Assessing Subnational Disparities in Population Ageing in European Regions 1990-2022: A Comparative Analysis Using Chronological and Prospective Indicators

Extended abstract

Markus Dörflinger, Sebastian Klüsener, Michael Mühlichen (Federal Institute for Population Research)

Introduction

The timing, pace and magnitude of population ageing vary greatly among European countries, as well as within countries (Kashnitsky et al. 2021; Ghio et al. 2022). In many countries, rural areas are experiencing rapid population ageing, while metropolitan regions tend to age more slowly (Cilek et al. 2025). This regional heterogeneity is primarily driven by long-term variations in fertility and different migration patterns (Kashnitsky et al. 2017). While population ageing has major economic and societal implications at the national level, it is also critical at the regional and local levels. For instance, labor shortages may be more pronounced in rapidly ageing regions, directly affecting regional economic development (Rees et al. 2012). Another challenge arises from the potentially growing demand for healthcare services, which depends heavily on the local age structure, i.e., the number of older residents requiring support. Therefore, it is essential to account for regional differences when assessing population ageing in European countries.

Conventionally, population ageing is measured using the proportion of the population aged 65 and over or by means of dependency ratios, such as the chronological old-age dependency ratio (OADR), which is calculated as the ratio of the population aged 65 and over to the so-called working-age population (e.g., those aged 18 to 64). The OADR serves as an approximation of the potential economic burden imposed by population ageing. While the threshold at age 65 may align with common retirement ages in many countries (Gietel-Basten et al. 2015), such a definition of "old" neglects other factors, such as health characteristics. This is particularly relevant in the context of long-term health improvements and increasing (healthy) life expectancy observed in European. Better health and higher life expectancy among older individuals affect not only the potential for extended labour force participation (Heller et al. 2022), but also the likelihood of providing grandchild care (Hank and Buber 2009) or engaging in voluntary work (Mergenthaler et al. 2019). Indicators based on a fixed old-age threshold of 65 largely overlook these potentials. Moreover, the potential burden of population ageing on the healthcare system may be overestimated, as such indicators implicitly assume that all individuals over the age of 65 have similarly increased needs for health and care services.

In this study, we make use of the prospective age approach which moves beyond chronological age to measure population ageing (Sanderson and Scherbov 2005, 2007). This approach is based on the idea that cognitive and physical health — which determine both the potential of healthy older adults and the actual need for health and care services — depend less on the number of years already lived, i.e., chronological age, than on the number of years of life remaining. Prospective age thus refers to the average number of years a person can still expect to live. As the exact remaining lifetime of an individual is unknown, it is defined based on the average remaining life expectancy. In the context of rising life expectancy, mortality rates — as an indicator of health — decrease over time at the same chronological age, e.g., at age 65. However, they remain relatively constant at the same prospective age, e.g., at 15 years of average remaining life expectancy (Sanderson and Scherbov 2020). In addition, mortality rates across countries with different life expectancies tend to be similar at the same prospective age (ibid.). This implies that health characteristics are more comparable across time and space when using prospective age rather than chronological age. As health substantially determines the potential implications of population ageing, prospective age provides a useful tool for comparing population ageing over time and across countries and regions.

