The COVID-19 pandemic as the next divergent phase of the East-West mortality gap in Europe

Adéla Pola*, Klára Hulíková Tesárková

Charles University, Faculty of science, Department of Demography and Geodemography, Czechia
* Corresponding author: adela.pola@natur.cuni.cz

ABSTRACT
This paper analyses the variability of life expectancy at birth in Europe after 1950. It aims to assess the development of the East-West mortality gap and to identify the sub-regions or countries that most influenced mortality divergent and convergent trends in Europe. To achieve the goals, European countries are divided into Western and Eastern according to their political history, and the squared coefficient of variation is used for analysis of variability. This measure is further decomposed into between- and within-group components. The results of the study show that there were 4 divergent periods during the study period associated with the delayed cardiovascular revolution and mortality crisis in Eastern Europe and the COVID-19 pandemic. Variability of mortality in Europe during the pandemic was the highest in comparison to all previous divergent periods. Throughout the studied period, the between-group variability was influenced by both the continual progress of Western Europe and the lagging of Eastern Europe, with both regions contributing more or less similarly. However, since the 1990s, in case of within-group variability, a strong dominance of Eastern Europe can be observed, and therefore post-socialist countries deserve special attention. The results also suggest that some longer-term trends in behavior and attitudes towards health may persist in society, and that in the case of an unexpected crisis, there is a greater risk of mortality divergence reappearing.

KEYWORDS
East-West mortality gap; life expectancy at birth; decomposition; post-socialist countries; COVID-19

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1. Introduction

Mortality in Europe has experienced a turbulent development in recent years in the context of the COVID-19 pandemic, with a disruption of the convergence in mortality between Western and Eastern Europe observed since roughly the beginning of the 21st century. The pandemic is therefore an example of how progress in medicine and relative economic and social stability clearly do not ensure positive mortality trends. On the contrary, the pandemic has reminded us that mortality trends are not linear, as it can be seen as another divergent phase of long-term divergent-convergent mortality sequences. Among other things, it highlighted the weaknesses of the health systems of some European countries, as different countries in Western and Eastern Europe were able to cope with the pandemic in different ways. The effect of the COVID-19 pandemic on the East-West gap needs to be evaluated in the long term and compared with past milestones of divergent-convergent mortality trends in Europe, which is what this article presents.

The rapid decline in mortality in Europe since the beginning of the 20th century can be measured, among other things, by an increase in life expectancy. However, it cannot be said that the development in this indicator of mortality has been constant and consistent in all European countries. On the contrary, since the Second World War, Central, and Eastern Europe has experienced a rapid increase in life expectancy, stagnation, a significant decline, and a renewed increase in the indicator (Aburto and Raalte 2018), while Western Europe has more or less experienced an improvement in mortality rates all along, although the tempo has changed as well. After the period of mortality homogeneity in the 1960s, the divergence between Western and Eastern Europe has been more evident in the male population, especially since the 1970s, when the cardiovascular revolution took place in Western Europe, while the post-socialist countries have not been successful in suppressing cardiovascular diseases. The gap between the two parts of Europe continued to widen, culminating in the 1990s, when mortality rates continued to improve in the West, while some Eastern European countries faced a mortality crisis (Meslé 2004). High mortality rates in Central and especially Eastern Europe have been associated with excess alcohol consumption, violence (Bye 2008; Leon et al. 1997), or high mortality rates among young men (McKee and Shkolnikov 2001).

Since the mid-1980s, it has been possible to observe divergence not only between Western and Eastern Europe but also within the Eastern region. In 1985 Grobachev introduced an anti-alcohol campaign, which had a short-term positive effect across all post-soviet countries. After 1987, however, mortality rates in the Eastern Region diverged (Aburto and Raalte 2018), as mortality trends began to reverse in Central Europe and one country after another restored health progress. In contrast, countries of the former Soviet Union have experienced a renewed decline in life expectancy. In the first half of the 1990s, the economic crisis associated with the transition to a market economy added to the unfavorable demographic trends, which together resulted in a mortality crisis (Meslé 2004).

Since the second half of the 1990s, life expectancy has been increasing all over Eastern Europe, and after the turn of the millennium, it began to converge towards Western Europe. In recent years, however, convergence has started to slow down and there has even been discussion of parallel development between European regions (Leon 2011).

A new perspective on the development of the East-West gap has been brought about by the COVID-19 pandemic when mortality rates worsened across all of Europe, but the course and impact varied between regions. In 2020, mortality rates increased across the whole of Europe, but Western European countries coped better with the pandemic and were able to restore progress in life expectancy in 2021. In contrast, post-socialist countries have been more affected by the pandemic, and life expectancy gains have not yet been restored in many of them. Thus, the COVID-19 pandemic has again widened the gap between Western and Eastern Europe (Shkolnikov et al. 2023).

