SSM - Population Health 21 (2023) 101312

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Neighborhood disadvantage and the risk of dementia and mortality among refugees to Denmark: A quasi-experimental study

Min Hee Kim [a,*], Else Foverskov [b,c], Trine Frøslev [b], Justin S. White [a,d], M. Maria Glymour [d], Jens Hainmueller [e], Lars Pedersen [b], Henrik T. Sørensen [b,f], Rita Hamad [a,g]

[a] Philip R. Lee Institute for Health Policy Studies, University of California San Francisco, San Francisco, CA, USA
[b] Department of Clinical Epidemiology, Aarhus University and Aarhus University Hospital, Aarhus, Denmark
[c] Section of Social Medicine, Department of Public Health, University of Copenhagen, Copenhagen, Denmark
[d] Department of Epidemiology & Biostatistics, University of California San Francisco, San Francisco, CA, USA
[e] Department of Political Science, Stanford University, Stanford, CA, USA
[f] Clinical Excellence Research Center, Stanford University, Stanford, CA, USA
[g] Department of Family & Community Medicine, University of California San Francisco, San Francisco, CA, USA

ARTICLE INFO

Keywords:
Immigration policy
Policy evaluation
Natural experiment
Survival analysis
Place-based effects

ABSTRACT

Objectives: Neighborhood disadvantage may increase the risk of adverse health outcomes among older refugees. Yet few studies rigorously estimate the effects of place-based factors on later-life health, particularly dementia and mortality. Evidence about refugees is especially sparse.

Methods: This study leveraged a natural experiment in the form of a Danish policy (1986–1998) that dispersed refugees quasi-randomly across neighborhoods upon arrival. We used longitudinal registers allowing 30 years of follow-up among refugees aged 40+ years upon arrival in Denmark (N = 9,854). Cox models assessed the association between neighborhood disadvantage and risk of dementia and mortality. We examined heterogeneous effects by sex, age, and family size. We also examined associations among non-refugee immigrants and native-born Danes.

Results: Neighborhood disadvantage was not associated with dementia in any group. One unit increase in neighborhood disadvantage index (ranges −8 to 5.7) was associated with greater mortality risk among non-refugee immigrants (HR 1.06, 95%CI: 1.02, 1.10) and native-born Danes (HR 1.11, 95%CI: 1.06, 1.17). In contrast, neighborhood disadvantage was associated with *lower* mortality risk among refugees (HR 0.96, 95%CI: 0.93, 0.99). Neighborhood disadvantage remained negatively associated with mortality risk in subgroups: refugees who are female (on moderate-disadvantage compared to low-disadvantage), aged 60+, and who arrived with families.

Discussion: While neighborhood disadvantage was associated with lower mortality risk among refugees, it was associated with greater mortality risk among non-refugee immigrants and native-born Danes, perhaps due to confounding in the latter groups or different place-based experiences by immigration status. Future research is warranted to explain the reasons for contrasting findings.

1. Introduction

1.1. Dementia and mortality among refugee populations

The population of older migrant adults has been growing in the last two decades due to geopolitical forces. Among these, refugees and asylum are particularly vulnerable. In 2020, approximately 3.2 million refugees over the age of 60 around the world were forced to flee their homes (UNHCR, 2021). Prior to and during their search for safety, refugees experience displacement, violence-related trauma, and a lack of access to timely health care (Agyemang & Norredam, 2020; Wren, 2003). They also may experience discrimination and isolation due to their often low socioeconomic position and cultural differences in resettlement (Wren, 2003). Older refugees are particularly vulnerable to all of these dangers (UNHCR, 2021). They face age-related health complications (Sadarangani & Jun 2015), exclusion from major

* Corresponding author. 3333 California St, San Francisco, CA, 94118, USA.
E-mail address: minhee.kim@ucsf.edu (M.H. Kim).

https://doi.org/10.1016/j.ssmph.2022.101312
Received 8 September 2022; Received in revised form 8 November 2022; Accepted 6 December 2022
Available online 17 December 2022

institutions such as work and education, and adjustment issues that differ from those of young refugees (Chenoweth & Burdick, 2001; Gautam, Mawn, & Beehler, 2018; Treas, 2015). As the population of older refugees balloons because of the war in Ukraine, investigations into determinants of health and aging among older refugees are urgent.

