Received: 20 June 2022 | Revised: 14 January 2023 | Accepted: 2 February 2023

DOI: 10.1111/rsp3.12648

ORIGINAL ARTICLE

Uneven geographies: ageing and population dynamics in Latvia

Zaiga Krisjane | Maris Berzins | Janis Krumins | Elina Apsite-Berina | Sindija Balode

Department of Geography, Faculty of Geography and Earth Sciences, University of Latvia, Riga, 1586, Latvia

Correspondence
Zaiga Krisjane, Department of Geography, Faculty of Geography and Earth Sciences, University of Latvia, Riga 1586, Latvia.
Email: zaiga.krisjane@lu.lv

Funding information
National Research Programme, Grant/Award Number: VPP-LETONIKA-2021/4-0002

Abstract

The twin phenomena of ageing populations and declining populations are profoundly transforming societies and economies in Europe. Driven by decreasing fertility rates and the continuing increased life expectancy, populations have not been ageing uniformly across time and space. In an increasingly urbanized world, the spatial distribution of the young and the elderly is a matter of growing scholarly and policy interest. In Europe, this process is more pronounced in peripheral areas than in the core regions, while the development of metropolitan areas is associated with suburbanization predominantly driven by young in-migrants. Latvia is an interesting case study for studying population ageing and its spatial imbalances due to the key role of emigration in population decline and ageing. By employing descriptive and spatial analysis, this study uses data from the Latvian census and population register to explore the relationships between population change and ageing processes. Global Moran's I and the local indicators of spatial association were used to identify spatial systems. The study confirmed global and local spatial autocorrelation for the both examined age variables. Using the Getis-Ord Gi* method identified spatial clusters of the young and the elderly. We found more pronounced residential clustering of the elderly aged 75 and over in the depopulating region of Latgale, whereas the Riga metropolitan region and areas around the largest towns tend to cluster young residents.

KEYWORDS
labor and demographic economics, demographic economics, demographic trends and forecasts, metropolitan and non-metropolitan regions, ageing population, population dynamics, Latvia

JEL CLASSIFICATION
J1, J11, R0, R19

1 | INTRODUCTION

The implications of population changes are a critical issue for urban and regional development in Central Eastern Europe (CEE) (Fihel & Okólski, 2019; Haase et al., 2016; Kulcsár & Brown, 2017). Even though the region as a whole is characterized by overall population decline, metropolitan areas have been experiencing population growth (Borén & Gentile, 2007; Kabisch et al., 2019; Ouředníček et al., 2015).

The key characteristics of population decline are birth rates below replacement level, low mortality, and rising life expectancy, which contribute to an increase in the number and proportion of the elderly population. Age distribution hampers Latvia's population growth (Bērziņš, 2019; Krūmiņš & Krišjāne, 2016). Overall, rural areas have seen the most extreme population loss (Pužulis & Kūle, 2016; Ubarevičienė et al., 2016).

Suburban growth has contributed to demographic inequalities between metropolitan and nonmetropolitan regions in Latvia, as in other CEE nations. Many of the region's core cities nowadays are characterized by reurbanization trends as well as ongoing parallel suburbanization processes in the city peripheries (Haase et al., 2010; Horňáková & Sýkora, 2021; Istrate et al., 2015; Krisjane & Berzins, 2012; Kurek et al., 2020; Ubarevičienė & Burneika, 2020).

Thus, the implications of demographic transition across metropolitan and nonmetropolitan areas are not uniform. Since the ageing of the population—caused by high life expectancy, in-migration of the elderly, out-migration of the young, and low birth rates—has not been heterogenous, the current demographic trends have prompted fears that an ageing population will exacerbate demographic polarization at both the local and regional levels (Gregory & Patuelli, 2015; Gutiérrez Posada et al., 2018; Kashnitsky et al., 2017; Kurek et al., 2020; Lang et al., 2022; Reynaud et al., 2018; Senbil & Yetiskul, 2022).

When investigating age-based residential patterns in metropolitan versus nonmetropolitan areas beyond CEE countries, spatially heterogenous ageing with different speeds of convergence and even divergence can be observed in Spain (Gutiérrez Posada et al., 2018). More specifically, the size of a municipality (urban versus rural) is negatively associated with ageing, whereas the distance of a municipality (central versus peripheral) holds a positive association. However, the magnitude of the association not only varies across space but also does not always have a restraining or triggering effect on ageing. Significant spatial differences in the distribution of the elderly, seemingly related to the area's urbanization level, are found in both Spain and Turkey (Gutiérrez Posada et al., 2018; Senbil & Yetiskul, 2022). Overall, across Organization for Economic Cooperation and Development (OECD) countries, population ageing is asymmetrical, and the elderly dependency rate in some countries can vary as much as 10% to 50%. Moreover, in the last two decades, the elderly dependency rate has increased in all the member states. The highest rise is observed in regions near metropolitan areas and the lowest in remote regions near small and medium-sized cities (OECD, 2020).

Similarly, differences in the level of population ageing and spatial dependencies can be seen when comparing age composition based on the degree of urbanization in CEE countries. In Czechia's Moravia region, the proportion of the elderly is higher in towns and cities than in rural areas (Vaishar et al., 2020). However, in Poland, there has been a decline in the rate of ageing in the largest functional urban areas due to suburbanization and reurbanization.

Meanwhile, the share of the pre-working age population in the cores of Polish functional urban areas is lower than in their peripheries (Kurek et al., 2020, 2021). There is greater spatial differentiation and dependence based on the size of the functional urban area. In the case of Slovakia, the districts in the metropolitan Bratislava region show the highest growth in the share of children compared to the rest of the country, revealing that population ageing in the region has slowed in the last decade (Kačerova et al., 2022).

The significance of recent studies on age-based residence patterns can be attributed to several factors. First, recent research efforts have focused more on the elderly or post-working population than the pre-working population, which can undermine the effectiveness of comprehensive planning. Second, since case studies tend to have contradictory findings and population distribution is rarely homogeneous, additional studies provide valuable input in the search for patterns. Third, to design effective spatial policies and planning, it is vital to understand the residential distribution and mobility of the ageing population, especially in smaller settlements that are affected by even small changes. Ageing and shrinking municipalities can face decreasing livability and a reduced workforce due to a lack of employment, which is a crucial factor in planning, significantly since shrinkage might not affect the region as a whole but its sub-municipalities and neighborhoods (Gutiérrez Posada et al., 2018; Segers et al., 2020; Senbil & Yetiskul, 2022).

Multiple transformations (Rink et al., 2019; Sýkora & Bouzarovski, 2012; Steinführer et al., 2011) can be utilized to understand the post-socialist urban changes, particularly the temporal and spatial dynamics of demographic change and their implications for policy, planning, and regional development. Numerous studies have found that demographic transition, ageing, fertility behavior, and diverse household structures have a significant impact on urban shrinkage, regional labor, and the real estate market (Botev, 2012; Buzar et al., 2005; Couch et al., 2012; Káčerová et al., 2014; Kashnitsky et al., 2021; Kazimierczak & Szafrańska, 2019; Kurek et al., 2017; Kurek & Wójtowicz, 2018; Steinführer & Haase, 2007; Wolff & Wiechmann, 2018).