The mortality burden of the pandemic can also be seen, for example, in the excess mortality, whose level and geographical distribution changed during the pandemic (Hajdu et al. 2024). According to their analysis, the increase in inequality was mainly due to much higher-than-average excess mortality in countries with low pre-pandemic life expectancy at birth as the bottom fifth of analyzed European countries have seen the largest reductions in life expectancy. The increase in variability was greatest in 2021, as confirmed by the largest difference between observed and expected life expectancy. They also pointed out that regional differences in life expectancy would have remained at roughly pre-pandemic levels if COVID-19 had not broken out. In 2022, the variance returned to pre-pandemic levels, although life expectancy was lower than would have been expected in the absence of the pandemic.

The post-war development of mortality in Europe is well known and widely described (e.g. Leon 2011; Meslé 2004; Meslé and Vallin 2002), but less attention has been paid to the variability of life expectancy, which offers a different perspective to assess convergent and divergent mortality trends. This paper fills this gap and presents an analysis of the variability of life expectancy at birth in Europe after 1950. Since mortality trends during the period under review differed not only between Western and Eastern Europe but also within regions, the analysis includes a decomposition of the overall variability into between- and within-group components. Thus, the aim of the

paper is not only to assess how mortality variability has changed in Europe after the Second World War but also to identify the turning points where the long-term trend in variability has been disrupted and the countries that caused the divergence. Finally, the paper aims to determine whether the increase in overall variability was driven more by differences between Western and Eastern Europe or by variability within these regions.

2. Data and methods

We analyzed the variability of life expectancy at birth in Europe between 1950 and 2022 using data from World Population Prospects (United Nations 2022). Most European countries were involved in the analysis, excluding those with less than 1 million inhabitants, and Bosnia and Herzegovina because of the war between 1992 and 1995, which could be expected to have a major impact on the results. As the aim of this paper is to examine trends, the fluctuation due to war is not desirable. For the purpose of the analysis, European countries were divided based on a political history and literature review into Western (Region 1) and Eastern (Region 2). Region 1 consists of 17 countries from Northern, Western, and Southern Europe, and Slovenia, which is included in the Western region for geographical reasons and also due to the development of mortality rates since the end of the 20th century, since when it has been remarkably converging towards Western European mortality trends. Region 2 includes 17 post-socialist countries from Central, South-Eastern, and Eastern Europe, the Baltic States and Albania, Northern Macedonia, and Serbia. A list of all countries analyzed, together with their affiliation to the Western or Eastern region, is provided in the Tab. 1.

Tab. 1 Analyzed European countries and their regional affiliation.

Region 1 = Western Europe	Region 2 = Eastern Europe
Austria	Albania
Belgium	Belarus
Denmark	Bulgaria
Finland	Croatia
France	Czechia
Germany	Estonia
Greece	Hungary
Ireland	Latvia
Italy	Lithuania
Netherlands	North Macedonia
Norway	Poland
Portugal	Republic of Moldova
Slovenia	Romania
Spain	Russian Federation
Sweden	Serbia
Switzerland	Slovakia
United Kingdom	Ukraine

The first step of the analysis was to assess convergence trends between Western and Eastern Europe. As a basic measure of variability, we used the coefficient of variation squared (as defined e. g. by Chameni Nembua 2006):

$$CV^2 = \frac{Var}{\mu^2} = \frac{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \mu^2}{\mu^2} = \frac{1}{2n\mu^2}\sum_{i=1}^{n} x_i^2 + \frac{1}{2n\mu^2}\sum_{j=1}^{n} x_j^2 - \frac{1}{\mu^2}\left(\frac{1}{n}\sum_{i=1}^{n} x_i\right)\left(\frac{1}{n}\sum_{j=1}^{n} x_j\right) =$$
$$= \frac{1}{2n^2\mu^2}\sum_{i=1}^{n}\sum_{j=1}^{n} x_i^2 + \frac{1}{2n^2\mu^2}\sum_{i=1}^{n}\sum_{j=1}^{n} x_j^2 - \frac{2}{2n^2\mu^2}\sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j =$$
$$= \frac{1}{2n^2\mu^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_i^2 + x_j^2 - 2x_i x_j\right) = \frac{1}{2n^2\mu^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_i - x_j\right)^2$$

where CV^2 stands for the square of the coefficient of variation, Var for the variance, and μ for the mean of population P with n units. The parameter x indicates country-specific (1, 2, … i and j represent particular countries) values of the evaluated variable (life expectancy at birth). Since the average value of the indicator, i.e. the life expectancy, enters the calculation, the result is the relative variability of the indicator around the average.

In the analysis, the overall observed changes in variability of the mortality trends were decomposed into two components – the within-group (WG) variability and the between-group (BG) variability. The first component represents the increase or decrease of variability within the groups of countries, while the other identifies the increase or decrease in differences between European regions.

In decomposition, the between-group component (CV_B^2) was estimated using the formula (Chameni Nembua 2006):

$$CV_B^2(P_h) = \frac{n_h}{n}\left(1 - \frac{\mu_h}{\mu}\right)^2 + s_h(1 - f_h)CV_h^2$$

$$f_h = \frac{n_h}{n} \; and \; s_h = \frac{n_h}{n}\left(\frac{\mu_h}{\mu}\right)^2$$

where P_h stands for a particular sub-population (one of the compared groups of countries in our case) and n_h for the number of countries in this group. Parameter μ_h represents the means of the evaluated variable in particular regions. Symbols without the lower index are related to the whole analyzed set of countries. The within-group component was estimated only as a difference between the total variability and the between-group part of it.

