frontiers | Frontiers in Sustainable Cities

TYPE Original Research
PUBLISHED 14 July 2025
DOI 10.3389/frsc.2025.1612980

OPEN ACCESS

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RECEIVED 16 April 2025
ACCEPTED 20 June 2025
PUBLISHED 14 July 2025

CITATION
Balode S and Bērziņš M (2025) Ethnic residential patterns in the inner-city core of Riga, Latvia using scalable individualized neighborhoods.
Front. Sustain. Cities 7:1612980.
doi: 10.3389/frsc.2025.1612980

Ethnic residential patterns in the inner-city core of Riga, Latvia using scalable individualized neighborhoods

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Urban residential segregation of immigrant populations is a key research area. Riga, Latvia, offers a unique context due to its Soviet-era migration legacy and increasing diversity from new immigration flows amidst demographic decline of established minorities. Analyzing the spatial patterns of emerging ethnic groups, who often exhibit residential clustering, is key to understanding potential spatial inequalities. This study investigated the residential concentration, isolation, and segregation of emerging ethnic groups in Riga's inner-city core using a multi-scalar geographic approach. Analyzing anonymized individual-level 2021 census data processed with EquiPop, we found that residential distribution and concentration varies significantly by spatial scale. Individualized neighborhoods effectively revealed multi-scalar patterns and intra-neighborhood heterogeneity. Results identified a concentration of new ethnic groups in the southern inner-city core, functioning as an "arrival space", alongside an influence of existing ethnic infrastructure on shaping residential patterns. This research provides crucial insights into the fine-scale spatial organization of new immigrant communities, informing the understanding and addressing of spatial inequalities, particularly those faced by non-European groups within the complex European context.

KEYWORDS

ethnic segregation, urban geography, k-nearest neighbor, immigration, Riga

1 Introduction

The escalating ethnic diversification of urban populations, driven by international migration, is a defining global trend of the twenty-first century. Within the European Union, this phenomenon has been particularly pronounced over the past decade, prompting urgent scholarly and policy attention toward understanding the complex relationship between immigration, shifting demographics, and spatial inequalities related to residential segregation. As Křížková and Šimon (2022) highlight, European nations display considerable heterogeneity in their ethnic neighborhood structures and associated inequalities, shaped by distinct welfare regimes, economic pathways, historical trajectories, and migration histories (Marcińczak et al., 2015). This inherent variability underscores the necessity for context-specific research into the dynamics of urban ethnic residential segregation.

Historically, research on ethnic segregation has been heavily influenced by the North American experience, which focused on deprived inner-city areas shaped by a sharp Black-White racial dichotomy and fueled by discriminatory federal policies (Massey et al., 2009). Although this paradigm is evolving with the rapid diversification of US suburbs (Walker, 2018), it provides a key point of contrast to Europe. The manifestation of ethnic

spatial inequalities across European cities is contingent upon varied migration histories (e.g., post-colonial, Soviet-era, intra-European) and different urban-political dynamics, including policies regarding social housing and privatization. In these European contexts, socioeconomic class has often played a more dominant role than race in shaping settlement patterns, resulting in different spatial patterns and lower levels of ethnic segregation (Arbaci, 2007).

Nevertheless, many European cities still exhibit significant ethnic minority concentrations within their central cores. Cities such as Berlin, Barcelona, Leeds, Brussels, and Rome exemplify this trend, with high levels of immigrant settlement and increasing multi-ethnicity in inner-city districts (Stillwell and Phillips, 2006; Martori and Apparicio, 2011; Salvati, 2016), alongside neighborhood polarization (Marcińczak and Bernt, 2021). Although European inner cities typically present more mixed socioeconomic profiles and more recent migrant populations than their American counterparts (Marcińczak et al., 2015; Stonawski et al., 2022b), they are not immune to pockets of deprivation where vulnerable immigrant groups in lower-quality housing face heightened risks of spatial isolation (Costa and de Valk, 2018).

Compounding the substantive analysis of these trends is the growing recognition of the methodological complexities inherent in measuring and comparing segregation. Residential segregation is a fundamentally multi-scalar phenomenon, contingent on context, the specific groups being analyzed, and the spatial scale of observation (Sleutjes et al., 2018; Lichter et al., 2020; Rogne et al., 2020). Consequently, conventional approaches relying on fixed, often arbitrarily defined administrative boundaries present significant challenges for comparative analysis and fail to capture the granular, dynamic nature of residential concentration. Addressing these methodological limitations is crucial for advancing our understanding of contemporary urban ethnic geographies.

This study directs its focus toward Riga, the capital of Latvia, situated on the eastern periphery of the European Union. Riga offers a unique socio-historical context for examining ethnic residential dynamics. Shaped significantly by Soviet-era migration policies, Latvia historically maintained a high proportion of foreign-born residents (14.0% in 2012, compared to the OECD average of 8.9%). However, recent demographic shifts indicate a decline in the long-established ethnic minority population (down to 11.9% by 2022) (Society at a Glance 2024, 2024), concurrent with new migration flows stimulated by globalization, geopolitical realignments, and European Union accession in 2004. These emerging flows, encompassing a greater diversity of origin countries and migration motivations and including a notable increase in immigrants from outside Europe, are reshaping Latvia's migration landscape.

Responding to these developments, this paper investigates the multi-scalar residential geographies of emerging ethnic groups within Riga's inner-city core. We seek to understand how spatial patterns of ethnic concentration, isolation, and segregation manifest and transform across different spatial scales. Specifically, we pose two central research questions: (1) What are the levels of residential concentration for emerging ethnic groups in Riga's inner-city core, and how do they vary with the scale of analysis? (2) How do indices of spatial isolation and segregation for these groups change across scales, and what do these variations reveal about the evolving dynamics of intra-urban ethnic diversity?

This research offers several distinct contributions. Methodologically, it introduces a novel multi-scalar approach to the Latvian context using fine-grained spatial units. It represents an early application of the 2021 census data to map the distribution of emerging immigrant communities in Riga's inner-city core across micro-, meso-, and macro-scales. Empirically, the study illuminates the changing migration dynamics within a post-socialist urban environment, leveraging Riga's distinctive demographic profile. By providing a fine-grained, scale-sensitive perspective on contemporary ethnic residential patterns, this analysis addresses a significant gap in the literature, particularly concerning newer immigrant populations in post-socialist cities. Furthermore, the findings contribute to a more nuanced understanding of ethnic community spatial organization—a subject of increasing public and political concern in Latvia—and hold important policy implications for anticipating and mitigating spatial inequalities as these emerging communities grow.

This paper is structured as follows. Section 2 reviews the literature on immigration and ethnic residential segregation. Section 3 introduces the study area, providing its historical and contemporary context. Section 4 details our methodology. Section 5 presents the empirical results. Finally, Section 6 discusses the implications of these findings, and Section 7 concludes the paper.

2 Immigration and ethnic residential segregation

As a persistent form of spatial inequality with profound social implications, ethnic residential segregation remains a central theme in urban studies. Residential segregation, broadly defined as the spatial separation of social groups along dimensions such as ethnicity, socioeconomic status, and age (Andersson et al., 2018), is intrinsically linked to shifts in urban residential configurations driven by international migration. Consequently, there is a link between a city's level of immigration and its degree of ethnic segregation (Skifter Andersen et al., 2016).

Although the discourse on ethnic residential segregation in European contexts is scarce, a key debate concerns the relative weight of its causal factors. Evidence points toward the significance of residential preferences and voluntary self-segregation, where individuals choose to live near co-ethnics for social support, cultural familiarity, or perceived safety (Bolt, 2009; Malmberg and Clark, 2021). However, structural and economic constraints, including housing market discrimination, affordability issues, and information barriers (Bolt et al., 2010), are also acknowledged as significant contributing factors, particularly shaping the residential outcomes of more vulnerable populations.

The intersection of socioeconomic status and ethnicity is crucial in reinforcing spatial segregation, as a lower socioeconomic status can significantly limit housing choices (Imeraj et al., 2018). This dynamic is particularly relevant in contexts with rising socioeconomic disparities, as observed across parts of Europe, including Eastern Europe (Marcińczak et al., 2015;

Lichter et al., 2020), even where overall urban ethnic residential segregation was comparatively low in the early 21st century (Musterd, 2005). The complexity of this intersection is evident in Southern European cities, where low spatial segregation often paradoxically reflects high social segregation due to an exclusionary, owner-dominated housing system (Arbaci, 2007). Consequently, the degree of socioeconomic integration represents an important set of constraints and opportunities that influence the initial and subsequent residential patterns of emerging immigrant populations.

Furthermore, empirical research consistently reveals differentiated segregation experiences across migrant groups. Notably, migrants of non-European origin often exhibit higher levels of spatial concentration in European cities compared to their European counterparts (Malmberg et al., 2018; Lichter et al., 2020), a trend also observed among smaller non-European groups in Krakow (Stonawski et al., 2022a). This is frequently attributed to initial settlement patterns, where newcomers facing precarious socioeconomic circumstances settle in established areas with existing co-ethnic support networks (Imeraj et al., 2018). The combination of socioeconomic vulnerability and greater cultural distance can thus foster distinct concentration patterns. Understanding these dynamics is vital for analyzing the residential geographies of diverse migration flows arriving in cities like Riga, where they interact with a demographic landscape shaped by a Latvian majority and large, established post-Soviet minority populations.

High levels of residential concentration, as a result of preference and constraint across socioeconomic and cultural dimensions, can lead to the formation of ethnic enclaves. These spaces can function ambivalently (Catney, 2016): offering initial vital resources, social capital, and a buffer against discrimination for newcomers (Harris, 2023), while potentially limiting wider social networks and long-term socioeconomic mobility (Hack-Polay, 2019). Strong concentrations of specific ethnic groups may also influence the residential decisions of other populations. While the term "white flight" carries specific historical connotations, broader processes of majority population avoidance or relocation from diversifying, predominantly non-European neighborhoods, driven by factors ranging from prejudice to preferences for social homogeneity or perceived changes in neighborhood status, have been observed in various European contexts (Bolt, 2009; Hårsman, 2006; Malmberg and Clark, 2021; Stonawski et al., 2022b). While this study's focus on a single time point cannot track such dynamics longitudinally, mapping the current multi-scalar concentrations of emerging non-European groups in Riga's inner-city core provides a crucial baseline for understanding potential future shifts in the residential distribution of all population segments within the area.

Ultimately, the spatial organization of ethnic groups has far-reaching consequences for migrants' individual opportunity structures and the overall trajectory of urban development. Residential location significantly shapes access to opportunities (employment, education, healthcare), exposure to risks (crime), and potential for social cohesion, or tension, with segregation amplifying these effects (Kaplan and Douzet, 2011). Furthermore, segregation reduces inter-ethnic contact and increases the risk of neighborhood stigmatization (Malmberg et al., 2018), contrasting with the benefits of ethnic mixing and diversification. Understanding how patterns of concentration and isolation for emerging ethnic groups vary across different spatial scales within Riga's rapidly diversifying inner-city core is therefore paramount for developing informed urban policies aimed at fostering equitable integration and mitigating potential spatial inequalities.

3 Study area: Riga's inner-city core

This study focused on the inner-city core of Riga, the capital of Latvia. This area, encompassing the historic Old Town and six adjacent neighborhoods (Centrs, Avoti, Grizinkalns, Brasa, Skanste, Petersala-Andrejsala), forms a distinct geographical and social unit within the city. The inner-city core of Riga is characterized by a predominantly regular street network, with residential neighborhoods that trace their origins to the early 20th century, prior to the onset of the First World War. The delineation of these neighborhoods largely aligns with the street network and the prevailing pattern of urban development (Figure 1). On the outskirts of the inner-city core, to the south and east lie former working-class residential districts and erstwhile manufacturing sites. In contrast, the northern areas comprise the former port, industrial, and railway territories.

Our focus on this area was based on three primary rationales. First, as demonstrated in previous research (Balode and Bērziņš, 2025) and corroborated by recent census data, Riga's inner-city core exhibits the most significant concentration and growth of newly emerging non-European ethnic minority groups compared to the rest of the city and country. Second, the area's unique urban morphology, which is largely characterized by 19th and early 20th-century architecture, creates a distinct built environment that contrasts sharply with the Soviet-era mass housing estates in surrounding neighborhoods, making it potentially more appealing to immigrant populations. Third, the inner core is geographically delineated by major railway lines and the Daugava River, creating a degree of spatial enclosure that limits social interactions and reinforces its suitability as a discrete analytical unit.

The administrative neighborhoods constituting the inner-city core display considerable heterogeneity in spatial extent (ranging from 94 to 373 hectares) and population size (1,900 to 30,700 residents in 2021). This results in substantial variations in population density (8.7 to 98.4 inhabitants per hectare), highlighting the potential pitfalls of using administrative boundaries for spatial analysis due to the Modifiable Areal Unit Problem (MAUP), encompassing both scale and zoning effects (Openshaw, 1996). This internal variability necessitates methods robust to these challenges.

3.1 Riga's inner-city core: from post-socialist legacies to fragmented gentrification

This subsection provides essential background on Riga's inner-city core, outlining the historical legacies, contemporary migration and socioeconomic trends, and housing characteristics that shape

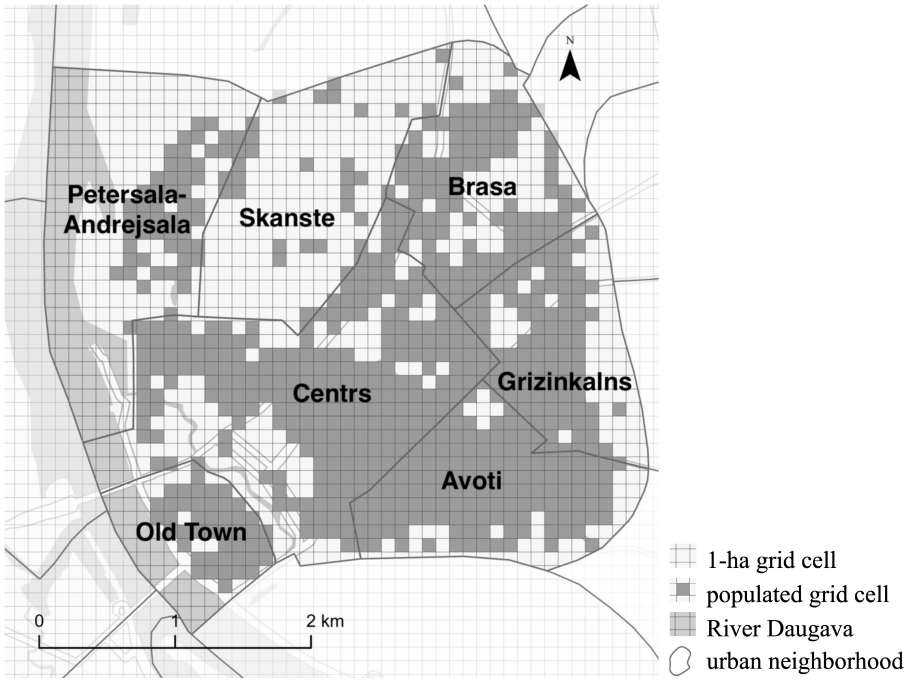

FIGURE 1
Study area: a grid of populated 100 m x 100 m cells and administrative neighborhoods of Riga's inner-city core.

the context for analyzing the residential patterns of emerging ethnic groups.

As Latvia's capital and primary economic hub, Riga's development has been significantly shaped by historical processes. During the Soviet era (1940–1991), the city experienced substantial in-migration, predominantly of Russian speakers, fundamentally altering its demographic composition. Understanding contemporary residential patterns requires acknowledging these legacies, particularly the Soviet-era housing allocation policies, subsequent large-scale privatization processes following independence, and a persistently underdeveloped social housing sector (Krišjāne et al., 2019). Notably, Soviet-era migrants usually possessed relatively high socioeconomic status (Bolt et al., 2010), and, consequently, Riga historically exhibited relatively low levels of both socioeconomic and ethnic residential segregation, lacking the pronounced ethno-social hierarchy similar to other post-socialist cities (Krišjāne et al., 2015; Hess et al., 2018). However, the emergence of new, post-independence migration flows necessitates a critical re-evaluation of ethnic segregation dynamics (Tammaru et al., 2016).