Population ageing through the lens of prospective age has already been examined in European countries. However, studies applying prospective age at the subnational level remain relatively scarce (e.g., Strozza et al. 2024 for Italian regions). Šídlo et al. (2019) compared both chronological and prospective measures of population ageing across European regions. While this study highlights that regional mortality disparities may substantially alter our understanding of regional population ageing, its analysis at the NUTS-2 level does not allow for the exploration of finer regional patterns, such as urban-rural differences. Moreover, it is limited to a cross-sectional perspective, without capturing temporal developments in mortality and age structure. Despite the persistent disparities in life expectancy among European countries, life expectancy has substantially converged across European regions, particularly during the 1990s and 2000s. In recent years, however, it appears to be diverging again (Sauerberg et al. 2024). Notably, the evolution of regional mortality disparities within countries varies largely. In Germany, for example, a North-South gap in life expectancy has emerged in recent years, rather than the dominant East-West divide of the 1990s (Hrzic et al. 2023; Mühlichen et al. 2023). In 2020 and following years, the COVID-19 pandemic affected European countries and regions differently, further contributing to mortality disparities (Bonnet et al. 2024). While the pandemic initially affected urban areas, it subsequently spread to peripheral areas and most of Eastern Europe (ibid.). In general, life expectancy in many European countries appears to be higher in metropolitan (capital) regions. In Germany, however, no consistent pattern can be found along the urban-rural continuum. For example, the largest cities demonstrate a wide range of life expectancies, with some of the highest and lowest values observed among all German districts (Rau and Schmertmann 2020). Notably, life expectancy in eastern Germany tends to be higher in urban and more densely populated areas, whereas evidence suggests the opposite pattern in western Germany (ibid.).

Against this background of mortality disparities both between and within European countries, we assess population ageing in European regions since the 1990s, taking differences in life expectancy as a proxy for health into account. Our analysis covers a large set of European countries spreading over Central, Eastern, Northern, Southern, and Western Europe. We compare changes in life expectancy and age structure on multiple regional levels and explicitly addresses potential urban-rural differences. By employing both chronological and prospective measures, we aim to provide a comprehensive picture of regional trends in population ageing.

Data and methods

In this paper, we use harmonized data on deaths and population counts by year, age, sex, and region for 19 European countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and Switzerland. Data were obtained from the national statistical offices and regional statistical offices (e.g., for German subnational data) as part of the REDIM project ('Regional Disparities in Cause-Specific Mortality in Europe'). The spatial resolution of the data is at least at the NUTS-3 level. For several countries, data at the LAU-1 level are available. Our analysis covers the period 1990-2022, with shorter time spans for countries with limited data availability.

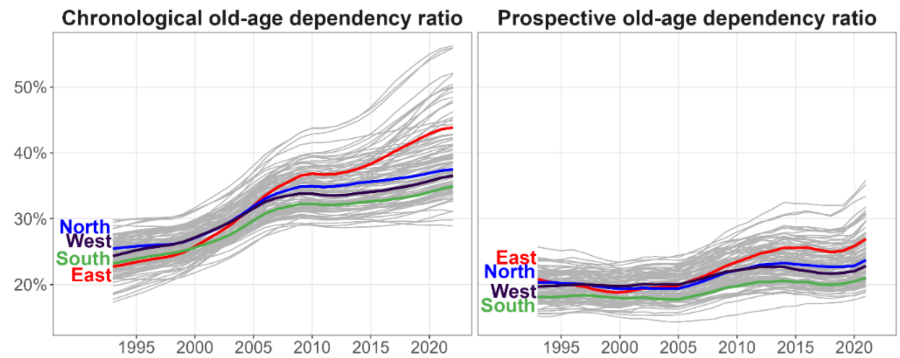
The analysis is conducted at various spatial levels. For Germany, these levels consist of four macro-regions, 96 spatial planning regions, and 400 districts (NUTS-3 level). The macro-region 'East' covers the area of the former German Democratic Republic (plus former West-Berlin). The macro-regions 'North', 'South'. and 'West' correspond to the former Federal Republic of Germany (without former West Berlin). The analysis of mortality changes over time at the level of the 400 German NUTS-3 regions would be associated with great uncertainty due to small population sizes (see Rau and Schmertmann 2020). Hence, we aggregate the 400 German districts into 96 spatial planning regions, according to the typology provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) (BBSR 2023). In the following, German spatial planning regions are referred to simply as 'regions'. To investigate potential urban-rural disparities in mortality and population ageing, we apply the Eurostat urban-rural typology to European NUTS-3 regions. For our example country, Germany, we have so far applied a national classification by settlement structure (BBSR 2023). This classification is based on the districts' population density and the proportion of the population living in cities and towns. The first category of districts includes 67 large cities with populations of at least 100,000 people that constitute their own districts. This category is considered the most urban (e.g., Cilek et al. 2025). Following the BBSR's classification, the remaining districts are divided into 133 other (predominantly) urban and 200 (predominantly) rural districts.