3. Results

Between 1950 and 2022, there was an overall decline in the variability of life expectancy at birth, with the squared coefficient of variation and both components of total variability reaching higher values for men

(Fig. 1). This downward trend was disrupted by four divergent periods which are defined on the basis of local minimum and maximum values of variability of life expectancy at birth (1973–1984, 1986–1994, 1998–2005, 2017–2022). The increases in variability are more pronounced in males, and therefore only results for men are presented in detail in this paper. The results for women are about the same, but less significant.

The first divergent period started in 1973 and it was the longest period of increasing variability in life expectancy at birth since the mid-20th century, peaking in 1984. The second divergent period began in 1986 and the variability increased until 1994. The largest absolute increase in variability occurred during this interval, with the squared coefficient of variation rising by 0.0034 years squared. Given the turbulent political, economic, and social changes in Eastern Europe at the turn of the 1980s and 1990s, it can be assumed that the considerable increase in variability in the second divergent period is precisely related to the heterogeneous development of mortality in post-socialist countries. The third divergent period started in 1998, reached its maximum in 2005, and can be characterized by the smallest increase in variability when the square of the coefficient of variation increased by 0.0007 years squared. The fourth divergent period started in 2017 and continued until the last year analyzed. The largest annual increments of the square of the coefficient of variation indicate a sharp increase in variability during that interval mainly after 2019 when the COVID-19 pandemic started. The importance of the last divergent period is demonstrated by the fact that the variability achieved due to different mortality trends during the pandemic overcame the turbulent and heterogeneous development in Europe during the transition years of the 1990s (Fig. 1).

Fig. 1 shows, among other things, that throughout the period under study, differences between groups, i.e. between Western and Eastern Europe, contributed more to the overall variability. The share of between-group variability in total variability peaked at 90% in 1990 and has remained above 80% since then. Until the late 1960s, differences between regions were more influenced by Eastern European countries, with a peak of about 65% in 1960. Since then, the contribution of the two regions to between-group variability has been more or less equal (Fig. 2). This means that during all four divergent periods, both the more rapid rise of Western European countries and the lagging behind of post-socialist countries have contributed equally to the growing gap between Western and Eastern Europe.

The development of within-group variability was more dynamic during the period under review. This component of the total variability was more pronounced almost throughout the entire period in Region 2, with the contributions of Eastern European countries starting to increase significantly in the 1990s. Since then, Region 2 has completely dominated the within-group variability, reaching a maximum contribution of over about 92% in 2014 (Fig. 2). This reflects the very different development of Western and Eastern Europe since the late 1980s and early 1990s, when Western European countries remained

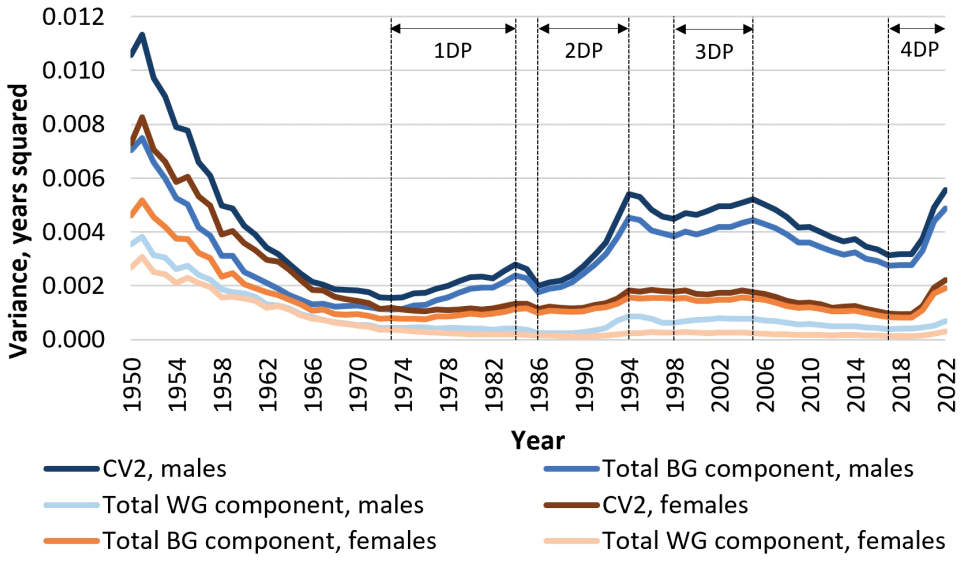

Fig. 1 Variability of life expectancy at birth expressed by square of the coefficient of variation and its components between- and within-group variability, men and women, European countries, 1950–2022.
Notes: The dashed vertical lines delineate the four divergent periods.
CV2 = square of the coefficient of variation; BG = between-group component of the total variability; WG = within-group component of the total variability; DP = divergent period
Data: United Nations