Latvia, like many Central and Eastern European (CEE) nations, fits within migration cycle theory as a country with relatively recent international migration patterns, characterized by a predominance of first-generation migrants (Arango, 2018). Migration policies are increasingly influenced by European Union directives, yet the specific trajectories of CEE countries are unlikely to simply replicate those of established Western European immigration nations due to recency of migrant reception, differing historical contexts, global positioning, and structural economic and social characteristics. Post-socialist cities across the region are witnessing new patterns of immigration (Křížková and Šimon, 2022), raising concerns about the potential for increased ethnic residential segregation as immigration levels rise.

The post-socialist transition to capitalism in Riga has coincided with increasing socio-spatial disparities, particularly evident within the inner city (Krišjāne and Bērzinš, 2014). Examining the interplay between contemporary immigration, ethnic change, and gentrification processes is therefore crucial, though it remains an understudied nexus. Existing international research often indicates a positive correlation between higher immigration rates and gentrification processes, particularly where less affluent neighborhoods experience ethnic diversification alongside urban renewal (Hwang, 2015). In-migration can stimulate housing demand, potentially leading to price escalation, subsequent in-migration of higher-income residents, and displacement pressures on lower-income populations (Haase et al., 2020; Malmberg and Clark, 2021). This highlights the complex role ethnic minorities can play as both potential victims and sometimes inadvertent agents of neighborhood change (Huse, 2018). Furthermore, fragmented socio-spatial transformations, encompassing marginal gentrification alongside non-EU migrant settlement, may intensify social divisions, especially if gentrifiers exhibit limited cross-ethnic social engagement while immigrants rely more heavily on neighborhood-based social networks (Malheiros et al., 2013).

Illustrating these dynamics, recent socio-demographic data (Table 1) revealed growing divergence between Riga's inner-city core and the rest of the city. Between 2011 and 2021, the inner core experienced significantly slower overall population decline, partly because of the smaller share of long-established declining ethnic groups and new in-migration. The inner core

TABLE 1 Demographic and socioeconomic characteristics of Riga's inner-city core and rest of the city in 2021, with changes from 2011 to 2021.

	Inner-city core (2021)	Change 2011–2021 (%)	Rest of the city (2021)	Change 2011–2021 (%)
Inhabitants (thousands)	82.3	−1.1	534.5	−7.1
Average age	38.8	−2.3	43.1	3.6
% of 15- to 44-year-olds	43.3	−4.6	36.1	−11.4
Income and education				
Median monthly net salary (EUR)*	837.9	129.7	718.6	123.7
Highest education**	52.7	24.9	38.7	22.1

*Reported annually, non-equalized.
**Share of permanent residents aged 18 and over who have highest education or doctorate degree.
Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).

TABLE 2 Housing profiles of Riga inner-city core neighborhoods: new-built (post-2011) and rental housing shares.

		% of residents in new-built housing	% of rental housing
Inner-city core neighborhoods	Avoti	0.3	48.0
	Brasa	2.2	27.4
	Centrs	1.7	37.8
	Grizinkalns	0.5	44.7
	Petersala-Andrejsala	8.6	20.8
	Skanste	50.3	18.3
	Old town	0.0	33.7
Riga avg.		2.7	17.4

Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).

also exhibited a younger population profile, which was also influenced by a notable surge among non-European residents in younger age classes—particularly males aged 15–29, suggesting an influx of international students (Apsite-Berina et al., 2023), and females aged 20–39 (Central Statistical Bureau of Latvia, 2025). Critically, markedly elevated median monthly net salaries and higher educational attainment levels in the inner core signaled a widening socioeconomic gap compared to the rest of Riga. This concentration of relative affluence risks exacerbating inequalities through differentiated housing markets, service provision, and urban policy outcomes.

The housing landscape within Riga's inner-city core is far from uniform, exhibiting significant heterogeneity at the administrative neighborhood level (Table 2). New-build gentrification appeared significant but spatially limited; only two neighborhoods showed a proportion of residents in new-build housing (post-2011) significantly above the city average (50.3% and 8.6% vs. city average of 2.7%). Such new developments can sometimes contribute to increased ethnic segregation (van Gent and Hochstenbach, 2020). The remaining inner-city neighborhoods, while displaying lower levels of new construction, have often experienced façade renovations and other forms of marginal gentrification.

A key characteristic was the high proportion of rental housing, which exceeded twice the city average in most inner-city neighborhoods. This prevalence of rental accommodation facilitates settlement for newcomers, contributing to the formation of "urban arrival spaces". These areas are often characterized by diverse international populations, high residential mobility (in- and out-migration), a concentration of disadvantaged residents, and relatively lower rents, though spatial outcomes remain strongly influenced by housing market dynamics (Hans et al., 2019; Haase et al., 2020). Notably, the neighborhoods featuring the highest share of new buildings tended to exhibit the lowest proportion of rental housing. This heterogeneous housing stock—encompassing older buildings, renovated structures, limited new builds, and extensive rental options—fundamentally shapes the opportunities and constraints faced by emerging ethnic groups seeking residence within Riga's inner-city core.

4 Data and methods

4.1 Data source and preparation

The primary data source for this analysis was the 2021 Population and Housing Census of Latvia, provided by the Central Statistical Bureau (CSB) of Latvia. We utilized anonymized, individual-level census records geo-referenced to precise residential locations. For analytical purposes, these individual data points were aggregated into a regular grid network of 1-hectare (100 m x 100 m) cells covering the study area (Figure 1). This grid-based approach provided spatially consistent units, overcoming the limitations of varying administrative boundary sizes.

The 2021 census identified 330 distinct ethnic groups based primarily on self-identified affiliation, usually tracing direct ancestral lineage. For this study, we focused on the spatial distribution of the two largest established populations (Latvians and Russians) and the three most rapidly expanding emerging ethnic groups identified in the inner core (Indians, Uzbeks, and Vietnamese). A key limitation of the census data is the lack of provision for mixed-ethnic identification and the inclusion of "unspecified" and "unknown" categories. The number of people who did not declare their ethnicity increased by about 5 times between the 2011 and 2021 censuses, and the share of non-responses/non-selection to the ethnicity question in the total population reached 4.4% in 2021 compared to 0.7% in 2011.

Recent demographic trends between 2011 and 2021 underscored the rationale for focusing on these specific groups. City-wide, the combined proportion of the five historically largest ethnic groups (Latvians, Russians, Belarusians, Ukrainians, and Poles) in Riga decreased from 96% to 92%, indicating a gradual decline in the dominance of established communities (Central Statistical Bureau of Latvia, 2025). Against this backdrop,

the inner-city core exhibited distinct dynamics, which can be characterized by two key movements detailed in Table 3. First, the absolute populations of all established ethnic communities, except Ukrainians, declined within the inner core, but despite the numerical decrease, the proportional share of Latvians in the inner core remained high and stable (64.9% in 2021), far exceeding their share in the rest of Riga (44.6% in 2021). Second, emerging communities from outside Europe experienced exceptionally high relative growth within the inner core. Indian, Uzbek, and Vietnamese populations grew by 95.7%, 89.8%, and 99.1% respectively. Although starting from a very low baseline, this rapid influx led to a substantial increase in their proportional representation (up to 16-fold). This observed demographic shift, characterized by the decline of established populations alongside the rapid, concentrated growth of specific non-European groups, marked the inner core as a key site of transformation warranting detailed multi-scalar analysis of their residential geographies, especially considering their recent arrival and potential socioeconomic vulnerabilities.

4.2 Addressing scale dependency: the k-nearest neighbors (k-NN) approach

To address the research questions regarding concentration, isolation, and segregation across varying spatial scales, and to mitigate the MAUP inherent in fixed administrative units, we employed a multi-scalar analytical approach based on k-nearest neighbors (k-NN), facilitated by advancements in software and high-resolution data availability.

The k-NN method was selected as it effectively mitigates the MAUP, enables nuanced multiscale analysis, and enhances inter-study comparability (Marcińczak et al., 2023). Multiscale measures derived from this approach reflect individual exposures to socio-spatial contexts, thereby providing a more comprehensive understanding of the multiscale nature of geographical context (Petrović et al., 2018). The k-NN method has proven instrumental in revealing subtle ethnic segregation patterns, as evidenced by numerous empirical studies, where residential segregation can simultaneously increase at one spatial scale while decreasing at another (Šimon et al., 2023). Segregation varies across contextual dimensions—including inter- and intra-city differences shaped by policies—as well as scalar and ethnic-group-specific dimensions driven by individual and institutional forces, with k-NN facilitating micro- and meso-level analyses that help to reveal highly localized concentrations, which are often masked at broader spatial scales (Malmberg et al., 2018; Marcińczak et al., 2023; Nielsen and Hennerdal, 2017; Sleutjes et al., 2018). In our study, the application of k-NN method facilitated a more comprehensive examination of the residential patterns of emergent ethnic groups at the inner-city core. Nonetheless, we recognize the conclusions of other researchers that this methodology does not encompass all potential advantages and does not entirely resolve the existing MAUP, as the current continuous grid coverage overlooks several physical aspects of the urban environment (Amcoff, 2025). While physical geographical constraints on mobility may influence meso-scale indices (Östh and Türk, 2020), this effect is considered mitigated within our study area, as discussed previously.

The k-NN method constructs local environments, or "bespoke neighborhoods", around each individual (or in this case, each grid cell centroid) based on population proximity rather than predefined boundaries. For each 1-hectare grid cell, the neighborhood is formed by expanding outwards until a specified population size (k) of nearest residential neighbors (individuals) is encompassed. This approach creates individualized, overlapping neighborhoods defined by the user-specified k-values, effectively mitigating MAUP and allowing for a nuanced assessment of segregation patterns across a continuum of spatial scales.

We implemented this approach using the EquiPop Flow software (Östh, 2024). Calculations were performed for eight different k-values: 50, 100, 200, 400, 800, 1,600, 3,200, and 6,400 nearest neighbors. This range allows examination of patterns from highly localized micro-scales (e.g., $k = 100$, representing local neighborhood) to broader meso- and macro-scales (e.g., $k = 6{,}400$, representing broader community) (Östh et al., 2015; Östh and Türk, 2020). Within Riga's inner-city core, these k-values corresponded to neighborhoods with average radii ranging from approximately 36 meters ($k = 50$) to 607 meters ($k = 6{,}400$), and areas from 0.4 hectares to 115.8 hectares, respectively, reflecting the varying spatial extents captured by different scales.

4.3 Quantitative indices

To measure different dimensions of spatial distribution, we calculated three indices for each of the five ethnic groups (Indians, Uzbeks, Vietnamese, Latvians, and Russians) at each analytical scale (k-value). The selected indices were the location quotient (LQ), the spatial isolation index (SII), and the index of segregation (IS), following the methodology of Tammaru et al., 2016 and van Ham et al. (2021), adapted for the k-NN context based on the methodology of Imeraj et al. (2018).

Location quotient (LQ) measures the relative concentration of an ethnic group within a specific k-NN neighborhood compared to the group's overall representation in the inner-city core study area. It identifies areas of over- or under-representation at different scales. The formula is:

$$\mathbf{LQ_{i,k}} = \frac{\mathbf{x_{i,k}}}{\mathbf{k}} \div \frac{\mathbf{X}}{\mathbf{T}} \tag{1}$$

where $x_{i,k}$ is the ethnic group size in neighborhood i with k-nearest neighbors; k is the number of nearest neighbors; X is the total ethnic group size in the study area; T represents the total population of the study area, serving as a benchmark to determine whether an ethnic group is more or less concentrated in an individualized neighborhood compared to its average presence across the entire study area. Consistent with Brown and Chung (2006), we defined a LQ range between 0.85 and 1.20, where a value of 1.20 or above indicates significant concentration and a value of 0.85 or below indicates under-representation.

Spatial isolation index (SII) measures the probability of an individual from an ethnic group encountering another individual from the same group across k-NN neighborhood. It reflects

TABLE 3 Changes in ethnic group composition and distribution in Riga's inner-city core and the rest of the city, 2011–2021.

		% population*				% change	
		Inner-city core		Rest of the city		Inner-city core	Rest of the city
		2011	2021	2011	2021	2011–2021	2011–2021
	Latvians	64.7	64.9	43.7	44.6	−3.5	−5.5
	Ethnic minorities	35.3	35.1	56.3	55.4	−4.3	−9.0
Declining ethnic groups	Russians	71.0	59.8	75.3	69.1	−19.4	−16.5
	Ukrainians	5.6	6.3	6.5	6.6	7.0	−7.8
	Belarusians	5.0	4.8	7.4	7.1	−8.9	−13.3
	Poles	3.8	3.4	3.4	3.2	−13.2	−14.0
	Jews	4.0	2.7	1.1	0.8	−35.3	−35.7
	Lithuanians	1.9	1.8	1.5	1.5	−9.5	−11.6
Growing ethnic groups	Vietnamese	0.0	0.4	0.0	0.0	99.1	83.8
	Indians	0.1	1.6	0.0	0.2	95.7	88.9
	Uzbeks	0.1	0.9	0.0	0.3	89.8	80.7
	Chinese	0.1	0.2	0.0	0.0	76.9	82.1
	French	0.2	0.5	0.0	0.0	60.5	59.2
	Azeris	0.2	0.4	0.3	0.3	47.2	−10.9

Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).
*Share of specific ethnic groups is calculated as a proportion of all ethnic minorities, i.e., excluding Latvians and those whose ethnic group is unspecified or unknown.

the degree of potential intra-group interaction within localized environments. The formula is:

$$\mathbf{SII_k} = \frac{\sum_{i=1} \left(\mathbf{x_{i,k}} \times \frac{\mathbf{x_{i,k}}}{\mathbf{k}}\right)}{\sum_{i=1} \left(\mathbf{x_{i,k}}\right)} \quad (2)$$

where k is the number of nearest neighbors; $x_{i,k}$ is the ethnic group size in neighborhood i with k-nearest neighbors; $\frac{x_{i,k}}{k}$ is the proportion of the ethnic group in neighborhood i with k-nearest neighbors. Values range from 0 (0% likeliness of encountering a co-ethnic neighbor) to 1 (100% certainty of encountering only co-ethnic neighbors).

Index of segregation (IS) measures the degree to which an ethnic group's spatial distribution across k-NN neighborhoods differs from that of the rest of the population. The formula is:

$$\mathbf{IS_k} = 0.5 \sum_{i=1} \left| \frac{\mathbf{x_{i,k}}}{\mathbf{X}} - \frac{\mathbf{k} - \mathbf{x_{i,k}}}{\mathbf{T} - \mathbf{X}} \right| \quad (3)$$

where $x_{i,k}$ is the ethnic group size in neighborhood i with k-nearest neighbors; X is the total ethnic group size in the study area; k is the number of nearest neighbors; T is the total population in the study area. Values range from 0 (perfect integration), where the group's distribution mirrors that of the rest of population, to 1 (complete segregation), where the group is exclusively concentrated.

We calculated the segregation indices using the Geo-Segregation Analyzer v.1.2. (Apparicio et al., 2014) and performed all subsequent spatial analysis and map production in ArcGIS Pro.

5 Results

The multi-scalar analytical strategy employed in this study yielded significant insights into the contemporary residential geographies of Riga's inner-city core, revealing stark contrasts between established populations and emerging ethnic communities, thereby addressing the central research questions regarding scale-dependent concentration, isolation, and segregation. The findings, derived from location quotient (LQ), spatial isolation index (SII), and index of segregation (IS) analyses of 2021 census data processed through a k-nearest neighbor framework, not only quantified current patterns but also situated them within Riga's unique post-socialist context and the broader dynamics of new migration in Central and Eastern Europe.

5.1 Aggregate concentrations and ethnic geographies

LQ analysis underscored the divergent spatial concentration processes operating within the inner core. The relatively even distribution of the established Latvian and slightly more concentrated Russian populations, exhibiting low and scale-stable maximum LQ values (Figure 2), aligned with Riga's historical legacy of comparatively low ethno-social segregation documented in the literature. Conversely, the emerging Indian, Uzbek, and Vietnamese communities demonstrated patterns characteristic of recent migration flows concentrating in specific urban locales and were highly sensitive to scale. Their exceptionally high maximum LQ values at micro- and meso-scales, despite more

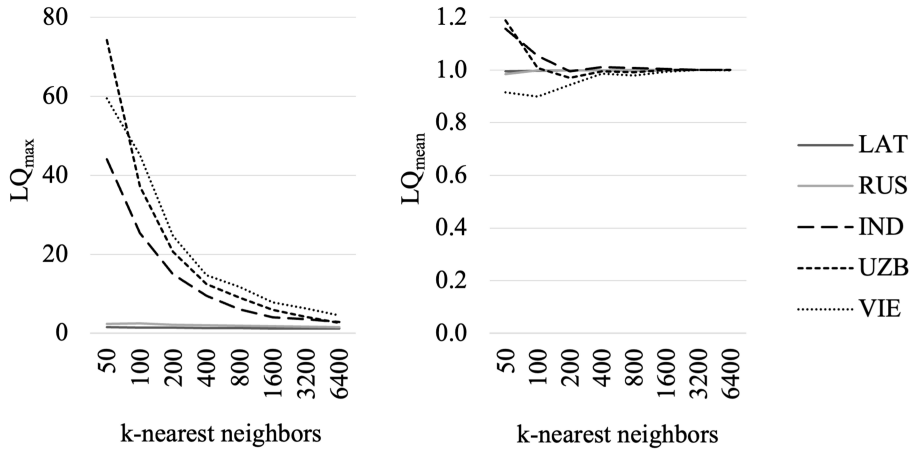

FIGURE 2
Maximum and mean location quotient in inner-city core of Riga, by ethnic group and k-nearest neighbors in 2021. Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).

moderate, seemingly balanced mean LQs—a consequence of zero presence in many generally populated local units—signified intense clustering rather than widespread integration. This finding validated the necessity of the multi-scalar methodology adopted, as aggregate measures or single-scale analyses would obscure the profound localized overrepresentation shaping the initial settlement geography of these newcomers.

Spatial mapping across varying scales (k = 200, 800, 6,400; Figure 3) further illuminated the distinct territorial expressions of these groups within Riga's transforming inner-city landscape. While all emerging groups exhibited high concentration clusters at all scales, their specific geographies differed: Indians showed clustering across several neighborhoods with a notable locus in the southwest, including Old Town, and balanced representation in the southeast; Uzbeks displayed partial overlap with Indians but were underrepresented in the east and also showed a distinct presence near established Russian communities in the north, particularly the western section; Vietnamese presented the most spatially confined pattern, concentrated strongly in the southeast across all scales. In contrast, at the micro- and meso-scale, both Indians and Uzbeks showed clusters of over- and underrepresentation across most study area, indicating localized concentrations within a broader distribution. Crucially, the macro-scale analysis revealed a convergence zone in the southern inner core for all studied groups. This area aligned with the characteristics of an "urban arrival space" identified in the contextual analysis—marked by higher residential density and rental housing prevalence indicative of transient populations, relative affordability attracting diverse socio-economic strata, and fragmented gentrification manifesting as uneven urban redevelopment—suggesting its pivotal role in accommodating diverse contemporary inflows.

Beyond this convergence, the divergent spatial patterns offered insights into the complex interplay of preferences, constraints, and ethnic infrastructure shaping settlement. The Indian concentration may reflect attraction to specific urban amenities, whereas the Uzbek proximity to Russian populations potentially indicates leveraging existing linguistic and social networks, consistent with Křížková and Šimon (2022) observations on the role of prior migration history on the availability of ethnic infrastructure. Simultaneously, the apparent spatial avoidance patterns—Latvians underrepresented near Russians, and Russians underrepresented where emerging groups concentrate—provided empirical traces of the potential socio-spatial separation within this diversifying post-socialist context, possibly linked to the broader processes of socio-economic divergence and gentrification previously discussed.

5.2 Spatial isolation and segregation

Turning to quantitative measures of isolation and segregation, the findings reinforced the scale-dependent nature of these phenomena. The SII indicated relatively stable potential for intra-group contact for established groups across scales, while for emerging groups, the higher, yet low probability of encountering co-ethnics within immediate micro-neighborhoods diminished to zero probability in broader contexts (Figure 4). Vietnamese consistently exhibited the highest isolation, reflecting their tight geographical clustering.

The IS demonstrated a markedly greater sensitivity to scale variation and inter-group variations than the SII and revealed profound levels of spatial separation for emerging groups, particularly at finer scales (Figure 4). Micro-scale IS values exceeding 0.7 starkly quantified the local unevenness, standing 3–4 times higher than those for Latvians and Russians and confirming the emergence of significant segregation patterns despite Riga's historical context of low ethnic segregation. The pronounced scale sensitivity of the IS, decreasing significantly but remaining high even at macro-scales (more than 2 times higher than those for Latvians and Russians), underscored the critical importance of the multi-scalar approach adopted. It is also important to note a methodological nuance: indices like the IS are sensitive to group size and can produce inflated values when applied to small ethnic populations at a fine neighborhood level, as minor clustering of a small group can result in a distribution that appears highly

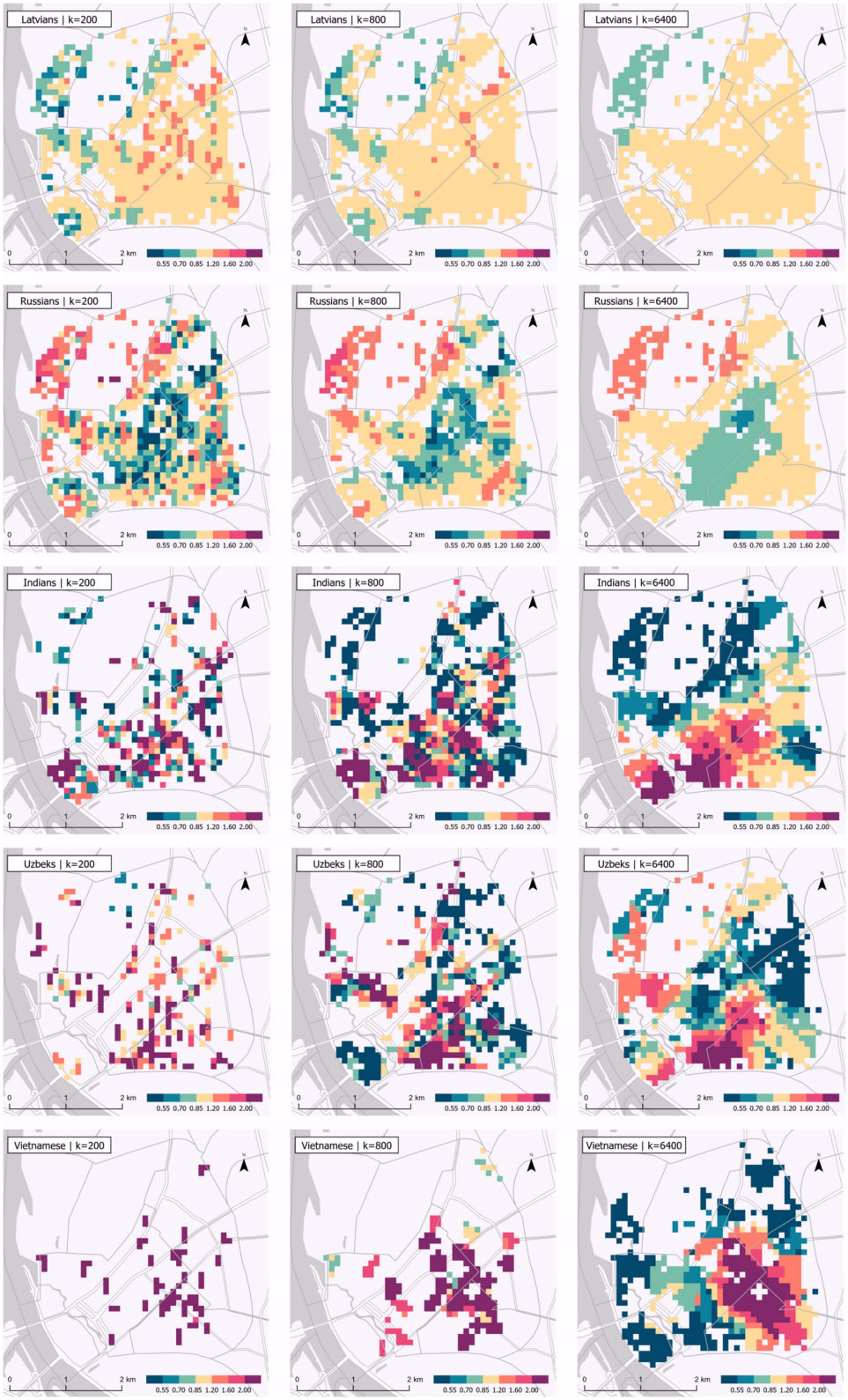

FIGURE 3
Distribution of location quotients of Latvians, Russians, Indians, Uzbeks, and Vietnamese in the inner-city core of Riga among 200, 800, and 6,400 nearest neighbors in 2021. Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).