This study addresses this need by focusing on dementia and mortality, two of the most important outcomes for later stages of the life course whose determinants are not well understood. Estimates indicate the number of people with dementia will increase from approximately 57.4 million globally in 2019 to 152.8 million in 2050 due to population growth and aging (GBD Dementia Forecasting Collaborators, 2022). Low-income and racial/ethnic minority communities face disproportionate risk (Weiss, 2021). Refugees also have a higher than average burden of risk factors for dementia, such as cardiovascular disease (Al-Rousan et al., 2022). Refugees are also at greater risk for mortality than non-refugee immigrants (DesMeules et al., 2005; Hollander et al., 2012; Syse, Dzamarija, Kumar, & Diaz, 2018). Pre-migration traumatic experiences as well as post-migration factors might play a role in this risk (Hollander, 2013).

1.2. Neighborhoods as determinants of dementia and mortality

Scholars and practitioners often focus on individual-level modifiable risk factors for dementia and mortality (e.g., smoking, social isolation, physical inactivity) (Barnes & Yaffe, 2011; Livingston et al., 2020), but upstream structural factors are gaining increased attention. One such factor is neighborhood disadvantage, which is a manifestation of structural conditions stemming from current and historical political, social, and economic arrangements that marginalize low-income and racial/ethnic minority people, and is closely linked to individual-level modifiable risk factors (Zuelsdorff et al., 2020). Thus identifying neighborhood disadvantage exposures that may increase dementia and mortality risk is vital to inform large-scale policy action, such as area-level planning on the design of neighborhoods.

Neighborhood characteristics may be linked to dementia and mortality outcomes through multiple mechanisms as neighborhoods have a direct role in shaping individuals' access to health-promoting resources, exposure to harmful environmental conditions, and social interactions (Fig. S1, conceptual diagram; Agyemang & Norredam, 2020; Diez Roux & Mair, 2010). Most research on the constrained socioeconomic opportunities in some neighborhoods—which can be summarized as neighborhood disadvantage—has focused on people seeking employment and education. However, neighborhood disadvantage may contribute to adverse outcomes for people beyond their working years through reduced access to health-promoting resources, such as health care. Likewise, neighborhood disadvantage is tended to be correlated with social infrastructures of neighborhood living, such as reduced opportunities for physical activities, access to healthy food, and social and intellectual stimulation (Besser, McDonald, Song, Kukull, & Rodriguez, 2017; Clarke et al., 2012), as well as exposure to environmental hazards (Morello-Frosch, Zuk, Jerrett, Shamasunder, & Kyle, 2011), all of which might contribute to increased risks of dementia and mortality. Increased psychological stress through biological embedding (Agyemang & Norredam, 2020) may also arise from exposure to a deteriorated physical infrastructure and high crime rates (Sampson, 2012). Finally, social cohesion in neighborhoods—community-level characteristics of residents being mutually supportive of each other (Fonseca, Lukosch, & Brazier, 2019)—may exacerbate or offset the way disadvantaged material and physical conditions generate population health inequities.

Prior evidence on the effects of neighborhood disadvantage on dementia is mixed. Recent studies conducted in the United States have reported that neighborhood disadvantage is associated with accelerated cortical thinning and lower total brain volume—two biological indicators for potential dementia incidence—in cognitively unimpaired individuals in cross-sectional neuroimaging data from longitudinal cohort studies (Hunt, Buckingham, et al., 2020; Hunt, Vogt, et al., 2020). In contrast, a study using longitudinal integrated healthcare delivery system data in Northern California found that neighborhood disadvantage was associated with dementia incidence for non-Hispanic White people but not for Asian Americans (Mobley et al., 2022). Furthermore, place-based deprivation was not associated with increased dementia risk among community-dwelling older adults sampled in France (Ouvrard, Meillon, Dartigues, Ávila-Funes, & Amieva, 2020) or England (Cadar et al., 2018). Prior work has also found that neighborhood disadvantage increases the risk of psychiatric disorders and cardiovascular risk factors for dementia and mortality among Scandinavian refugee populations (Foverskov et al., 2022; Hamad et al., 2020; White et al., 2016).