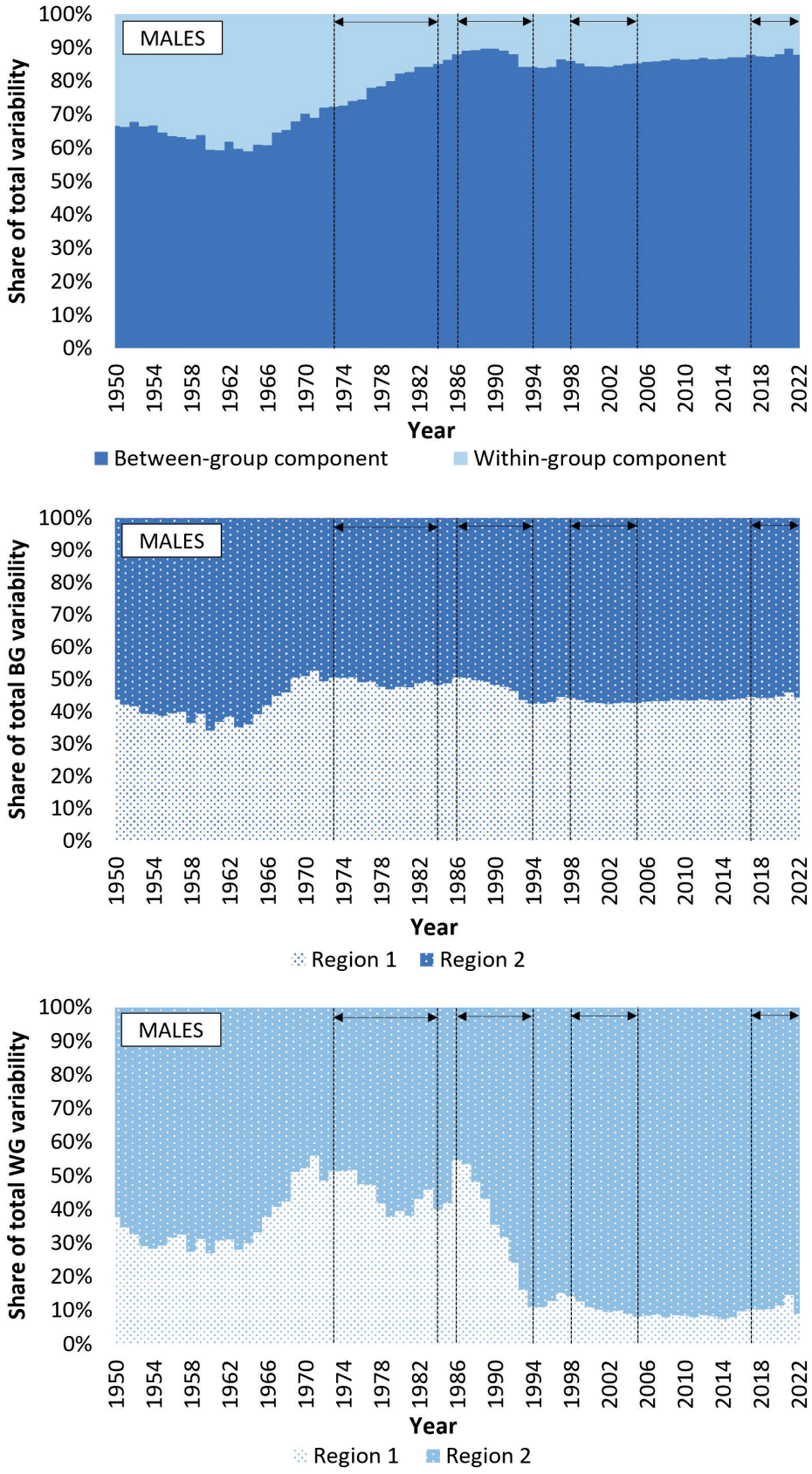

Fig. 2 Contributions of between- and within-group components to the total variability (upper panel) and contributions of Regions to the between- (middle panel) and within-group (bottom panel) components of the total variability, men and women, European countries, 1950–2022.

Notes: The dashed vertical lines delineate the four divergent periods.

BG = between-group component of the total variability; WG = within-group component of the total variability; Region 1 = Western Europe; Region 2 = Eastern Europe

Data: United Nations

homogeneous, while mortality trends among post-socialist countries differed greatly in the context of the transition and subsequent mortality crisis.

For a better understanding of the development of the variability and its components, the following Fig. 3, 4, 5, and 6 show the development of life expectancy at birth during the four divergent periods. The graphs always compare life expectancy in two years – the year before the divergent phase began, i.e. the year with the local minimum value of the squared coefficient of variation, and the year when variability peaked in a given divergent period (1973–1984, 1986–1994, 1998–2005 and 2017–2022). These divergent periods are analyzed in more detail to identify the countries that are most responsible for the increase in mortality variability.

During the first divergent period (1973–1984), all Western European and some Eastern European countries experienced an increase in life expectancy at birth. In Region 2, however, the level of the indicator stagnated or even declined in several cases. The largest increases between 3 and 4 years occurred in Albania and Macedonia, and in Region 1 in Portugal, Finland, Italy, and Spain. Belarus experienced the greatest loss of life expectancy at birth by almost 3 years, but due to its relatively good starting position in 1973, it was not among the countries with the lowest level of the indicator at the end of the first divergent period. This position was held by Russia and the Republic of Moldova at both the beginning and the end of this period, despite different trends, with life expectancy in Russia declining by about one and a half years between 1973 and 1984, while in Moldova the indicator increased by about one and a half years (Fig. 3). Thus, regarding the first divergent period, we can conclude that there were changes in both Regions, which corresponds to the results above that the share of Western and Eastern European countries in between-group variability was comparable during this period. However, the variability was higher in Region 2, and therefore the contribution of Eastern Europe to within-group variability increased at the expense of Western Europe (Fig. 2).

Even in the second divergent period (1986–1994), all Western European countries experienced an increase in life expectancy at birth. In the case of Eastern Europe, some countries showed increasing trends (mainly Central European countries), but most faced a deterioration in mortality rates. The largest declines in life expectancy (by more than 3 years) occurred in Ukraine, the Baltic States, Belarus, and especially in Russia, where the level of the indicator fell by almost 7 years. Moreover, Russia had the worst starting position in 1986, so that, combined with the largest drop in life expectancy at birth, it lagged behind not only Western Europe but also other Eastern European countries at the end of the second divergent period. In contrast, the largest gains in life expectancy at birth in Region 2 can be observed in Slovenia, which was more in line with Eastern Europe during the second divergent period of life expectancy levels, but its convergent tendency towards Western Europe is evident

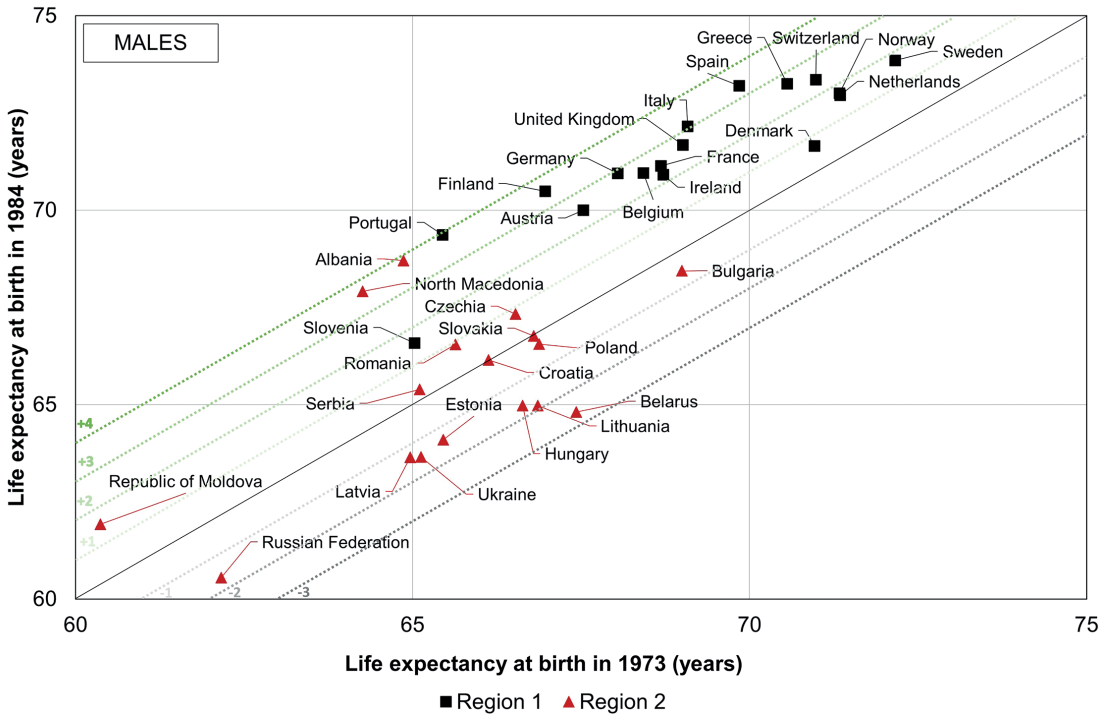

Fig. 3 Changes in life expectancy at birth between 1973 and 1984, men, European countries.
Notes: Region 1 = Western Europe; Region 2 = Eastern Europe
Data: United Nations