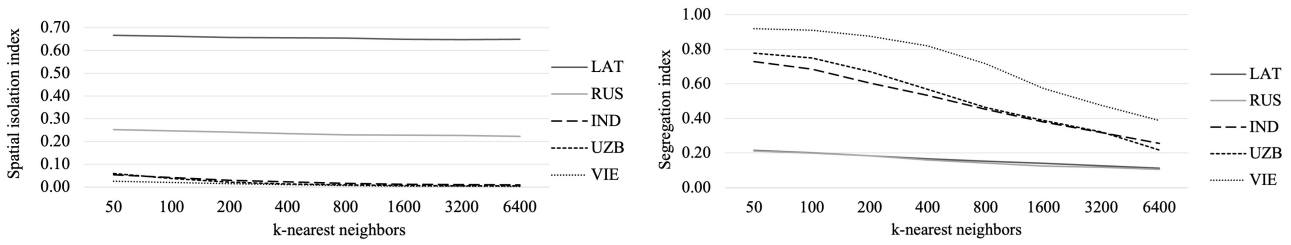

FIGURE 4
Spatial isolation index and segregation index in the inner-city core of Riga, by ethnic group and k-nearest neighbors in 2021. Source: Authors' calculations based on Central Statistical Bureau of Latvia (2025).

uneven (Stonawski et al., 2022a). Furthermore, the differential rates at which IS declined for each emerging group—highest for Uzbeks and lowest for Vietnamese—suggests that segregation intensity and its scale-dependency are influenced by complex factors beyond mere group size, likely including cultural differences and underlying socioeconomic vulnerabilities discussed earlier. This observation is supported by the work of Stonawski et al. (2022a), who also identified that even groups of a similar size can experience highly different levels of concentration.

In essence, these results painted a complex picture of Riga's inner-city core undergoing dynamic diversification. While the established groups maintained patterns resonant with historical integration, emerging communities were carving out distinct, highly concentrated, and significantly segregated niches within the urban fabric. The intensity and nature of these patterns were profoundly scale-dependent, highlighting the necessity of nuanced, multi-scalar analysis for understanding contemporary urban segregation processes, particularly within the evolving context of new migration to post-socialist European cities.

6 Discussion

The empirical findings of this study, which revealed high, scale-dependent residential segregation for emerging ethnic groups within Riga's inner-city core, necessitate a critical engagement with established theoretical frameworks, particularly spatial assimilation theory. While this theory posits a gradual dispersal from initial co-ethnic clusters contingent upon cultural and socioeconomic integration, the patterns observed in Riga present risks of growing spatial inequalities. Although it remains early to ascertain long-term outcomes, the intensity of emerging ethnic group local clustering raises important questions about the future socio-spatial fabric of the city.

The uncertainty surrounding the assimilation pathway for Riga's emerging groups is further amplified by broader empirical evidence questioning the universality and pace of spatial integration. Literature consistently highlights persistent ethnic hierarchies and limitations on upward spatial mobility, particularly for non-European migrants, even when controlling for income gains (Wessel et al., 2017; Kadarik, 2020). Other studies indicate that ethnic desegregation can occur based on upward economic status (Catney and Simpson, 2010; Catney, 2016), however, when it occurs, is often a slow process, spanning more than a decade and typically involving only a fraction of an immigrant cohort (Andersen, 2016; Vogiazides and Chihaya, 2020), with assimilation potentially proceeding even more gradually for groups originating from lower-income or culturally distinct countries (Murayama and Nagayasu, 2021). A similar pattern has also been observed in Prague, where groups with greater cultural and socio-economic distance from majority population exhibit higher residential segregation (Šimon et al., 2023). These insights are highly pertinent to Riga, suggesting that the pronounced initial clustering observed for Indians, Uzbeks, and Vietnamese may reflect not only voluntary self-segregation but also structural barriers, making a smooth transition toward dispersal unlikely without targeted interventions.

The concentration of emerging groups within specific inner-city areas identified as "arrival spaces"—characterized by higher rental housing prevalence and relative affordability—underscores the critical mediating role of the housing market (Hans et al., 2019). As noted by Imeraj et al. (2018), liberalized private housing markets can inadvertently exacerbate ethnic concentration. This context renders simplistic policy solutions, such as promoting mixing solely based on socioeconomic criteria, potentially ineffective or even counterproductive. Such approaches often underestimate systemic barriers like discrimination and can yield unintended consequences, including accelerated gentrification or deepening segregation within specific housing tenures (Bolt et al., 2010). The findings for Riga highlight this complexity; for instance, the spatial patterning of the Uzbek community, partially overlapping with areas of higher Russian concentration, suggests a significant influence of pre-existing ethnic infrastructure, a factor often overlooked in standard mixing policies. Therefore, effective integration strategies need to be sensitive to the multi-scalar nature of the observed segregation, acknowledge the importance of ethnic networks and infrastructure, confront potential discrimination, and operate within the realities of Riga's specific post-socialist housing legacies and ongoing fragmented gentrification. Ultimately, effective strategies must address the structural inequalities, housing market dynamics, and potential discriminatory barriers that shape residential outcomes to foster genuine integration opportunities within this evolving urban landscape.

7 Conclusions

This study presented a geographically detailed analysis of ethnic residential patterns within the inner-city core of Riga, focusing

on emerging ethnic groups. By utilizing individualized scalable neighborhoods, we addressed key research questions concerning the scale-dependent nature of concentration, spatial isolation, and segregation. In answer to our first research question, the analysis demonstrated high levels of residential concentration for emerging groups (Indians, Uzbeks, Vietnamese), particularly at micro-scales and manifesting spatially as distinct clustering, which contrasted sharply with the relative dispersal of established groups. Addressing the second question, the analysis revealed high segregation for emerging groups, particularly at local scales, which decreased substantially yet remained elevated at broader scales. Spatial isolation, while lower overall, also showed scale dependence for these groups, decreasing from micro- to macro-scales. Together, these findings revealed patterns of large variability across spatial scales and ethnic groups, and with indices tending to decrease as the scale broadens, confirmed the most pronounced segregation is at the hyper-local level. This study confirmed that substantial variability across scales persists even within a relatively compact urban zone, underscoring the importance of methodological approaches that capture this complexity.

Furthermore, distinct geographical patterns emerged, including the clustering of emerging groups in an "arrival space" within the south of Riga's inner-city core, aligning with observations in other European settings on "urban arrival spaces", where ethnically diverse populations, elevated rates of population turnover, and comparatively lower rents foster residential areas favorable to immigrants (Haase et al., 2020; Gerten et al., 2023). The noted overlap between Uzbeks and Russians also suggests the influence of pre-existing ethnic infrastructure. These findings indicated that both self-segregation and place stratification mechanisms may be at work, potentially leading to challenges related to socio-spatial inequalities and complicating straightforward spatial assimilation narratives, especially given the uncertain assimilation trajectories for non-European immigrants (Drouhot and Nee, 2019; Zuccotti, 2019).

Our findings contribute significantly to understanding ethnic residential patterns in this specific urban context of urban shrinkage and post-socialist transition and lay groundwork for observing the progression of ethnic residential patterns in Riga as the city continues to experience increased diversity. Acknowledging the time-bound scope of this analysis, which cannot definitively assess residential trajectories, future longitudinal studies are pivotal to determine if current patterns represent a temporary stage or more entrenched segregation. Moreover, research incorporating activity spaces and daily mobility patterns would yield a more holistic understanding of inter-ethnic interactions beyond residential areas, thus addressing the limitation of this study's emphasis on nighttime segregation (Silm and Ahas, 2014).

Ultimately, our findings suggest that although emerging ethnic groups currently represent a relatively small segment of Riga's population, their further expansion and significant spatial concentration within the inner-city core may presage challenges related to socio-spatial inequalities. Thus, the results carry substantial policy implications, underscoring the need for policymakers to acknowledge the multi-scalar and potentially enduring nature of segregation for emerging groups. Rather than presuming that spatial assimilation will naturally transpire over time, policies should address structural inequalities and specific housing obstacles faced by non-European immigrants in securing housing across diverse neighborhoods, moving beyond simplistic socio-economic mixing approaches. As Riga and similar Central and Eastern European cities navigate increasing diversity, developing a nuanced, scale-sensitive understanding of ethnic segregation, supported by appropriate methodological approaches, is essential for promoting inclusive urban development and social cohesion.

Data availability statement

The georeferenced census data utilized in this study are governed by an agreement between the Central Statistical Bureau of the Republic of Latvia and the University of Latvia. Disaggregated ethnic data are deemed sensitive, and their dissemination may potentially compromise individual privacy. The data in question were anonymized and processed in compliance with a confidentiality agreement, adhering to all data protection, privacy regulations, and contractual obligations. For further information regarding data usage, please contact maris.berzins@lu.lv.

Author contributions

SB: Methodology, Writing – original draft, Investigation, Visualization, Validation, Formal analysis, Software, Writing – review & editing. MB: Data curation, Formal analysis, Conceptualization, Writing – review & editing, Supervision, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was supported by the Recovery and Resilience Facility Project "Internal and External Consolidation of the University of Latvia" Under Grant No. 5.2.1.1.i.0/2/24/I/CFLA/007.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Gen AI was used in the creation of this manuscript. During manuscript preparation, the AI language model Gemini Advanced 2.5 Pro (Google) was utilized for language editing.

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References

Amcoff, J. (2025). Reflections on the use of k-nearest neighbour bespoke neighbourhoods in urban studies. *Tijdschr. Econ. Soc. Geogr.* doi: 10.1111/tesg.70001

Andersen, H. S. (2016). Spatial assimilation? The development in immigrants' residential career with duration of stay in Denmark. *J. Hous. Built Environ.* 31, 297–320. doi: 10.1007/s10901-015-9459-0

Andersson, E. K., Lyngstad, T. H., and Sleutjes, B. (2018). Comparing patterns of segregation in north-western Europe: a multiscalar approach. *Eur. J. Popul.* 34, 151–168. doi: 10.1007/s10680-018-9477-1

Apparicio, P., Martori, J. C., Pearson, A. L., Fournier, É., and Apparicio, D. (2014). An open-source software for calculating indices of urban residential segregation. *Soc. Sci. Comput. Rev.* 32, 117–128. doi: 10.1177/0894439313504539

Apsite-Berina, E., Robate, L. D., Berzins, M., Burgmanis, G., and Krisjane, Z. (2023). International student mobility to non-traditional destination countries: evidence from a host country. *Hung. Geogr. Bull.* 72, 143–157. doi: 10.15201/hungeobull.72.2.3

Arango, J. (2018). "Early starters and latecomers," in *European Immigrations* (Amsterdam: Amsterdam University Press).

Arbaci, S. (2007). Ethnic segregation, housing systems and welfare regimes in Europe. *Eur. J. Hous. Policy* 7, 401–433. doi: 10.1080/14616710701650443

Balode, S., and Bērziņš, M. (2025). *Exploring Patterns of Ethnic Diversification and Residential Intermixing in the Neighborhoods of Riga*. Preprints. Available online at: https://www.preprints.org/manuscript/202505.1034/v1 (Accessed June 5, 2025).

Bolt, G. (2009). Combating residential segregation of ethnic minorities in European cities. *J. Hous. Built Environ.* 24, 397–405. doi: 10.1007/s10901-009-9163-z

Bolt, G., Phillips, D., and Van Ronald, K. (2010). Housing policy, (de)segregation and social mixing: an international perspective. *Hous. Stud.* 25, 129–135. doi: 10.1080/02673030903564838

Brown, L. A., and Chung, S. Y. (2006). Spatial segregation, segregation indices and the geographical perspective. *Popul. Space Place* 12, 125–143. doi: 10.1002/psp.403

Catney, G. (2016). Exploring a decade of small area ethnic (de-)segregation in England and Wales. *Urban Stud.* 53, 1691–1709. doi: 10.1177/0042098015576855

Catney, G., and Simpson, L. (2010). Settlement area migration in England and Wales: assessing evidence for a social gradient. *Trans. Inst. Br. Geogr.* 35, 571–584. doi: 10.1111/j.1475-5661.2010.00400.x

Central Statistical Bureau of Latvia (2025). *Population Statistics* [Database]. Available online at: https://stat.gov.lv/en (Accessed June 5, 2025).

Costa, R., and de Valk, H. A. G. (2018). Ethnic and socioeconomic segregation in Belgium: a multiscalar approach using individualised neighbourhoods. *Eur. J. Popul.* 34, 225–250. doi: 10.1007/s10680-018-9480-6

Drouhot, L. G., and Nee, V. (2019). Assimilation and the second generation in Europe and America: blending and segregating social dynamics between immigrants and natives. *Annu. Rev. Sociol.* 45, 177–199. doi: 10.1146/annurev-soc-073117-041335

Gerten, C., Hanhörster, H., Hans, N., and Liebig, S. (2023). How to identify and typify arrival spaces in European cities: a methodological approach. *Popul. Space Place* 29:e2604. doi: 10.1002/psp.2604

Hårsman, B. (2006). Ethnic diversity and spatial segregation in the Stockholm region. *Urban Stud.* 43, 1341–1364. doi: 10.1080/00420980600776434

Haase, A., Schmidt, A., Rink, D., and Kabisch, S. (2020). Leipzig's inner east as an arrival space? Exploring the trajectory of a diversifying neighbourhood. *Urban Plan.* 5, 214–225. doi: 10.17645/up.v5i3.2902

Hack-Polay, D. (2019). Migrant enclaves: disempowering economic ghettos or sanctuaries of opportunities for migrants? A double lens dialectic analysis. *J. Enterprising Communities* 13, 418–437. doi: 10.1108/JEC-01-2019-0008

Hans, N., Hanhörster, H., Polívka, J., and Beißwenger, S. (2019). The role of arrival spaces in integrating immigrants: a critical literature review. *Raumforsch. Raumordn.* 77, 443–457. doi: 10.2478/rara-2019-0019

Harris, R. (2023). A tale of four cities: neighbourhood diversification and residential desegregation in and around England's 'no majority' cities. *Geogr. J.* 189, 345–360. doi: 10.1111/geoj.12561

Hess, D. B., Tammaru, T., and van Ham, M. (2018). *Housing Estates in Europe*. Cham: Springer.

Huse, T. (2018). "Gentrification and ethnicity," in *Handbook of Gentrification Studies* (Cheltenham, UK: Edward Elgar Publishing).

Hwang, J. (2015). Gentrification in changing cities: immigration, new diversity, and racial inequality in neighborhood renewal. *Ann. Am. Acad. Pol. Soc. Sci.* 660, 319–340. doi: 10.1177/0002716215579823

Imeraj, L., Willaert, D., and de Valk, H. A. G. (2018). A comparative approach towards ethnic segregation patterns in Belgian cities using multiscalar individualized neighborhoods. *Urban Geogr.* 39, 839–862. doi: 10.1080/02723638.2018.1446584

Kadarik, K. (2020). Immigrants' mobility towards native-dominated neighbourhoods: the role of individual resources, country of origin, and settlement context. *Geogr. Ann. Ser. B Hum. Geogr.* 102, 25–42. doi: 10.1080/04353684.2019.1697939

Kaplan, D., and Douzet, F. (2011). Research in ethnic segregation III: segregation outcomes. *Urban Geogr.* 32, 589–605. doi: 10.2747/0272-3638.32.4.589

Krišjāne, Z., and Bērzinš, M. (2014). Intra-urban residential differentiation in the post-Soviet city: the case of Riga, Latvia. *Hung. Geogr. Bull.* 63, 235–253. doi: 10.15201/hungeobull.63.3.1

Krišjāne, Z., Bērzinš, M., and Kratoviš, K. (2015). "Occupation and ethnicity: patterns of residential segregation in Riga two decades after socialism," in *Socio-Economic Segregation in European Capital Cities: East Meets West* (London: Routledge).

Krišjāne, Z., Bērzinš, M., Sechi, G., and Kruminš, J. (2019). "Residential change and socio-demographic challenges for large housing estates in Riga, Latvia," in *Urban Book Series* (Cham: Springer).