Finally, current research on the COVID-19 pandemic shows that the risk of death among infected people increases rapidly with age. Additionally, it was shown that illness incidence is higher in densely inhabited and urbanized areas (Ferguson et al., 2020; Gurram et al., 2022; Nazia, 2022; Pilkington et al., 2021). European regions are ageing unequally; thus, coronavirus SARS-CoV-2 poses particular challenges to regions and populations with greater proportions of vulnerable older people (Kashnitsky & Aburto, 2020). Geographical differences in population age compositions partly explain the spread of COVID-19 (Dowd et al., 2020). Looking at population age structures with considerable variations in the degree of ageing is critically important to assess the potential impact of the pandemic in ageing European regions (Kashnitsky & Schöley, 2018). The increasing proportion of older people in Latvia raised concerns associated with the COVID-19 outbreak. The most recent study reveals the negative cumulative effect of COVID-19 exposure on excess mortality in Latvia (Gobiņa et al., 2022).

The current study aimed to better understand the relationships between population change and ageing processes in Latvia's metropolitan and nonmetropolitan regions. For this purpose, we utilized the 2000 census and the most recently available population register data to investigate changes in the residential patterns and numbers of youths (aged form birth to 14 years) and the elderly.

Accordingly, this study had two research objectives. First, we provide an overview of population dynamics and ageing over the past two decades across Latvia's regions by using a combination of data pertaining to changes in the young and elderly populations at the aggregated territorial units of the sub-municipal level. Second, we explore geographical variation in the residential patterns of both considered age groups, downscaled at a fine-grain spatial resolution.

This article is divided into four parts. The following section briefly presents the study's data and methods. The third or results section addresses both research objectives: (1) the relationships between population dynamics and ageing over the past two decades and (2) residential patterns of both considered age groups for two observation years and by the regional breakdown of interest. Explorative geographical analyses were conducted to delve into changes in the distribution of young and elderly populations over space and time. In the final section, we discuss the results and offer a conclusion framed within broader ongoing debates of depopulation, remoteness, and access to services.

2 | DATA AND METHODS

2.1 | Data

Data on the size and distribution of the young and elderly populations were drawn from the 2000 population census and the 2020 population register. Both datasets come from Latvia's Central Statistical Bureau, ensuring appropriate anonymization of individual-level data and mutual comparability. For the spatial analysis, we used geocoded individual-level data regarding the population's size and age, encompassing the entire territory of Latvia. The research presented here was undertaken for two age groups: the young population, aged 0–14 years, and the elderly population, aged 75 and over. Both age groups were analyzed by comparing their size and distribution changes over the past two decades to better understand the relationships between population dynamics and ageing processes in Latvian regions. The distribution of the selected age groups was examined using spatial autocorrelation and spatial clustering analysis. For the spatial analysis, we used territorial units at the sub-municipal level and a fine-grain hexagonal grid of 16 hectares cells to apply the hot spot mapping technique to explore the residential patterns of both considered age groups. The available population data were geocoded according to the place of residence, and thus, linked to cells in the hexagonal grid we created. Each cell contains individual-level data on the registered residents' age and allows determination of the size of the analyzed age groups. Although the generated grid and cells may only partially correspond to the administrative boundaries of regions and municipalities, they provide the most geographically consistent detailed spatial scale and comparative robustness.

2.2 | Methods of spatial autocorrelation and clustering

This study employs quantitative methods to observe the residential patterns of the young and the elderly in Latvian metropolitan and nonmetropolitan regions. First, we investigated the spatial autocorrelation of the selected age groups using the global Moran's I index to assess whether the residential patterns of the young and the elderly populations are spatially clustered, dispersed, or randomly distributed (Lloyd, 2014; Matthews & Parker, 2013). The generated hexagonal grid was the primary input data for the spatial autocorrelation and clustering analysis. The Moran's I estimation is based on the following equation:

$$I = \frac{n}{W} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \overline{x}) (x_j - \overline{x})}{\sum_{i=1}^{n} (x_i - \overline{x})^2} \tag{1}$$

Here, n is the number of spatial units (grid cells); X is the variable of interest (given age group); $\overline{X}$ acts as the mean of X; $w_{i,j}$ the spatial weight between all pairs of points i and j; and W is the sum of all $w_{i,j}$ values. The value of the global Moran's I index ranges from -1 (clustering of dissimilar values) to $+1$ (clustering of similar values), and a value of 0 indicates no spatial autocorrelation. Index values closer to $+1$ indicate higher spatial autocorrelation; index values closer to -1 indicate greater spatial disparity. The calculations were performed using ESRI ArcGIS Spatial Analysis. The tool calculates the values of the global Moran's I, along with the z-score and p-value, which help to evaluate the index's significance. The global Moran's I analysis results are interpreted within the context of its null hypothesis of random spatial distribution. One cannot reject the null hypothesis when the p-value is not statistically significant. When the p-value is statistically significant, the spatial distribution is not randomly distributed. A positive *z*-score indicates spatial clustering, while a negative *z*-score indicates spatial dispersion. If the *z*-score equals 0, the autocorrelation is absent in the observed area.

Local indicators of spatial association (LISA) can help to identify spatial systems or cells from an adopted hexagonal grid surrounded by neighboring cells with high or low values (so-called hot spots and cold spots) of both age variables. To complement the global spatial statistics, local spatial statistics were used to evaluate where the clustering or dispersion tested by Moran's I index is located across the regions of Latvia. We used the Getis-Ord Gi* statistics to detect statistically significant local concentrations of hot spots and cold spots. In essence, this tool identifies each neighboring cell within the context of the analyzed feature (selected age group) and observed area and assesses whether the feature is part of spatially aligned statistically significant spatial clusters (Getis & Ord, 1992). The Getis-Ord Gi* local statistics were calculated using the formula:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^{n} w_{i,j}^{2} - \left(\sum_{j=1}^{n} w_{i,j}\right)^2}{n-1}}} \tag{2}$$

Here, *n* grid cells are assumed with numerous measurements $X = [x_1, \ldots, x_n]$. Additionally, $\bar{X}$ acts as the mean of all measurements; *S* as the standard deviation of all measurements; $w_{i,j}$ as the spatial weight between all pairs of cells *i* and *j*. The Getis-Ord Gi* is sensitive to the distance in which the spatial relationships among features are calculated (Songchitruksa & Zeng, 2010). A positive G_i^* value shows that high values cluster around cell *i*; hence the area is deemed a hot spot; a negative G_i^* value shows that low values cluster around cell *i*, so the area is termed a cold spot. The analyses were applied using ESRI ArcGIS software and mapped for age groups that show clustered conditions according to the global Moran's I. Spatial autocorrelation, and clustering methods have been widely used in studies related to spatial demography (Kurek et al., 2021; Matthews & Parker, 2013; Raymer et al., 2019).

3 | RESULTS: YOUNG AND ELDERLY POPULATIONS IN LATVIA

Since the early 1990s, Latvia and other CEE countries have experienced sudden and simultaneous turnabouts in all the main demographic processes: fertility, mortality, and migration (Fihel & Okólski, 2019). The consequent depopulation, urban shrinkage, and population ageing marked the most far-reaching societal changes of the post-Soviet (socialist) transformations. These transformations resulted in a radical demographic shift characterized by increased life expectancy, low fertility rates, more diverse family patterns. and the increasing significance of migration (Frejka et al., 2016; Krūmiņš & Krišjāne, 2016). Due to low fertility rates from the 1990s onwards, increasing longevity, and the emigration of young adults, Latvia, similar to other CEE countries, is have one of the oldest populations in Europe in the near future (Bērziņš, 2019).