Evidence on the association between neighborhood disadvantage and mortality is more consistent. One meta-analysis found higher mortality among inhabitants of areas with low local socioeconomic status, with stronger associations shown for men and younger age groups (Meijer, Röhl, Bloomfield, & Grittner, 2012). In the US Moving to Opportunity (MTO) experiment—a rare randomized study that offered randomly selected families living in high-poverty housing projects vouchers to move to low-poverty neighborhoods—low neighborhood poverty was associated with lower mortality risk among girls but not boys (Jacob, Ludwig, & Miller, 2013). None of these studies have addressed refugees specifically.

Studies of the influence of neighborhood characteristics on dementia and mortality face several methodological challenges. First, unmeasured factors such as socioeconomic status and pre-existing health may confound the association between neighborhood characteristics and health (Oakes, 2004). The association may merely reflect the residential sorting that occurs during childhood and early adulthood, such that individuals with poor health may be selected into disadvantaged neighborhoods (Diez Roux, 2004). Second, there are multiple ways to define and operationalize neighborhoods (e.g., where to set the boundary or which scale to use) (Diez Roux, 2001; Diez Roux & Mair, 2010; van Ham & Manley, 2012), requiring attention to historical, social, and contextual factors (e.g., administrative boundaries and people's perceptions) (Diez Roux, 2001). Third, selective survival may bias the relationship between neighborhood disadvantage and dementia (Berry, Ngo, Samelson, & Kiel, 2010). Individuals living in high-disadvantage neighborhoods may have higher premature mortality (Meijer, Röhl, et al., 2012) and thus may die before dementia onset. The inverse association is possible in that living in low-disadvantage neighborhoods may increase dementia incidence and thus die from dementia (e.g., Rosella et al., 2018). Therefore, evaluating both outcomes can facilitate understanding of neighborhood-dementia association in relation to mortality. Finally, we need a dataset with long follow-ups because dementia and many other chronic diseases have long latency periods (Braak, Thal, Ghebremedhin, & Del Tredici, 2011).

The current study's exploration of the association between neighborhood disadvantage and the risk of dementia and mortality among older refugees in Denmark leverages a Danish policy that distributed newly arrived refugees quasi-randomly across the country during 1986–1998. We use parishes, historically meaningful geographic units in Denmark, as proxies for neighborhoods. Previous studies have used parish boundaries to capture shared social and economic environments and found they meaningfully coincide with area-level health impact (e.g., Meijer, Kejs, et al., 2012). The data spans 32 years–1986 to 2018. We also compared estimates for older refugees with those from older non-refugee immigrants and native-born Danes to gauge how neighborhood selection bias may influence the disadvantage exposure and facilitate the interpretation of our findings. This research comes at a time of increasing attention to the welfare of refugees and thus offers important policy implications.

2. Methods

2.1. Dispersal policy as a natural experiment

In 1986, a growing number of incoming refugees from several global crises led to the adoption and implementation of the first refugee dispersal policy in Denmark, which was in force until 1998. The policy called for the assignment of newly arrived refugees across counties and municipalities in proportion to population size (Damm, 2005). Placement officers had access only to information on refugees' age, marital status, family size, and nationality—not to the unobserved factors (e.g., educational attainment) that typically confound associations between neighborhood factors and health (Hasager & Jørgensen, 2021). Previous studies on neighborhood effects treating this as a natural experiment have supported the assumption of quasi-random (i.e., arbitrary) neighborhood assignment conditional on the information available to placement officers (Hamad et al., 2020; Hasager & Jørgensen, 2021). Thus this study's estimates of neighborhood effect minimize confounding (Diez Roux, 2004). The policy placed no restrictions on relocation, and welfare support was not dependent on staying in the initially assigned residence. The current study is thus an intent-to-treat analysis, similar to the randomized encouragement design used in the U.S. MTO study, i.e., it estimates the effect of the initial quasi-random neighborhood assignment rather than later neighborhoods to which refugees may have moved. Characteristics of later places of residence, therefore, represent mediating pathways rather than confounders, and they do not bias our study findings (Groenwold, Palmer, & Tilling, 2021).

2.2. Data source and cohort

We used several Danish national registers linked via the unique identification numbers assigned to all Danish residents (Schmidt et al., 2019) to create cohorts described below. All socio-demographic characteristics—including date of death—were obtained from population registers maintained by Statistics Denmark (Denmark's census bureau). These socio-demographic characteristics were merged with health data from Denmark's national patient register, psychiatric central register, and national prescription register (Table S1). All analyses in this study were prespecified; we received a permission to use the data from Statsitics Denamrk, the Danish Data Protection Agency, and the Danish Health Data Agency. We accessed anonymized data via a password protected server managed by Statistics Denmark.

We first constructed the refugee cohort data. Between 1986 and 1998, 80,871 persons arrived and obtained a residence permit in Denmark for the first time from the eight largest refugee-sending countries—former Yugoslavia, Iraq, Iran, Afghanistan, Sri Lanka, Vietnam, Somalia, and Lebanon (mainly Palestinians). Refugees from former Yugoslavia were only included after 1991 because very few permits were granted to people from this area in prior years. Although registers do not include the refugee status of arriving immigrants, these refugee-sending countries accounted for 93% of all permits granted to refugees during the study period. In line with the United Nations cutoff for older adults (UNHCR, 2021), we further restricted the sample to individuals aged 40 and older, who were likely to reach 60 during the follow-up period (N = 9854). We excluded individuals reuniting with family in Denmark as they were not subject to the dispersal policy. See Fig. S2 for additional exclusion criteria, which is similar to those developed in prior studies of the dispersal policy (Damm, 2009; Hamad et al., 2020).

Next, we created a non-refugee immigrant comparison cohort data, which included all immigrants from non-refugee-sending countries aged 40 and older upon arrival in Demark during the same years as the refugees (1986–1998) (N = 12,259). Finally, for the native-born Dane cohort, we matched native-born Danes to the refugee cohort using a sampling ratio of 1–5, without replacement (N = 45,789) (Heide-Jørgensen, Adelborg, Kahlert, Sørensen, & Pedersen, 2018). Matching was based on the following characteristics: age (with 5-year birth year intervals), year of refugee arrival, sex, and the parish to which the refugee was initially assigned.

2.3. Measures

2.3.1. Outcomes

The two primary outcomes were dementia and all-cause mortality. Dementia was a composite outcome including the following diagnoses: Alzheimer's disease; vascular dementia; frontotemporal dementia; other dementias; and unspecified dementia. We combined these due to the challenges of disentangling a primary etiology in clinical settings and the mixed etiologies of many dementias (Phung et al., 2007), and limited statistical power to stratify by diagnosis. We used an individual's first occurrence of a relevant diagnosis, using codes from the *International Classification of Diseases* (ICD), *Eighth Revision* until 1994, and *Tenth Revision* thereafter, based on previous work of the Danish Dementia Research Centre (Taudorf, Nørgaard, Waldemar, & Laursen, 2021). We also used the first-time redemption of prescribed dementia-related medications based on relevant Anatomical Therapeutic Chemical (ATC) codes to identify additional dementia cases (Table S2). We applied a 2-year washout period for all groups (i.e., excluding individuals with dementia diagnosis within the first 2 years of follow-up after the year of arrival) to minimize the influence of pre-existing conditions. We followed the three cohorts (refugees, non-refugee immigrants, and matched Danes) until the dementia diagnosis date, death, emigration, or the end of follow-up (December 31, 2018), whichever occurred first.

2.3.2. Neighborhood assignment and disadvantage measure

The primary exposure was initial neighborhood socioeconomic disadvantage after arrival in Denmark. We determined neighborhood characteristics using the same population registers for all residents. As mentioned above, we used parishes as proxies for neighborhoods, which is the smallest available geographic unit in register data, and nested within municipalities.

Because official records do not document the actual neighborhood assigned by placement officials, we used residential history data available in the Danish registers to identify the first neighborhood in which refugees lived after obtaining a residence permit. If an individual relocated to another neighborhood within one year, we defined the second location as the initial neighborhood, based on the understanding that in those cases, the second location is the placement official assignment since many refugees stay in temporary housing, and typically for less than a year (Damm, 2005).

We merged individual data with 1986–1998 neighborhood disadvantage exposure (i.e., a composite neighborhood index variable), created from Danish population data delineated by parishes. After excluding parishes with fewer than 50 family units, our data included 2097 parishes nested within 271 municipalities, with sizes ranging from 0.1 to 159 km^2 (median 16 km^2) and 101 to 20,848 persons (median: 1133 people). For each year, we used principal component analysis (PCA) to combine four neighborhood-level socio-demographic characteristics (household income, education, unemployment, and receipt of welfare) that represent different theoretical constructs capturing disadvantage (Messer et al., 2006). PCA captures the largest variance in the disadvantage construct based on the linear combination of predictor variables. We assigned a specific disadvantage value for each parish based on the variable loadings from the first principal component from PCA. Higher values indicate a greater disadvantage. See Tables S3–S5 for details.

In one set of models, we used the composite disadvantage index as a continuous variable to evaluate linear relationships between exposure and outcomes. In another set of models, we categorized neighborhoods by tertiles of a disadvantage composite index (low, moderate, and high) for each year to examine possible non-linear relationships between the exposure and outcomes. As expected, neighborhood characteristics differed by disadvantage level (e.g., average unemployment rates were 5.3%, 6.5%, and 9.2% across low, moderate, and high disadvantage neighborhoods, respectively; see Table S6).

2.3.3. Covariates

We included individual-level covariates that were available to placement officers and, therefore, might represent confounders of the relationship between neighborhood disadvantage and the outcomes of interest: sex, baseline age, and age-squared, country of origin, family size (categorized as 1–2, 3–4, and 5+), and marital status. In addition, we included fixed effects (i.e., indicator variables) for the year of arrival to account for secular (i.e., underlying) trends in the outcomes and fixed effects for the initial municipality. The latter allowed us to account for all time-invariant unobserved confounding factors (e.g., geographical differences in the organization of health care and access to health care services) at the municipality level. The placement of refugees was based in part on the existing share of refugees in a given municipality (Damm, 2005). Thus, including fixed effects for the initially assigned municipality (the smallest unit of randomization) strengthens causal inference by comparing refugees assigned to neighborhoods of different levels of disadvantage within the same municipality.

For non-refugee immigrants, we included an indicator variable for Western vs. non-Western. As defined by Statistics Denmark, Western countries included the member states of the European Union (including the United Kingdom), Andorra, Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland, Vatican City, Canada, the United States, Australia, and New Zealand.

2.4. Analytic methods

2.4.1. Primary analysis

We estimated the association of neighborhood disadvantage with dementia and mortality among refugees using Cox proportional hazard models. These models are well suited for examining the likelihood of experiencing an event among persons with varying levels of exposure over long follow-up periods. We used both continuous and categorical exposure (i.e., neighborhood disadvantage tertiles) variables to examine possible non-linear relationships between the exposure and outcomes, although these models are likely underpowered relative to models in which the exposure was continuous.

We adjusted for the covariates above in all models and estimated cluster-robust standard errors by initially assigned parish to account for correlations across individuals at the neighborhood level and nested levels (i.e., families). All analyses were performed using SAS version 9.4.

2.4.2. Checking model assumptions

First, we ran balance tests to support our identifying assumption that the individuals were distributed quasi-randomly across neighborhoods. We regressed neighborhood disadvantage assignment on the characteristics of the refugees known and unknown to the placement officers at the time of allocation. Education variable, unknown to officers, was categorized as basic education (0–11 years), upper secondary education (12–15 years, including vocational education and training), and higher education (15 years or more, including short-cycle higher education), and unknown. Since the placement officers did not know the level of education of the refugees, it should not be correlated with the neighborhood characteristics they were assigned to.

Next, we examined whether neighborhood disadvantage on arrival was associated with emigration. The estimated effect of neighborhood disadvantage on dementia will be biased if emigration is a competing event. Specifically, the effect of disadvantage on dementia may be underestimated if living in a high-disadvantage neighborhood increases the likelihood of leaving the country.

2.4.3. Secondary analyses for refugee cohort

We tested heterogeneous effects of neighborhood disadvantage by sex (as a proxy for gender identity and exposure to gendered psychosocial experiences), age at arrival (40–59 versus 60 years old or more), and family size (1 [arriving alone] versus 2+). Different socialization patterns by these characteristics may influence the way individuals interact with neighborhood features.

In addition, we tested whether the disadvantage-outcome association was altered after adjusting for other neighborhood-level variables that capture potentially relevant features of the place. First, we adjusted for the proportion of individuals from the same country/region of origin as refugees (divided into Africa, Asia, Europe, North America, Oceania, and South America). This measure serves as a proxy for shared cultural values and racialized experiences; living in an ethnic enclave sometimes represents voluntary geographic segregation, not necessarily resulting from exclusionary practices (Phillips, 2007). Second, we adjusted for population density (number of residents per km^2), an indicator of dense social infrastructure. They are not conceptualized as confounders because they did not influence the quasi-randomly assigned neighborhood disadvantage exposure, but rather represent alternative exposures that may be related to the outcomes. Both factors could also benefit refugee health by providing a robust social network and support essential for social integration (Martén, Hainmueller, & Hangartner, 2019).

2.4.4. Comparison analysis among non-refugee immigrants and native Danes

We next estimated the association of neighborhood disadvantage with each outcome among the two cohorts not subject to the dispersal policy: 1) non-refugee immigrants and 2) native-born Danes. We applied similar Cox models to each cohort with the same specifications as the refugee cohort. For the non-refugee immigrant cohort, we further applied subgroup analysis by country/region of origin (i.e., Western versus non-Western immigrants). Due to the possibility of confounding (i.e., self-selection), these estimates can be interpreted in the context of correlational analysis, in contrast to the quasi-experimental design of the refugee cohort analysis.

3. Results

3.1. Cohort characteristics

Table 1 presents the descriptive characteristics of each cohort. The mean age was 53.8 years for refugees, 50.6 years for non-refugee immigrants, and 54.6 years for Danes. Refugees were 50% female, and 74.4% were married at baseline. Most refugees were from former Yugoslavia (50.3%), followed by Iran (10.1%) and Vietnam (9.9%), while 67% of most non-refugee immigrants were from Western countries. The cumulative incidence of dementia was 2.4% for refugees, 2.0% for non-refugee immigrants, and 1.8% for native-born Danes. The cumulative all-cause mortality incidence rate was 15.3% among refugees, 13.6% among non-refugee immigrants, and 11.4% among native-born Danes. About 30.4% of the refugee population emigrated during follow-up, compared with 55.2% of non-refugee immigrants and 11.3% of native-born Danes. The refugee cohort was represented in 889 parishes nested within 271 municipalities, while non-refugee immigrants and matched Danes resided in 1423 and 885 parishes, respectively.

3.1.1. Checking model assumptions

Table 2 shows characteristics of the refugee cohort by neighborhood disadvantage level. