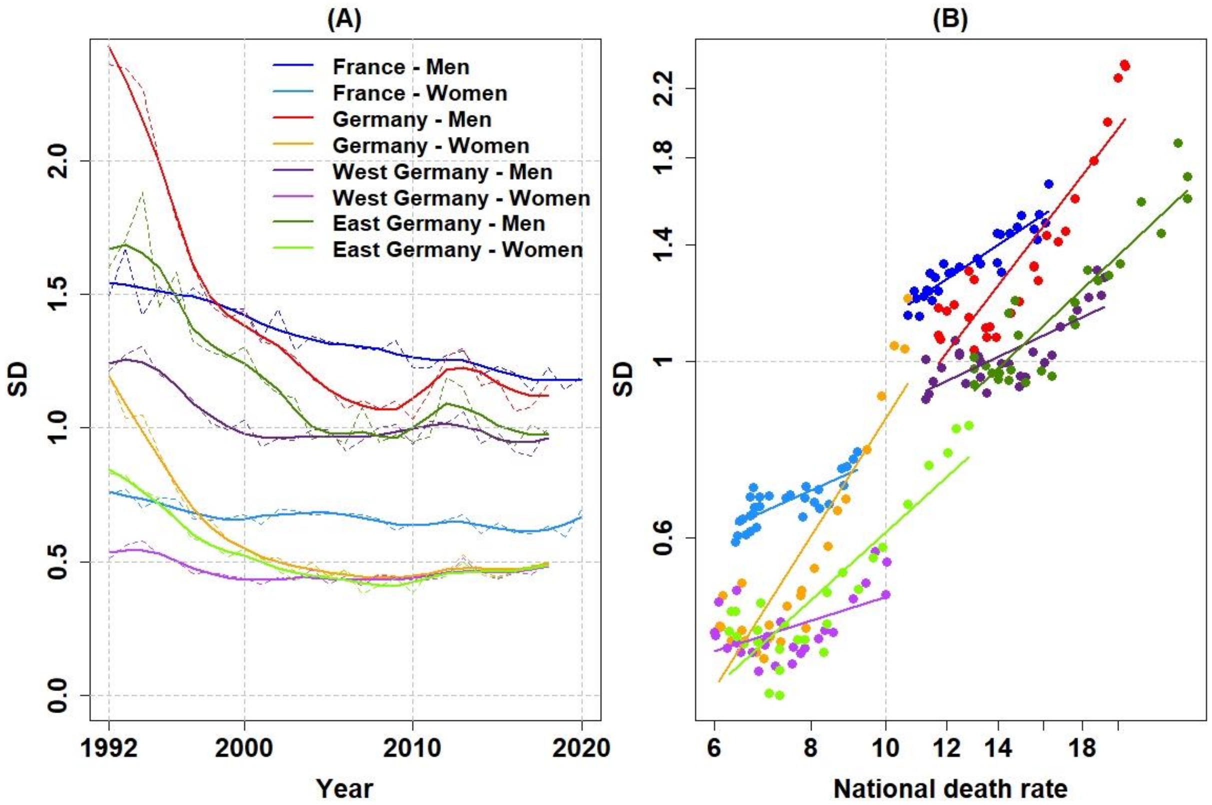
Appendices

Figure A1 : Spatial inequality indicators and National SDR in France, for selected decade age groups.



Notes: "Std. Dev." means standard deviation of regional mortality rates. Values of regional death rates are weighted by regional population to calculate standard deviations. The national mortality rate is the mortality rate for all regions in France. Panel of 95 regions. Data from 1979 to 2020.

Figure A2: Trends of spatial inequality indicators in France, Germany, West Germany and East Germany (A); Spatial inequality indicators and national mortality rates in France, Germany, West Germany and East Germany (B).



Notes: "SD" means standard deviation of regional mortality rates. The values of the regional death rates are weighted by the regional population for the calculation of standard deviations. The national death rate is the death rate for all regions in each country. Panel of 95 regions in France, 96 regions in Germany. Data from 1992 to 2020 for France, and from 1992 to 2018 for Germany.