3.1 | Ageing and population dynamics

Numerous indicators have been used to study population ageing (for example, see Lutz, 2009). These indicators often depend on an age threshold defining the "older" population. In the developed world, 65 years is the typical age for defining the older population, as this age is usually linked to retirement age. In this study, we focused on the share of the young and elderly as a summary measure to analyze the changes in the population age structure and its spatial patterns. Despite the widely used threshold of 65 years, we used the age of 75 and over as the threshold for the old population. Those aged 75 and over represent the fastest-growing section of the population in the developed world (Matthews et al., 2005). In the case of Latvia, it is also evident that this age group has had the most remarkable growth compared to other age groups during the study period (Figure 1). This is likewise true for Riga's metropolitan and nonmetropolitan areas. We also opted to analyze the changes and distribution of the young population group (aged 0–14 years). Specifically, we investigated the major macro-regions, distinguishing the Riga metropolitan area from the rest of the country (nonmetropolitan areas).

1.9 million people were living in Latvia as of 2020, of whom almost half were concentrated in the capital city, Riga (32.6%), or the surrounding metropolitan region (13.3%). The total population of the capital's metropolitan area was slightly lower than that of the nonmetropolitan population. Just over half (54.1%) of the country's population lived in regions outside the capital (Table 1). Overall, Latvia has been experiencing depopulation, and since 2000, the population has decreased by 19.9%. Population dynamics show a decline in most of Latvia's regions since 2000, apart from those within close proximity of Riga. Only suburbs have witnessed a population increase (18.1%). This is associated with the processes of suburbanization and positive in-migration (Berzins et al., 2021). The most significant decrease in the share of the population is observed in the nonmetropolitan regions. In total, these areas have witnessed their population decline by more than a quarter. The region of Latgale has experienced the most significant decrease, losing approximately one-third of its population. This easternmost region lags behind other regions within the European Union and is characterized by emigration and population ageing.

The median age in the country increased between 2000 and 2020 from 37 to 43 years, indicating that the population is ageing considerably. In 2000, the highest median age was observed in Riga (39 years) and the lowest in its suburbs (36 years). The nonmetropolitan regions of Kurzeme (in Latvia's west), Vidzeme (in the north), and Zemgale (in the south) were slightly below the national average and showed similar ageing patterns to Riga's suburbs. In the nonmetropolitan region of Latgale (in the eastern), the median age was 38 years.

In contrast, for 2020, the highest median age indicators were in the nonmetropolitan regions (44 years), especially in Latgale, where it reached 47 years. The median age has also increased in the Riga metropolitan region;

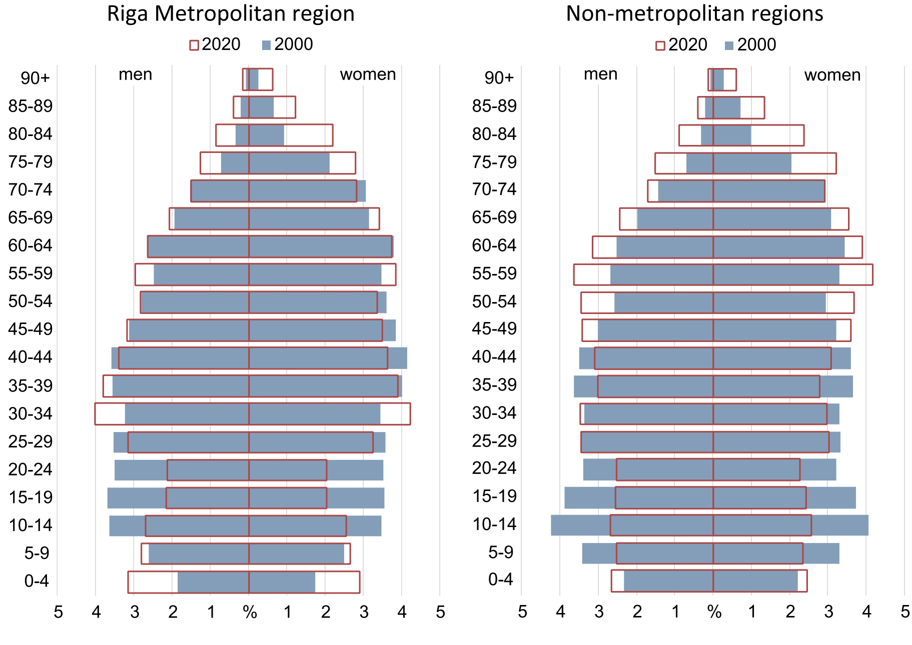

FIGURE 1 Standardized gender age structure for the Riga metropolitan region and Latvia's nonmetropolitan regions in 2000 and 2020. *Source*: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

TABLE 1 Population change and median age in Latvia (2000–2020).

	Population in 2020		Population change %	Median age	
	Thousands	Distribution %	2000–2020	2000	2020
Riga metropolitan region	875	45.9	−10.2	39	42
Riga city	621	32.6	−19.0	39	42
Suburbs	254	13.3	+18.1	36	40
Nonmetropolitan regions	1,032	54.1	−26.6	36	44
Kurzeme	283	14.8	−24.8	36	44
Vidzeme	262	13.7	−25.4	36	45
Zemgale	230	12.1	−21.7	36	43
Latgale	257	13.5	−33.3	38	47
Latvia	1,907	100.0	−19.9	37	43

Source: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

however, the increase is less than in other regions. Therefore, Riga and its suburbs were below the national average in 2020.

Data on the age composition of Latvia's population reveal that the young population has not changed as dramatically as the elderly population in recent decades. There are, however, geographical variations and a rise in the number of children in the Riga metropolitan area (Figure 1).

The bars in Figure 1 show the relative share of each age category in the respective year and by region. This allows us to see the disproportionate age distribution by the dichotomous regional split.

The age pyramid for Latvia shows that the metropolitan area of the capital city and nonmetropolitan areas were not demographically affected in the same way. While fertility decline and out-migration created a general ageing trend, relatively rapid suburbanization over the past two decades has lured many young families with children to the suburbs of metropolitan areas. In contrast, the populations of nonmetropolitan areas in Latvia have got older, with a higher proportion of the middle-aged and elderly but a relatively low proportion of children and young adults compared to the Riga metropolitan area.

Regarding both observed population groups, the elderly (75 plus years) have witnessed the highest relative increase, especially among women. In contrast, the population share of children has considerably decreased among 10–14 year olds in both the metropolitan and nonmetropolitan regions. The pattern of 0–4 year olds and 5–9 year olds is differentiated territorially and temporarily. The share of 5–9-year-old children in the Riga metropolitan region has slightly increased, whereas in nonmetropolitan regions it has decreased.

In order to assess the change in spatial distribution, we categorized the territorial units into four groups based on the increase/decrease of the total population and the specific age group. The predominant population change pattern for the younger population has been its decrease, supplemented with a decline in the total population (Figure 2). More patterns are evident among most territorial units of the Riga metropolitan region, where the total population has increased, including the younger population, except for three units where the younger population has dwindled. Larger urban centers in the Riga metropolitan area and peripheral rural territories show a negative pattern. Therefore, there has been a difference between the metropolitan and nonmetropolitan regions, with the former being more positive and the latter mostly negative.