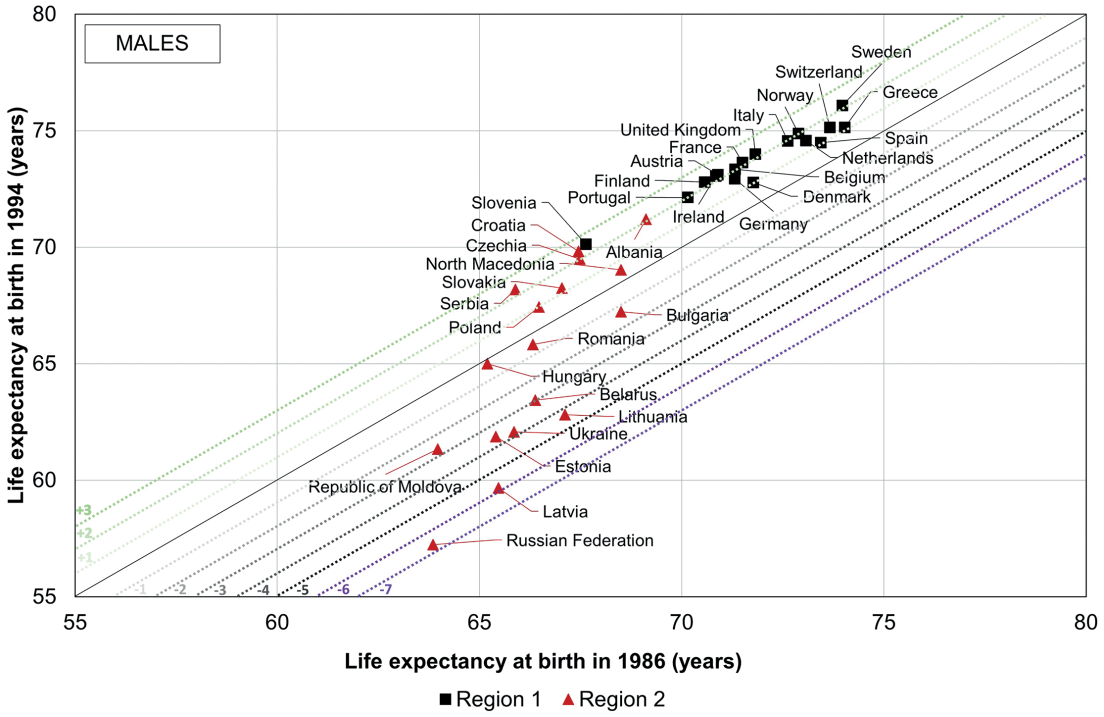

Fig. 4 Changes in life expectancy at birth between 1986 and 1994, men, European countries.
Notes: Region 1 = Western Europe; Region 2 = Eastern Europe
Data: United Nations

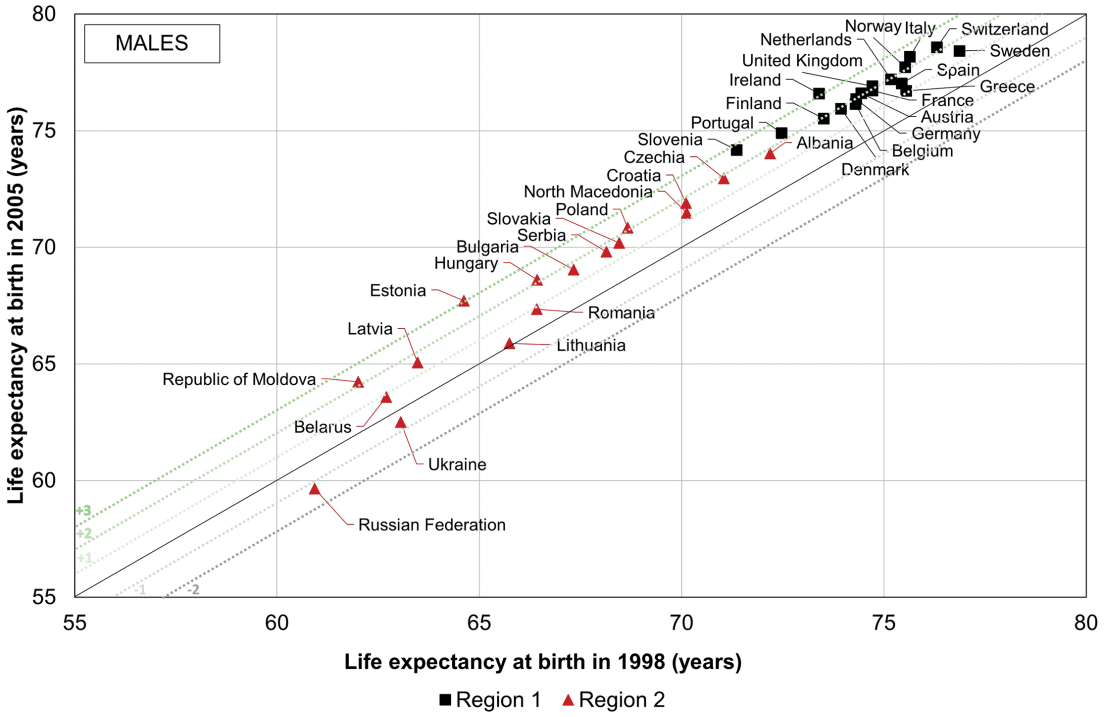

Fig. 5 Changes in life expectancy at birth between 1998 and 2005, men, European countries.
Notes: Region 1 = Western Europe; Region 2 = Eastern Europe
Data: United Nations

(Fig. 4). The increase in between-group variability during this period was influenced by both regions, as Western Europe experienced a substantial increase in life expectancy, while Eastern Europe showed a slower increase and in some cases a substantial decrease. The large increase in the share of Region 2 in within-group variability (Fig. 2) corresponds with the large differences between Eastern European countries, while Western European countries held much more together.