As key indicators of population ageing, we draw on two variations of the old-age dependency ratio. The chronological old-age dependency ratio (OADR) is based on a fixed old-age threshold at age 65 and describes the ratio of the old-age population (aged 65 and older) to the working-age population (aged 18 to 64). While this conventional approach relies on chronological age, i.e. the number of years a person has already lived, prospective age describes how many years a person can still expect to live. Thus, the prospective old-age dependency ratio (POADR) is based on an old-age threshold that is determined by the average remaining life expectancy. Following existing literature on prospective age, we define the prospective old-age threshold (POAT) as the age at which the average remaining life expectancy equals 15 years (both sexes combined). Based on the regional POAT in each year, the prospective old-age dependency ratio is calculated as the ratio of the prospective old-age population (aged at or above the POAT) to the working-age population (aged 18 to below the POAT).

Preliminary results

Figure 1 compares the chronological and the prospective variants of the old-age dependency ratio. With the prospective old-age threshold exceeding age 65, fewer people are counted as old and more people are counted as of working-age. Hence, the prospective perspective provides a less drastic old-age dependency in German (macro-)regions than conventional indicators based on chronological age. Up until the early 2000s, improvements in life expectancy contributed to a relatively stable prospective old-age dependency ratio in German (macro-)regions, while the chronological indicator based on the fixed old-age threshold was already rising. In earlier stages of population ageing, the phenomenon of a stable or even decreasing prospective old-age dependency ratio as in eastern Germany in the 1990s is observed globally (Sanderson and Scherbov 2008). Since the early 2000s, however, the prospective old-age dependency ratio has been rising in all macro-regions and most regions. Thus, despite large improvements in life expectancy, the number of older individuals per person in working-age has increased – though at a slower pace than when 'older people' are simply defined as those aged 65 and above.

Figure 1: Chronological and prospective old-age dependency ratio (in %), Germany, macro-regions and regions, 1993-2021