The most predominant population change pattern among elderly people from 2000 to 2020 has been a decrease in the total population and an increase in the elderly population. This has been the most apparent characteristic in nonmetropolitan regions, such as Kurzeme, Zemgale, and Vidzeme, whereas the eastern part of Latvia has predominantly decreased both in terms of the total population and the elderly subpopulation. However, the Riga

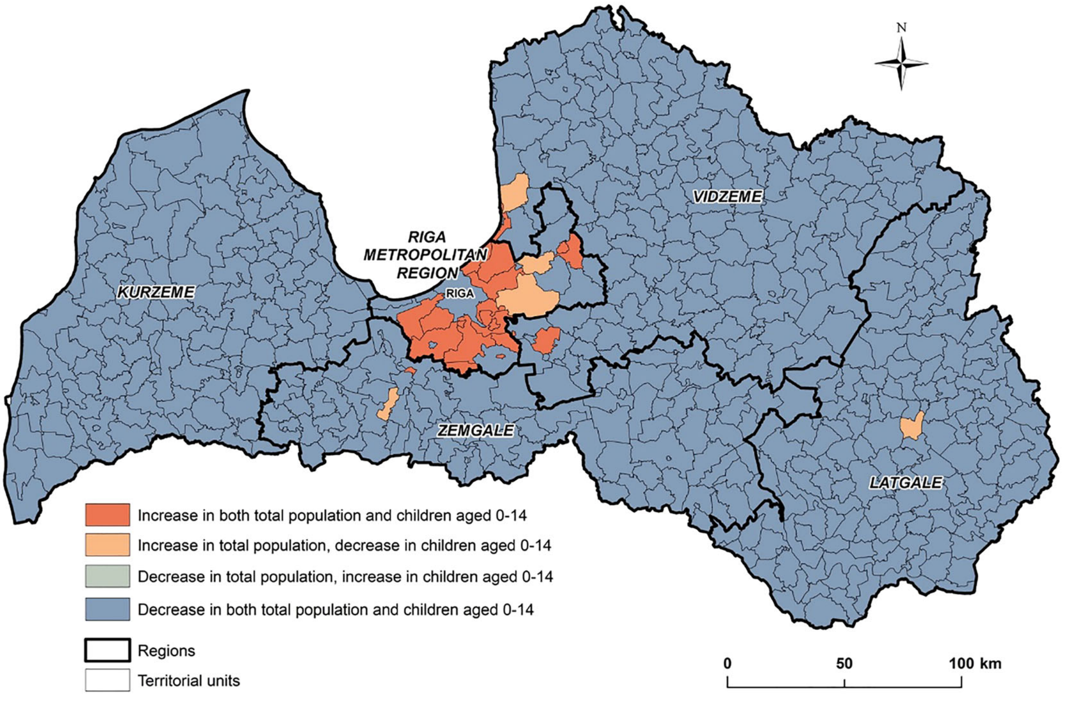

FIGURE 2 Distribution of the young population (0–14 years old) in Latvia, 2000–2020. *Source*: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

metropolitan region has witnessed an increase in the elderly in all territorial units, along with a rise in the total population in most units.

The overall pattern shows a relative increase in the younger population (0–14 years old) from 2000 to 2020 on a territorial unit level in the units near Riga, whereas for the units farther away, the younger and total population have decreased. In contrast, the elderly population has increased in most territorial units, including those within the Riga metropolitan region (Figure 3).

3.2 | Analysis of global Moran statistics

The results of the global spatial autocorrelation analysis are shown in Table 2. When analyzing the obtained results, a statistically significant positive spatial autocorrelation (p-value > 0.0000) was observed for both age groups in the studied years. This indicates the strong spatial autocorrelation of both selected age variables, meaning that the young and the elderly in Latvia are not randomly distributed.

The young populations in 2020 and the elderly populations in 2000 have the highest spatial autocorrelation values. Thus, it can be concluded that both selected age variables exhibit moderate or high spatial autocorrelation. When comparing the tested years, it should be noted that an increase in spatial autocorrelation values was observed for the young residents. In contrast, a decrease was observed for elderly residents over the last 20 years. As a result, the young population has become more spatially concentrated, while the elderly population has become less spatially concentrated. The calculated z-scores are positive and statistically significant, indicating that both age groups studied are clustered, that is, areas with high (hot) and low (cold) values tend to be close,

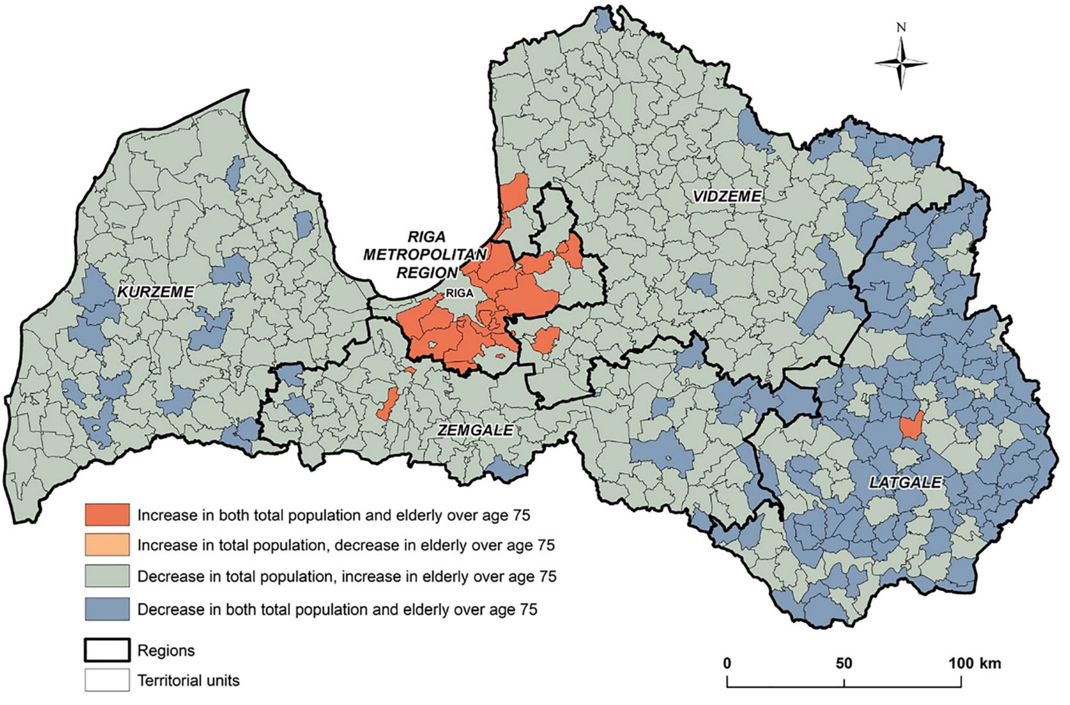

FIGURE 3 Distribution of the elderly (75 plus years) population in Latvia, 2000–2020. *Source*: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

TABLE 2 Global Moran's I statistics for selected age variables.

Year	2000		2020	
Age variable	0–14	75+	0–14	75+
Moran's I	0.7025	0.8980	0.8719	0.7572
z-score	1236.7*	1581.9*	1336.1*	1160.4*
p-value	0.0000	0.0000	0.0000	0.0000

*statistically significant, $p < 0.05$.

respectively. Given the nature of data aggregation on the hexagonal grid, we used inverse distance to conceptualize spatial relationships for both global and local analysis.