Overall, the third divergent period (1998–2005) can be characterized by the lowest mortality levels, as an increase in life expectancy at birth occurred in all Western and Eastern European countries except Ukraine and Russia. At first glance, it is clear that Region 1 is much more homogeneous, while the variability within Region 2 is large, which corresponds to the dominant share of Eastern European countries in the overall within-group variability (Fig. 2). It can even be observed that Region 2 has split into more subgroups during this divergent period. Best mortality rates are shown by Central European countries, Albania, Croatia or Northern Macedonia. The Baltic States are a special group, which is moving away from the other post-Soviet countries, with Estonia showing an increase in life expectancy of about 3 years, one of the largest gains in this period. The situation is most severe again in Russia and Moldova, but also in Ukraine and Belarus (Fig. 5). This heterogeneous development of the Region 2 countries, and in particular the convergent tendencies of some post-socialist countries towards Western Europe and the separation of some post-Soviet countries, shows that the different countries have managed to cope with the consequences of the transition and the mortality crisis at different paces.

For the fourth divergent period (2017–2022), it can no longer be said that all Western European countries experienced an increase in life expectancy at birth, as the value of the indicator fell slightly in Germany and Greece. However, the loss was marginal compared to Eastern Europe. In Region 2, by contrast, mortality rates deteriorated in all countries except Croatia, Estonia, and Latvia. At first glance, it is clear that Western Europe was much more homogeneous than Eastern Europe during the fourth divergence period, where even Moldova, Ukraine, and Russia were separated. These three countries had the worst starting positions in 2017 and also experienced a decline in life expectancy. The largest drop of about 6 years in the indicator occurred in Ukraine. It is also worth noting the evolution of Slovenia, which completed its convergence towards Western Europe (Fig. 6). Even during the fourth divergence period, the two regions affected between-group variability in very similar ways, as Western Europe saw further progress in life expectancy at birth, while Eastern Europe experienced an increase in mortality. The greater divergence within Eastern European countries then corresponds with the continued dominance of Region 2 in total within-group variability over that period (Fig. 2).

4. Discussion

The results of this study show that since the second half of the 20th century, mortality rates in Europe have not only improved, but that there were also periods or regions affected by more or less temporary mortality worsening, despite general progress in health care, standards of living, or social and economic development. This heterogeneous development

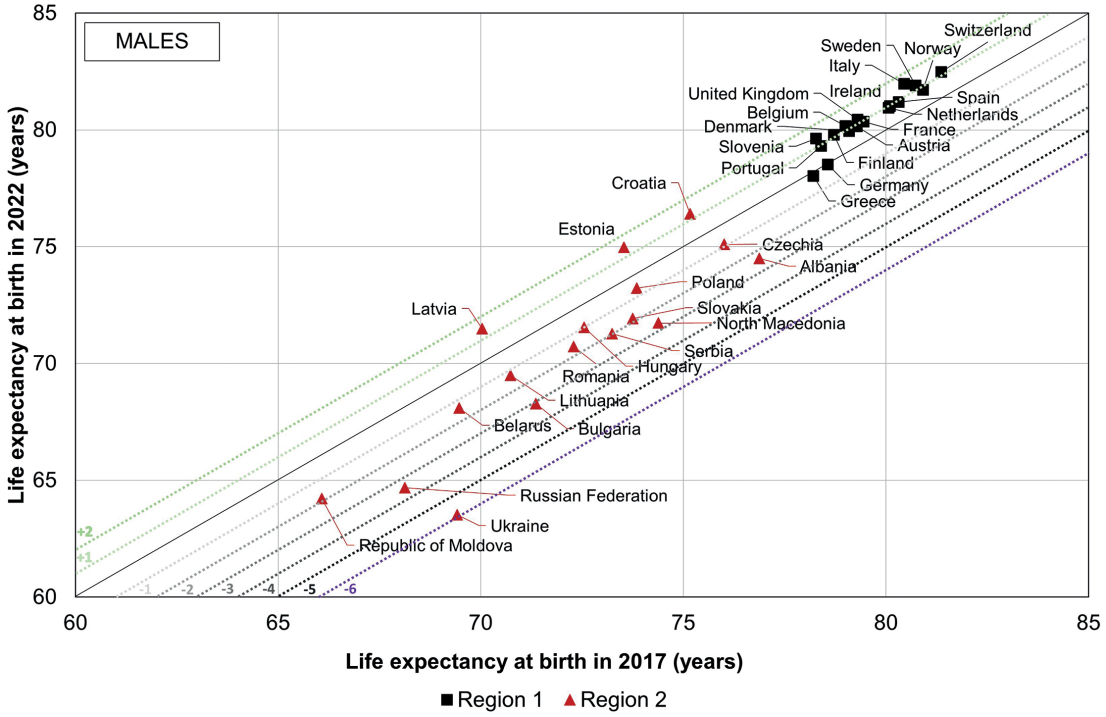

Fig. 6 Changes in life expectancy at birth between 2017 and 2022, men, European countries.
Notes: Region 1 = Western Europe; Region 2 = Eastern Europe
Data: United Nations

was reflected in the variability of mortality rates, which experienced four divergent periods during the period under review.

The increase in variability since the mid-1970s has been associated with the cardiovascular revolution. In the late 1960s, life expectancy at birth began to increase in Western European countries, due to the successful control of cardiovascular diseases. However, this significant progress did not take place in Eastern Europe, which instead entered a long period of stagnation or even an increase in mortality, especially in the case of men (Vallin and Meslé 2004). The decline in variability in the second half of the 1980s was related to the introduction of an anti-alcohol campaign in the countries of the former Soviet Union between 1985 and 1987, but the effect was short-lived due to lack of policy follow-up (Caselli et al. 2002).

This was followed by a widening of the gap between Western and Eastern Europe, which reached a peak around the mid-1990s. However, the mortality crisis did not affect all Eastern European countries equally. In fact, since the mid-1980s, it has been possible to distinguish the former Soviet republics from the countries of Central Europe, where advances in health care were made earlier and, after the collapse of the Soviet Union, one country after another began to reverse the adverse mortality trends (Meslé 2004). The countries of the former Soviet Union did not see a reduction in mortality rates until about the mid-1990s, as by then they faced not only a mortality crisis but also an economic crisis associated with the transition to a market economy (Shkolnikov et al. 1998; Gavrilova et al. 2001). Moreover, the improvement was first seen in the Baltic States. The different mortality trends in Central Europe and the Baltic States compared to other Eastern European countries are explained by many factors, including changes in nutrition, progress in medicine, and the countries' entrance into the European Union. Although they did not officially join the EU until 2004, already in the 1990s the governments of the accession countries had to take measures in areas ranging from housing to workplace safety that could have had a positive impact on health (Leon 2011). It was not until around the turn of the millennium that mortality rates began to decline in the remaining post-Soviet countries, and since then it has been possible to speak again of a convergence of mortality rates in Europe.

This positive trend was disrupted at the end of the second decade of the 21st century when variability increased sharply. The observed trends in variability among the European countries are a natural consequence of the pandemic period (COVID-19). As was already shown (Schöley et al. 2022; Shkolnikov et al. 2023), the first pandemic year (2020) brought a mortality worsening to almost all European countries, regardless of the region of the country. On the other hand, the second pandemic year (2021) was the source of increasing mortality variability in Europe. In 2021, many of the Western European countries returned to the pre-pandemic mortality levels, however, most of the Eastern European countries suffered even deeper mortality worsening. Thus, we can conclude that the impact of the pandemic was more severe in countries with worse pre-pandemic mortality rates and the COVID-19 pandemic deepened significantly the European mortality differences.

Frequently mentioned factors influencing the impact of a pandemic include, for example, the resilience of countries to external influences and their ability to adapt to circumstances (Haldane et al. 2021; Berawi 2020), or the degree of involvement in international trade and tourism (Ascani et al. 2020; Bontempi and Coccia 2021). For this reason, Western European countries in many cases experienced higher excess mortality at the beginning of the pandemic because of more intense trade links, whereas the epidemic did not spread as rapidly to Central and Eastern European countries at the very beginning. However, by the second pandemic year, Western European countries were already showing better adaptation and response, whereas Eastern Europe was more affected by the pandemic, again confirming the link between the impact of the pandemic and pre-pandemic levels of life expectancy. In other words, lifestyle, nutrition, health care or infrastructure can be said to influence life expectancy levels perhaps even more during pandemics than outside of them. This is important for policy makers and the future development of the risk countries, which are less resilient to epidemics and need more external support.

5. Conclusion

The divergent-convergent development of mortality in Europe in the second half of the 20th century is evident in the results of this study. We can observe a steady increase in life expectancy at birth in all Western European countries in the first (1973–1984), second (1986–1994), and third (1998–2005) divergent periods, while Eastern European countries have in most cases experienced stagnation or decline in the indicator. Related to this is the increase in the influence of the between-group component on overall variability since the 1960s, with Western and Eastern Europe contributing almost equally to the between-group differences since the 1970s. The increase in variability was rapid in the second divergent period when the between-group component of variability was at its highest and the difference between Western and Eastern Europe was therefore the largest. At that time, life expectancy continued to rise in Western European countries, while some countries in Eastern Europe faced a mortality crisis, especially Russia, the Baltic States, Ukraine, and Belarus. This is related to the significant increase in contributions of Region 2 to the total within-group component of variability after

1985. Divergence within the Eastern European region also played a role in the increase in variability in the late 1990s when first the Central European countries and then the Baltic states separated from the rest of the post-socialist countries.

During the most recent divergent period associated with the COVID-19 pandemic, there was a larger increase in variability than in all the other divergent periods. The between-group component of total variability was again influenced by both Regions, i.e., progress in Western Europe (especially in Switzerland, Norway, Sweden, and Italy) and deterioration in mortality in Eastern Europe (especially in Russia, Ukraine, and Moldova). Within-group variability continued to be more affected by Region 2, although the contribution of Region 1 increased slightly.

The four divergent periods show that the increase in mortality variability can be due to many factors, whether it is the gradual manifestation of progress in health care, political and economic changes, or epidemics. It is, therefore, necessary to assume that further divergent-convergent mortality sequences will occur in the future, and it is extremely important to learn how to respond to mortality crises so that future ones have as little impact as possible, not only on European societies.

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