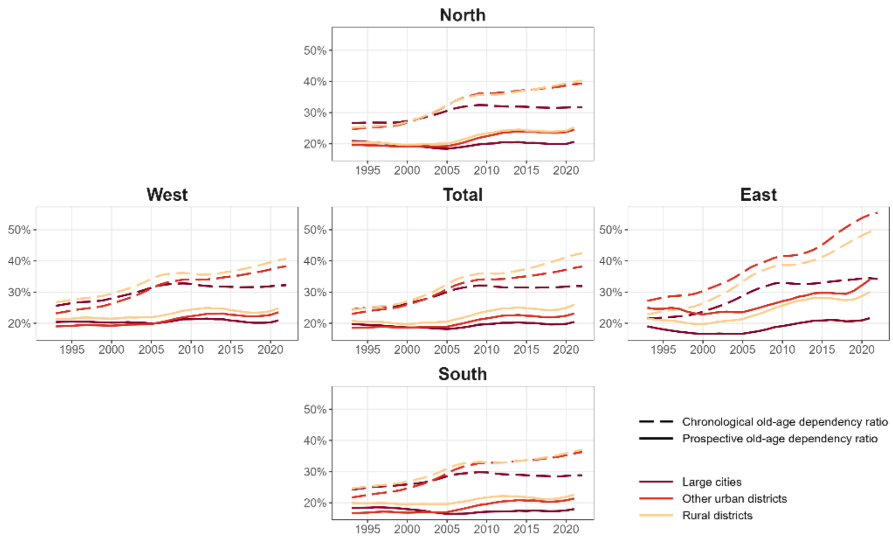


Regardless of the approach used to measure population ageing, regional trends in old-age dependency reveal pronounced East-West differences. While the chronological old-age dependency ratio — using a fixed old-age threshold at age 65 — was still lowest in the macro-region East in the early 1990s, a significantly faster increase has been observed since the late 1990s, resulting in a widening East-West gap over time. This reflects the long-term differences in the demographic development of eastern and western Germany. Particularly noteworthy is the sharp decline in the number of births in eastern Germany during the transformation period of the 1990s and early 2000s (Goldstein and Kreyenfeld 2011), which, with some time lag, is also reflected in a rapidly rising old-age dependency ratio. Additionally, eastern Germany experienced a significant outflow of young people to western Germany during this period (Stawarz et al. 2020). This, along with persistently lower international immigration to eastern Germany, has been a contributing factor to these different trajectories. Another notable pattern is the lower level of population ageing in the macro-region South. This is evident in both chronological and prospective views. However, the lower prospective old-age dependency ratio in the macro-region South is also driven by its higher life expectancy. This becomes evident if the life expectancy of this macro-region is applied as the standard to the age structures of all macro-regions. If life expectancy were as high in all macro-regions as in the macro-region South, the prospective old-age dependency ratio in 2021 would be 0.8 (North) to 1.6 percentage points (East) lower than it actually is.

Figure 2 illustrates the development of the chronological and prospective old-age dependency ratios in Germany by settlement type. Notably, in all macro-regions large cities exhibit the lowest levels of population ageing compared to other urban districts and rural districts in recent years. These differences were already pronounced in the macro-region East during the 1990s, while in other macro-regions, they emerged later. Since the late 2000s, however, both old-age dependency ratios in the large cities have remained relatively stable across all macro-regions, whereas they have continued to increase in other urban districts and rural districts. This has led to substantial disparities between large cities and other districts, which are most pronounced in the macro-region East. Not only do other urban districts and rural districts in the East display considerably higher old-age dependency ratios than large cities, they also display higher ratios than their counterparts in the rest of the country. With respect to the large cities, however, East-West differences are relatively small. Hence, the higher pace of population ageing in East Germany appears to be mainly driven by rapidly ageing regions outside the largest cities.

The differences in population ageing between large cities and other districts persist when applying the prospective old-age threshold. In the macro-region East, these differences are further reinforced by lower life expectancy outside the large cities. Once again, we apply the life expectancy of other urban districts in the South (highest life expectancy at age 65) as the standard for all macro-regions and settlement types. Closing the mortality gap would reduce the prospective old-age dependency ratio in other urban districts and rural districts in the East by 4.6 and 3.3 percentage points, or 13.6% and 11.1%, respectively. This illustrates that, from a prospective view, the potential burden of population ageing in districts outside the large cities in the East is not solely determined by their age structure, but is also intensified by mortality disadvantages. To a lesser extent, this likewise applies to other areas with lower life expectancy compared to urban districts in the South.

Figure 2: Chronological and prospective old-age dependency (in %), Germany, macro-regions and settlement type, 1993-2021



The analyses presented here will be expanded to our sample of European countries. Where data availability permits, we will complement these analyses with a more detailed examination of urban-rural differences in population ageing. Furthermore, we plan to compute Theil indices to determine the extent to which regional heterogeneity in population ageing across Europe can be attributed to differences within countries and between countries. Similarly, we will evaluate the contribution of regional differences between urban and rural areas to overall disparities in population ageing within countries since the 1990s.

References

BBSR (2023): BBSR Raumgliederungen. URL: https://www.bbsr.bund.de/BBSR/DE/forschung/raumbeobachtung/Raumabgrenzungen/downloads/raumgliederungen-referenzen-2023.xlsx

Bonnet, F., Grigoriev, P., Sauerberg, M., Alliger, I., Mühlichen, M., and Camarda, C.-G. (2024): Spatial disparities in the mortality burden of the covid-19 pandemic across 569 European regions (2020-2021). *Nature communications* 15(1): 4246.

Cilek, L., Loichinger, E., Swiaczny, F., Schlömer, C., Hoymann, J., and Maretzke, S. (2025): Future Subnational Population Change in Germany: The Role of Internal and International Migration. *Population, Space and Place* 31(1).

Ghio, D., Goujon, A., and Natale, F. (2022): Assessing the demographic impact of migration on the working-age population across European territories. *Demographic Research* 46: 261–272.

Gietel-Basten, S., Scherbov, S., and Sanderson, W. (2015): Remeasuring Ageing in Southeast Asia. *Asian Population Studies* 11(2): 191–210.

Hank, K., and Buber, I. (2009): Grandparents Caring for their Grandchildren. *Journal of Family Issues* 30(1): 53–73.

Heller, C., Sperlich, S., Tetzlaff, F., Geyer, S., Epping, J., Beller, J., and Tetzlaff, J. (2022): Living longer, working longer: analysing time trends in working life expectancy in Germany from a health perspective between 2002 and 2018. *European journal of ageing* 19(4): 1263–1276.

Hrzic, R., Vogt, T., Brand, H., and Janssen, F. (2023): District-Level Mortality Convergence in Reunified Germany: Long-Term Trends and Contextual Determinants. *Demography* 60(1): 303–325.

Kashnitsky, I., Beer, J. de, and van Wissen, L. (2017): Decomposition of regional convergence in population aging across Europe. *Genus* 73(2): 1–25.

Kashnitsky, I., Beer, J. de, and van Wissen, L. (2021): Unequally ageing regions of Europe: Exploring the role of urbanization. *Population Studies* 75(2): 221–237.

Mergenthaler, A., Sackreuther, I., and Staudinger, U.M. (2019): Productive activity patterns among 60–70-year-old retirees in Germany. *Ageing and Society* 39(06): 1122–1151.

Mühlichen, M., Lerch, M., Sauerberg, M., and Grigoriev, P. (2023): Different health systems - Different mortality outcomes? Regional disparities in avoidable mortality across German-speaking Europe, 1992-2019. *Social science & medicine (1982)* 329: 115976.

Rau, R., and Schmertmann, C.P. (2020): District-Level Life Expectancy in Germany. *Deutsches Ärzteblatt international* 117(29-30): 493–499.

Rees, P., van der Gaag, N., Beer, J. de, and Heins, F. (2012): European Regional Populations: Current Trends, Future Pathways, and Policy Options. *European journal of population* 28(4): 385–416.

Sanderson, W.C., and Scherbov, S. (2005): Average remaining lifetimes can increase as human populations age. *Nature* 435(7043): 811–813.

Sanderson, W.C., and Scherbov, S. (2007): A new perspective on population aging. *Demographic Research* 16: 27–58.

Sanderson, W.C., and Scherbov, S. (2008): Rethinking Age and Aging. *Population Bulletin* 63(4): 1–20.

Sanderson, W.C., and Scherbov, S. (2020): Choosing between the UN's alternative views of population aging. *PloS one* 15(7).

Sauerberg, M., Bonnet, F., Camarda, C.G., and Grigoriev, P. (2024): Mortality Convergence in Europe? Spatial Differences in Life Expectancy Gains Between 1995 and 2019. *Population and Development Review* 50(4): 1401–1427.

Šídlo, L., Šprocha, B., and Klapková, M. (2019): Regional differences in population aging in Europe viewed through prospective indicators. *Erdkunde:* 225–240.

Strozza, C., Egidi, V., Testa, M.R., and Caselli, G. (2024): Ageing and diversity: Inequalities in longevity and health in low-mortality countries. *Demographic Research* 50: 347–376.