3.3 | Analysis of local spatial autocorrelation and clustering

While the global Moran's I index values show the general trend, the Getis-Ord Gi* shows the spatial pattern in local spatial autocorrelation and clustering. We used the Getis-Ord Gi* statistics to detect the hot spots and cold spots of young and elderly residents across the regional divides in Latvia. Different mapping techniques are used to depict hot spots in spatial analysis (Chainey et al., 2008; Songchitruksa & Zeng, 2010). We used the previously described unified hexagonal grid to map the residential patterns of the young and the elderly, effectively aggregating the data and spatial details by the specified area of 16 hectares. Hot spots detected through this mapping approach are

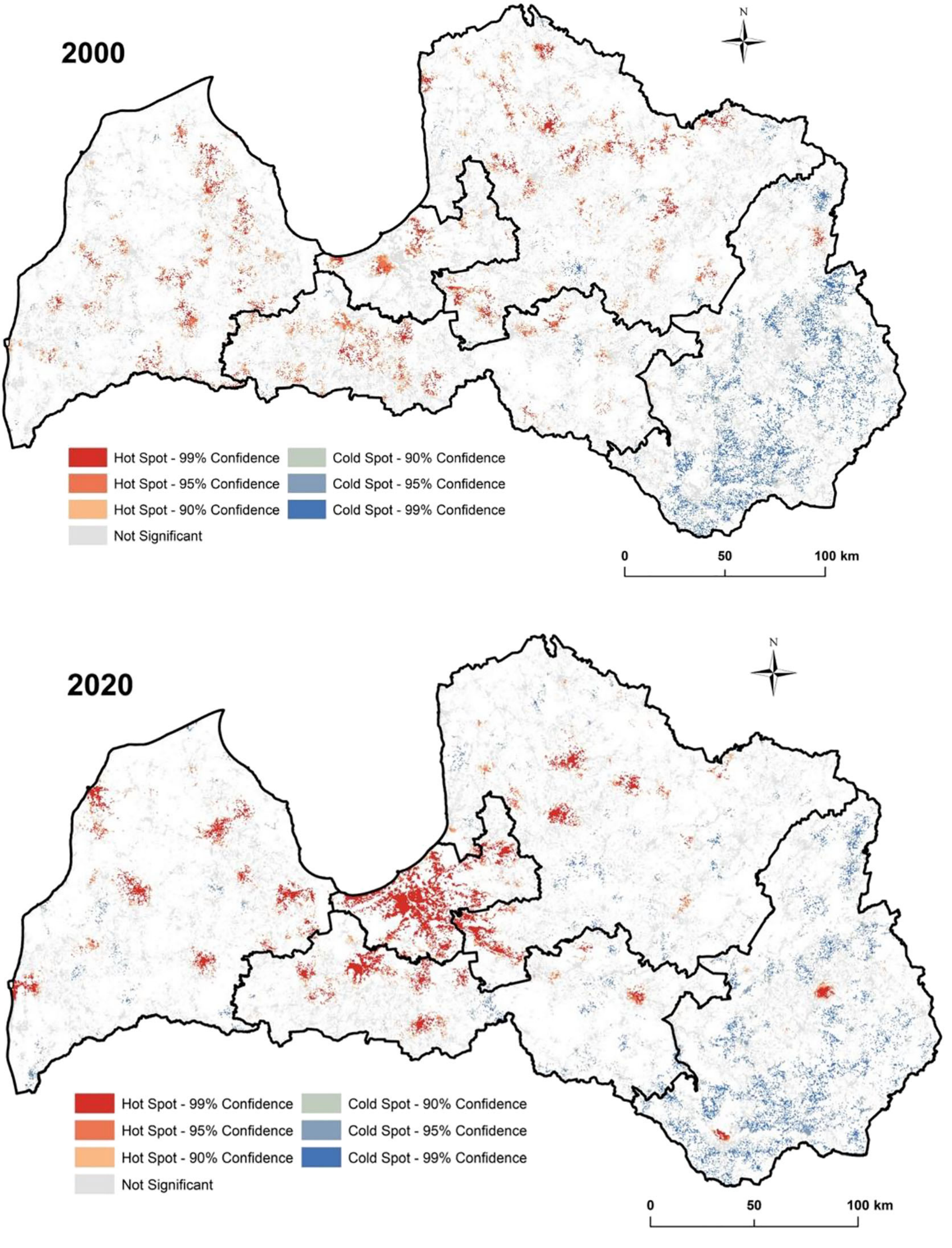

FIGURE 4 Getis-Ord Gi* statistics for the young population (0–14 years old), 2000 and 2020. *Source*: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

restricted to the shape of the grid cells, which should be considered when interpreting the results. The local Getis-Ord Gi* statistic demonstrates the diversity of clusters, which considers various confidence intervals. The result of the Getis-Ord Gi* statistic in 2000 showed multiple areas of statistically significant high clustering of young

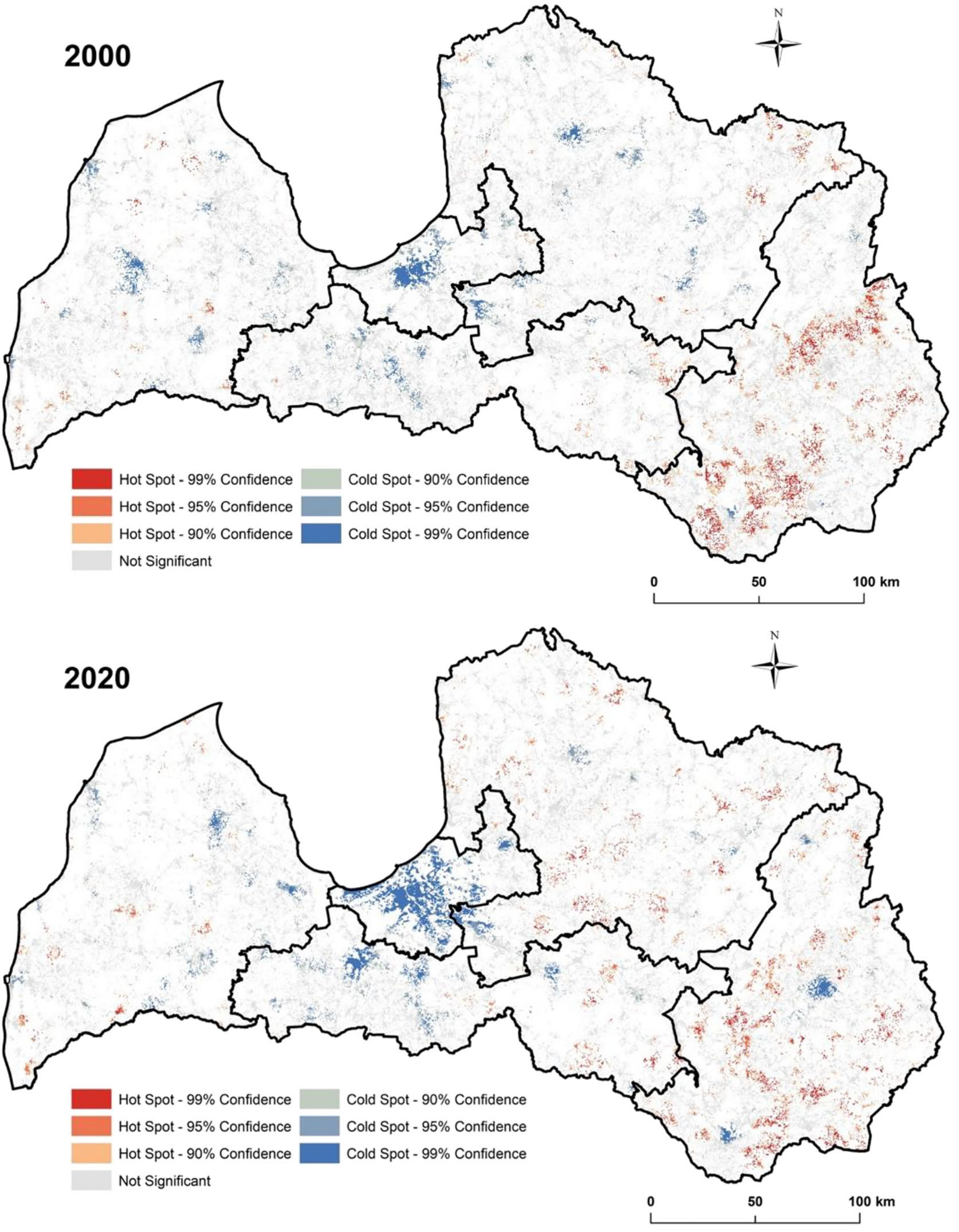

FIGURE 5 Getis-Ord Gi* statistics for the elderly (75 plus) population, 2000 and 2020. *Source*: Authors' calculations based on Central Statistical Bureau data (CSB) of Latvia, (2022).

residents in the rural regions and low clustering in eastern Latvia (the Latgale region). Thus, the hot spots of young residents in 2000 are sparsely located across the country, apart from the Latgale region. In 2020, the hot spots of young residents were more clustered in the Riga metropolitan region, especially in the suburbs, all the largest towns, and their surrounds, including the Latgale region (Figure 4). The concentration of cold spots in 2020 remained high in Latgale and was visible in other regions of Latvia to a much lesser extent.

Similarly, the Getis-Ord Gi* analysis revealed a noticeable regional split in easternmost Latvia, which is typically older with high clustering of elderly residents in the Latgale region (Figure 5). The hot spots indicate that the elderly in 2000 were mainly concentrated in rural areas in the east of the country. Meanwhile, a noticeable cold spot of elderly residents was detected in the capital city, Riga, and some areas around the large towns in the nonmetropolitan regions other than the Latgale region.

The Getis-Ord Gi* results revealed interesting changes when comparing the two studied years. The Riga metropolitan region highlighted a clear cold spot in the capital city and its suburbs in 2020 for elderly people. In fact, elderly cold spots were found in all the nonmetropolitan regions around the largest towns. Conversely, hot spots for the elderly were still primarily concentrated in rural areas of the country's easternmost region and, to a lesser extent, in certain rural areas of nonmetropolitan regions.

4 | CONCLUSION

Over the past two decades, a declining and ageing population have been the most significant demographic phenomena in Latvia. Fertility rates in all regions of the country have long been below the replacement level, resulting in natural population decline, while the continuing increase of life expectancy has increased number of older people. The only areas experiencing population growth are suburbs in the Riga metropolitan region, where in-migration from the core city and all nonmetropolitan regions is primarily driving population increase. This unprecedented demographic shift has substantially impacted the population's size and composition across Latvia's regions. Although the elderly population is increasing, their increase is rather heterogeneous across the regions, and there is a lack of geographical study to contextualize adequately and theorize the relationships between population change and ageing, and more specifically, residential patterns of certain age groups.

This study analyzed changes to the size of the young and the elderly populations in the context of the overall population dynamics and explained geographical variation in the residential patterns of both considered age groups. We used spatial analysis and mapping techniques, which allowed us to respect the established metropolitan/ nonmetropolitan divide and take advantage of the fine-grain data.

There have been significant changes in the population's gender–age structure during the observed period, with a substantial increase in the number of elderly people in all regions of Latvia and a noticeable gender imbalance in age groups above 65 years of age. Meanwhile, the results of our study reveal that the population growth in the suburbs of the Riga metropolitan region largely overlaps with the growth of the young and the elderly in these areas. Thus, despite initial expectations, there was no remarkable divergence in the dynamics of analyzed age groups within the Riga metropolitan region. The results indicate that the increase of the young and the elderly tend to converge in the metropolitan region. In contrast, all of Latvia's nonmetropolitan regions have experienced an overall decline in the total population and the young population, along with an increase in the elderly population, indicating more pronounced ageing. The exception is the easternmost Latgale region, which has experienced depopulation over the past two decades. Population decline is set to overtake population growth and, alongside regionally uneven ageing patterns, become the primary trend of population dynamics in most European countries (Kashnitsky & Aburto, 2020; Newsham & Rowe, 2022).

The findings indicated that both the young and the elderly in Latvia exhibited spatial autocorrelation on a global and local scale. The global Moran's I and the Getis-Ord Gi* spatial autocorrelation methods identified statistically significant clustering of both studied age groups. In the case of both age variables and across both analyzed years, the global Moran's I statistics revealed statistically significant moderate or strong spatial autocorrelation. Positive autocorrelation of the young and the elderly means there is a tendency to cluster spatially across the applied hexagonal grid. An analysis of local spatial autocorrelation statistics revealed a division into metropolitan/nonmetropolitan regions or more precisely, into central eastern Latvia, where the former is characterized by more favorable demographic trends, especially Riga's suburbs. We found less pronounced residential clustering of the elderly (aged 75 years and over) in areas with positive demographic dynamics, such as in-migration and lower fertility rates, particularly in the Riga metropolitan region. Similarly to other case studies conducted in CEE countries, our results show that the proportion of the elderly population is growing in both metropolitan and nonmetropolitan areas, with the growth being more rapid in nonmetropolitan regions (Kačerova et al., 2022; Kurek et al., 2020; Vaishar et al., 2020). At the same time, the increase in the share of children is exclusively limited to the metropolitan area. Our findings on the elderly population align with studies of ageing patterns beyond CEE countries, for example, in Spain, where more urbanized areas are found to age at a slower rate (Gutiérrez Posada et al., 2018). The study showed that spatial autocorrelation methods can be useful in analyzing age variables, including their temporal variation. Spatial autocorrelation at a fine-grain resolution can be a useful tool in analyzing the extent of processes, such as suburbanization, gentrification, and rural shrinkage.

Our analysis of population dynamics, depopulation pathways, and residential patterns of the selected age groups has important policy implications. It can serve as a useful tool to identify at-risk areas and regions of future concern in need of urgent policy intervention to mitigate or prevent the negative consequences associated with population decline and ageing. Moreover, the ageing population require direct and sustained public services, provisions, support, and resources. Therefore, the applied methods of spatial statistics may support identifying vulnerable areas characterized by similar or different values of selected demographic variables, allowing for the monitoring and planning of needed services.

Further research is required to thoroughly investigate the spatial and temporal relationships in population change, ageing, and distribution. In comprehensive policy design, it is important not to overemphasize the focus on the elderly population and also consider the changes in the number and proportion of children. As Latvia, along with the other CEE countries, is becoming one of the more rapidly ageing in Europe, policies must be adaptive, especially considering that the elderly population is also becoming more spatially dispersed.

ACKNOWLEDGEMENTS

The authors are grateful to the editor and anonymous reviewers for their comments on earlier version of the paper. This research is funded by the Latvian Council of Science, project DemoMigPro, project No. VPP-LETONIKA-2021/4-0002 and the University of Latvia.

ORCID

Zaiga Krisjane https://orcid.org/0000-0002-3422-1958
Maris Berzins https://orcid.org/0000-0002-5773-3307
Janis Krumins https://orcid.org/0000-0003-2262-9742
Elina Apsite-Berina https://orcid.org/0000-0001-5537-5879
Sindija Balode https://orcid.org/0000-0002-6968-512X

REFERENCES

Bērziņš, A. (2019). Iedzīvotāju sastāva novecošana. Krūmiņš, J., Krišjāne, Z.(zin. red.) *Tautas ataudze Latvijā un sabiedrības atjaunošanas izaicinājumi*. LU Akadēmiskais apgāds, Rīga, https://doi.org/10.22364/talsai.07

Berzins, M., Krisjane, Z., Krumins, J., & Spude, M. (2021). Ethnic and regional disparities of ageing in Latvia: Measuring residential segregation by age. New Challenges in Economic and Business Development–2021: Post-Crisis Economy, 92.