Křížková, I., and Šimon, M. (2022). Measuring residential segregation of non-European migrants using the individualised neighbourhood method: how does Czechia fit to the European landscape? *Appl. Geogr.* 144, 102730. doi: 10.1016/j.apgeog.2022.102730

Lichter, D. T., Parisi, D., and Ambinakudige, S. (2020). The spatial integration of immigrants in Europe: a cross-national study. *Popul. Res. Policy Rev.* 39, 465–491. doi: 10.1007/s11113-019-09540-3

Malheiros, J., Carvalho, R., and Mendes, L. (2013). Gentrification, residential ethnicization and the social production of fragmented space in two multi-ethnic neighbourhoods of Lisbon and Bilbao. *Finisterra* 48, 65–87. doi: 10.18055/finis3619

Malmberg, B., Andersson, E. K., Nielsen, M. M., and Haandrikman, K. (2018). Residential segregation of European and non-European migrants in Sweden: 1990–2012. *Eur. J. Popul.* 34, 169–193. doi: 10.1007/s10680-018-9478-0

Malmberg, B., and Clark, W. A. V. (2021). Migration and neighborhood change in Sweden: the interaction of ethnic choice and income constraints. *Geogr. Anal.* 53, 259–281. doi: 10.1111/gean.12250

Marcińczak, S., and Bernt, M. (2021). Immigration, segregation and neighborhood change in Berlin. *Cities* 119:103417. doi: 10.1016/j.cities.2021.103417

Marcińczak, S., Mooses, V., Strömgren, M., and Tammaru, T. (2023). A comparative study of immigrant-native segregation at multiple spatial scales in urban Europe. *J. Ethn. Migr. Stud.* 49, 199–222. doi: 10.1080/1369183X.2021.2008887

Marcińczak, S., Musterd, S., Van Ham, M., and Tammaru, T. (2015). "Inequality and rising levels of socio-economic segregation: lessons from a pan-European comparative study," in *Socio-Economic Segregation in European Capital Cities: East Meets West* (London: Routledge).

Martori, J. C., and Apparicio, P. (2011). Changes in spatial patterns of the immigrant population of a southern European metropolis: the case of the Barcelona metropolitan area (2001–2008). *Tijdschr. Econ. Soc. Geogr.* 102, 562–581. doi: 10.1111/j.1467-9663.2011.00658.x

Massey, D. S., Rothwell, J., and Domina, T. (2009). The changing bases of segregation in the United States. *Ann. Am. Acad. Pol. Soc. Sci.* 626, 74–90. doi: 10.1177/0002716209343558

Murayama, K., and Nagayasu, J. (2021). Toward coexistence of immigrants and local people in Japan: implications from spatial assimilation theory. *Sustainability* 13:3849. doi: 10.3390/su13073849

Musterd, S. (2005). Social and ethnic segregation in Europe: levels, causes, and effects. *J. Urban Aff.* 27, 331–348. doi: 10.1111/j.0735-2166.2005.00239.x

Nielsen, M. M., and Hennerdal, P. (2017). Changes in the residential segregation of immigrants in Sweden from 1990 to 2012: using a multi-scalar segregation measure that accounts for the modifiable areal unit problem. *Appl. Geogr.* 87, 73–84. doi: 10.1016/j.apgeog.2017.08.004

Openshaw, S. (1996). "Developing GIS-relevant zone-based spatial analysis methods," in *Spatial Analysis: Modelling in a GIS Environment* (Cambridge: GeoInformation International).

Östh, J. (2024). *EquiPop Flow*. Available online at: https://www.uu.se/en/department/human-geography/research/equipop (Accessed June 5, 2025).

Östh, J., Clark, W. A. V., and Malmberg, B. (2015). Measuring the scale of segregation using k-nearest neighbor aggregates. *Geogr. Anal.* 47, 34–49. doi: 10.1111/gean.12053

Östh, J., and Türk, U. (2020). "Integrating infrastructure and accessibility in measures of bespoke neighbourhoods," in *Handbook of Urban Segregation* (Cheltenham: Edward Elgar Publishing).

Petrović, A., van Ham, M., and Manley, D. (2018). Multiscale measures of population: within- and between-city variation in exposure to the sociospatial context. *Ann. Am. Assoc. Geogr.* 108, 1055–1074. doi: 10.1080/24694452.2017.1411245

Rogne, A. F., Andersson, E. K., Malmberg, B., and Lyngstad, T. H. (2020). Neighbourhood concentration and representation of non-European migrants: new results from Norway. *Eur. J. Popul.* 36, 71–99. doi: 10.1007/s10680-019-09522-3

Salvati, L. (2016). Demographic diversity, immigration, and gentrification: patterns of re-urbanization in a southern European city. *Int. Soc. Sci. J.* 66, 83–94. doi: 10.1111/issj.12120

Silm, S., and Ahas, R. (2014). The temporal variation of ethnic segregation in a city: evidence from a mobile phone use dataset. *Soc. Sci. Res.* 47, 30–43. doi: 10.1016/j.ssresearch.2014.03.011

Šimon, M., KrÍŽková, I., and Klsák, A. (2023). "Residential segregation in Prague and the Central Bohemian Region in 2012–2018: a multiscalar approach using individualised neighbourhoods," in *Prague and Central Bohemia* (Prague: Karolinum Press).

Skifter Andersen, H., Andersson, R., Wessel, T., and Vilkama, K. (2016). The impact of housing policies and housing markets on ethnic spatial segregation: comparing the capital cities of four Nordic welfare states. *Int. J. Hous. Policy* 16, 1–30. doi: 10.1080/14616718.2015.1110375

Sleutjes, B., de Valk, H. A. G., and Ooijevaar, J. (2018). The measurement of ethnic segregation in the Netherlands: differences between administrative and individualized neighbourhoods. *Eur. J. Popul.* 34, 963–975. doi: 10.1007/s10680-018-9479-z

Society at a Glance 2024 (2024). *OECD*. Paris: OECD Publishing.

Stillwell, J., and Phillips, D. (2006). Diversity and change: understanding the ethnic geographies of Leeds. *J. Ethn. Migr. Stud.* 32, 1131–1152. doi: 10.1080/13691830600821851

Stonawski, J., Brzozowski, J., Pedziwiatr, K., and Georgati, M. (2022a). Investigating neighborhood concentration of immigrants in Poland: exploratory evidence from Krakow. *Bull. Geogr. Socioecon. Ser.* 56, 7–24. doi: 10.2478/bgss-2022-0060

Stonawski, M., Rogne, A. F., Christiansen, H., Bang, H., and Lyngstad, T. H. (2022b). Ethnic segregation and native out-migration in Copenhagen. *Eur. Urban Reg. Stud.* 29, 357–381. doi: 10.1177/09697764211039183

Tammaru, T., Marcińczak, S., van Ham, M., and Musterd, S. (2016). *Socio-Economic Segregation in European Capital Cities: East Meets West*. London: Routledge.

van Gent, W., and Hochstenbach, C. (2020). "The impact of gentrification on social and ethnic segregation," in *Handbook of Urban Segregation* (Cheltenham: Edward Elgar Publishing).

van Ham, M., Tammaru, T., Ubarevičiene, R., and Janssen, H. (2021). *Urban Socio-Economic Segregation and Income Inequality: A Global Perspective*. Cham, Switzerland: Springer.

Vogiazides, L., and Chihaya, G. K. (2020). Migrants' long-term residential trajectories in Sweden: persistent neighbourhood deprivation or spatial assimilation? *Hous. Stud.* 36, 875–902. doi: 10.1080/02673037.2019.1636937

Walker, K. (2018). Locating neighbourhood diversity in the American metropolis. *Urban Stud.* 55, 636–650. doi: 10.1177/0042098016641002

Wessel, T., Andersson, R., Kauppinen, T., and Andersen, H. S. (2017). Spatial integration of immigrants in Nordic cities: the relevance of spatial assimilation theory in a welfare state context. *Urban Aff. Rev.* 53, 812–846. doi: 10.1177/1078087416638448

Zuccotti, C. V. (2019). Ethnicity and neighbourhood attainment in England and Wales: a study of second generations' spatial integration. *Popul. Space Place* 25:e2252. doi: 10.1002/psp.2252