Borén, T., & Gentile, M. (2007). Metropolitan processes in post-communist states: An introduction. *Geografiska Annaler: Series B, Human Geography*, *89*(2), 95–110. https://doi.org/10.1111/j.1468-0467.2007.00242.x

Botev, N. (2012). Population ageing in central and Eastern Europe and its demographic and social context. *European Journal of Ageing*, *9*(1), 69–79. https://doi.org/10.1007/s10433-012-0217-9

Buzar, S., Ogden, P. E., & Hall, R. (2005). Households matter: The quiet demography of urban transformation. *Progress in Human Geography*, *29*(4), 413–436. https://doi.org/10.1191/0309132505ph558oa

Central Statistical Bureau (CSB) of Latvia. (2022). Population statistics (Database).

Chainey, S., Tompson, L., & Uhlig, S. (2008). The utility of hot-spot mapping for predicting spatial patterns of crime. *Security Journal*, *21*(1), 4–28. https://doi.org/10.1057/palgrave.sj.8350066

Couch, C., Cocks, M., Bernt, M., Grossmann, K., Haase, A., & Rink, D. (2012). Shrinking cities in Europe. *Town & Country Planning*, *81*(6), 264–270.

Dowd, J. B., Andriano, L., Brazel, D. M., Rotondi, V., Block, P., Ding, X., & Mills, M. C. (2020). Demographic science aids in understanding the spread and fatality rates of COVID-19. *Proceedings of the National Academy of Sciences*, *117*(18), 9696–9698. https://doi.org/10.1073/pnas.2004911117

Ferguson, N., Laydon, D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M., & Ghani, A. C. (2020). Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand. *Imperial College London*, *10*(77482), 491–497. https://doi.org/10.25561/77482

Fihel, A., & Okólski, M. (2019). Demographic change and challenge. In *Social and economic development in central and Eastern Europe* (pp. 101–132). Routledge. 10.4324/9780429450969-6

Frejka, T., Gietel-Basten, S., Abolina, L., Abuladze, L., Aksyonova, S., Akrap, A., & Zvidrins, P. (2016). Fertility and family policies in central and Eastern Europe after 1990. *Comparative Population Studies*, *41*(1), 3–56. https://doi.org/10.12765/CPoS-2016-03

Getis, A., & Ord, J. K. (1992). The analysis of spatial association by use of distance statistics. *Geographical Analysis*, *24*(3), 189–206. https://doi.org/10.1111/j.1538-4632.1992.tb00261.x

Gobiņa, I., Avotiņš, A., Kojalo, U., Strēle, I., Pildava, S., Villeruša, A., & Briģis, Ģ. (2022). Excess mortality associated with the COVID-19 pandemic in Latvia: A population-level analysis of all-cause and noncommunicable disease deaths in 2020. *BMC Public Health*, *22*(1), 1–12, 1109. https://doi.org/10.1186/s12889-022-13491-4

Gregory, T., & Patuelli, R. (2015). Demographic ageing and the polarisation of regions—An exploratory space–time analysis. *Environment and Planning a*, *47*(5), 1192–1210. https://doi.org/10.1177/0308518X15592329

Gurram, M. K., Wang, M. X., Wang, Y. C., & Pang, J. (2022). Impact of urbanisation and environmental factors on spatial distribution of COVID-19 cases during the early phase of epidemic in Singapore. *Scientific Reports*, *12*(1), 1–15, 9758. https://doi.org/10.1038/s41598-022-12941-8

Gutiérrez Posada, D., Rubiera Morollon, F., & Viñuela, A. (2018). Ageing places in an ageing country: The local dynamics of the elderly population in Spain. *Tijdschrift voor Economische en Sociale Geografie*, *109*(3), 332–349. https://doi.org/10.1111/tesg.12294

Haase, A., Bernt, M., Großmann, K., Mykhnenko, V., & Rink, D. (2016). Varieties of shrinkage in European cities. *European Urban and Regional Studies*, *23*(1), 86–102. https://doi.org/10.1177/0969776413481985

Haase, A., Kabisch, S., Steinführer, A., Bouzarovski, S., Hall, R., & Ogden, P. (2010). Emergent spaces of reurbanisation: Exploring the demographic dimension of inner-city residential change in a European setting. *Population, Space and Place*, *16*(5), 443–463. https://doi.org/10.1002/psp.603

Horňáková, M., & Sýkora, J. (2021). From suburbanisation to reurbanization? Changing residential mobility flows of families with young children in the Prague metropolitan area. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, *75*(4), 203–220. https://doi.org/10.1080/00291951.2021.1970014

Istrate, M., Muntele, I., & Bănică, A. (2015). Spatial resilience of the ageing population in the Romanian functional urban areas. *International Journal of Humanities and Social Sciences*, *9*(5), 1565–1575.

Kabisch, N., Haase, D., & Haase, A. (2019). Reurbanisation: A long-term process or a short-term stage? *Population, Space and Place*, *25*(8), e2266. https://doi.org/10.1002/psp.2266

Kačerova, M., Mladek, J., & Kusendova, D. (2022). Temporal and spatial analysis of population ageing and growing younger in Slovakia. *Folia Geographica*, *64*(1), 112–130.

Káčerová, M., Ondačková, J., & Mládek, J. (2014). Time-space differences of population ageing in Europe. *Hungarian Geographical Bulletin*, *63*(2), 177–199. https://doi.org/10.15201/hungeobull.63.2.4

Kashnitsky, I., & Aburto, J. M. (2020). COVID-19 in unequally ageing European regions. *World Development*, *136*, 105170. https://doi.org/10.1016/j.worlddev.2020.105170

Kashnitsky, I., De Beer, J., & Van, L. (2021). Unequally ageing regions of Europe: Exploring the role of urbanisation. *Population Studies*, *75*(2), 221–237. https://doi.org/10.1080/00324728.2020.1788130

Kashnitsky, I., De Beer, J., & Van Wissen, L. (2017). Decomposition of regional convergence in population aging across Europe. *Genus*, *73*(1), 1–25, 2. https://doi.org/10.1186/s41118-017-0018-2

Kashnitsky, I., & Schöley, J. (2018). Regional population structures at a glance. *The Lancet*, *392*(10143), 209–210. https://doi.org/10.1016/S0140-6736(18)31194-2

Kazimierczak, J., & Szafrańska, E. (2019). Demographic and morphological shrinkage of urban neighbourhoods in a post-socialist city: The case of Łódź, Poland. *Geografiska Annaler: Series B, Human Geography*, *101*(2), 138–163. https://doi.org/10.1080/04353684.2019.1582304

Krisjane, Z., & Berzins, M. (2012). Post-socialist urban trends: New patterns and motivations for migration in the suburban areas of Rīga, Latvia. *Urban Studies*, *49*(2), 289–306.

Krūmiņš, J., & Krišjāne, Z. (2016). Demogrāfiskā attīstība Latvijā: problēmas un izaicinājumi. *Latvijas Zinātņu Akadēmijas Vēstis" a" daļa*, *70*(3), 40–50.

Kulcsár, L. J., & Brown, D. L. (2017). Population ageing in Eastern Europe: Toward a coupled micro-macro framework. *Regional Statistics*, *7*(1), 115–134. https://doi.org/10.15196/RS07107

Kurek, S., & Wójtowicz, M. (2018). Reurbanisation in a post-socialist city: Spatial differentiation of the population in the Kraków area (Poland). *Geographia Polonica*, *91*(4), 449–468. https://doi.org/10.7163/GPol.0130

Kurek, S., Wójtowicz, M., & Gałka, J. (2017). Does suburbanisation contribute to the rejuvenation of a metropolitan area?: Changes in the age structure of the Kraków metropolitan area in Poland in the light of recent suburbanisation. *Geographia Polonica*, *90*(2), 59–70. https://doi.org/10.7163/GPol.0085

Kurek, S., Wójtowicz, M., & Gałka, J. (2020). The Population Ageing Process in Functional Urban Areas. In *Functional urban areas in Poland* (pp. 91–127). Springer.

Kurek, S., Wójtowicz, M., & Gałka, J. (2021). Using spatial autocorrelation for identification of demographic patterns of functional urban areas in Poland. *Bulletin of Geography. Socio-Economic Series*, *52*(52), 123–144. https://doi.org/10.2478/bog-2021-0018

Lang, T., Burneika, D., Noorkõiv, R., Plüschke-Altof, B., Pociūtė-Sereikienė, G., & Sechi, G. (2022). Socio-spatial polarisation and policy response: Perspectives for regional development in the Baltic States. *European Urban and Regional Studies*, *29*(1), 21–44. https://doi.org/10.1177/09697764211023553

Lloyd, C. D. (2014). Assessing the spatial structure of population variables in England and Wales. *Transactions of the Institute of British Geographers*, *40*(1), 28–43. https://doi.org/10.1111/tran.12061

Lutz, W. (2009). The demography of future global population aging: Indicators, uncertainty, and educational composition. *Population and Development Review*, *5*(2), 357–365. https://doi.org/10.1111/j.1728-4457.2009.00282.x

Matthews, R. J., Smith, L. K., Hancock, R. M., Jagger, C., & Spiers, N. A. (2005). Socioeconomic factors associated with the onset of disability in older age: A longitudinal study of people aged 75 years and over. *Social Science & Medicine*, *61*(7), 1567–1575. https://doi.org/10.1016/j.socscimed.2005.02.007

Matthews, S. A., & Parker, D. M. (2013). Progress in spatial demography. *Demographic Research*, *28*, 271–312. https://doi.org/10.4054/DemRes.2013.28.10

Nazia, N. (2022). Spatial variations of COVID-19 risk by age in Toronto, Canada. *Geospatial Health*, *17*(s1), 203–220. https://doi.org/10.1080/00291951.2021.1970014

Newsham, N., & Rowe, F. (2022). Understanding the trajectories of population decline across rural and urban Europe: A sequence analysis. *Population, Space and Place*, e2630. https://doi.org/10.1002/psp.2630

OECD. (2020). Regions and cities facing ageing. In *OECD regions and cities at a glance 2020*. OECD Publishing. 10.1787/9a6f8396-en

Ouředníček, M., Šimon, M., & Kopečná, M. (2015). The reurbanisation concept and its utility for contemporary research on post-socialist cities: The case of the Czech Republic. *Moravian Geographical Reports*, *23*(4), 26–35. https://doi.org/10.1515/mgr-2015-0022

Pilkington, H., Feuillet, T., Rican, S., de Bouillé, J. G., Bouchaud, O., Cailhol, J., Bihan, H., Lombrail, P., & Chantal, J. (2021). Spatial determinants of excess all-cause mortality during the first wave of the COVID-19 epidemic in France. *BMC Public Health*, *21*(1), 1–10. https://doi.org/10.1186/s12889-021-12203-8

Pužulis, A., & Kūle, L. (2016). Shrinking of rural territories in Latvia. *European Integration Studies*, *10*, 90–105. https://doi.org/10.5755/j01.eis.0.10.14988

Raymer, J., Willekens, F., & Rogers, A. (2019). Spatial demography: A unifying core and agenda for further research. *Population, Space and Place*, *25*(4), e2179. https://doi.org/10.1002/psp.2179

Reynaud, C., Miccoli, S., & Lagona, F. (2018). Population ageing in Italy: An empirical analysis of change in the ageing index across space and time. *Spatial Demography*, *6*(3), 235–251. https://doi.org/10.1007/s40980-018-0043-6

Rink, D., Couch, C., Haase, A., Krzysztofik, R., Nadolu, B., & Rumpel, P. (2014). The governance of urban shrinkage in cities of post-socialist Europe: Policies, strategies and actors. *Urban Research & Practice*, *7*(3), 258–277. https://doi.org/10.1080/17535069.2014.966511

Segers, T., Devisch, O., Herssens, J., & Vanrie, J. (2020). Conceptualising demographic shrinkage in a growing region–creating opportunities for spatial practice. *Landscape and Urban Planning*, *195*, 103711. https://doi.org/10.1016/j.landurbplan.2019.103711

Senbil, M., & Yetiskul, E. (2022). Spatial variation of elderly population and its dynamics in Turkey. *Population, Space and Place*, *28*(3), e2516. https://doi.org/10.1002/psp.2516

Songchitruksa, P., & Zeng, X. (2010). Getis–Ord spatial statistics to identify hot spots by using incident management data. *Transportation Research Record*, *2165*(1), 42–51. https://doi.org/10.3141/2165-05

Steinführer, A., & Haase, A. (2007). Demographic change as a future challenge for cities in east Central Europe. *Geografiska Annaler: Series B, Human Geography*, *89*(2), 183–195. https://doi.org/10.1111/j.1468-0467.2007.00247.x

Steinführer, A., Kabisch, S., & Grossmann, K. (2011). In A. Haase (Ed.), *Residential change and demographic challenge: The Inner City of east Central Europe in the 21st century* (1st ed.). Routledge. 10.4324/9781315605654

Sýkora, L., & Bouzarovski, S. (2012). Multiple transformations: Conceptualising the post-communist urban transition. *Urban Studies*, *49*(1), 43–60. https://doi.org/10.1177/0042098010397402

Ubarevičienė, R., & Burneika, D. (2020). Fast and uncoordinated suburbanisation of Vilnius in the context of depopulation in Lithuania. *Environmental & Socio-Economic Studies*, *8*(4), 44–56. https://doi.org/10.2478/environ-2020-0022

Ubarevičienė, R., Van Ham, M., & Burneika, D. (2016). Shrinking regions in a shrinking country: The geography of population decline in Lithuania 2001–2011. *Urban Studies Research*, *2016*, 1–18. https://doi.org/10.1155/2016/5395379

Vaishar, A., Šťastná, M., Zapletalová, J., & Nováková, E. (2020). Is the European countryside depopulating? Case study Moravia. *Journal of Rural Studies*, *80*, 567–577. https://doi.org/10.1016/j.jrurstud.2020.10.044

Wolff, M., & Wiechmann, T. (2018). Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990–2010. *European Urban and Regional Studies*, *25*(2), 122–139. https://doi.org/10.1177/0969776417694680

How to cite this article: Krisjane, Z., Berzins, M., Krumins, J., Apsite-Berina, E., & Balode, S. (2023). Uneven geographies: ageing and population dynamics in Latvia. *Regional Science Policy & Practice*, 1–16. https://doi.org/10.1111/rsp3.12648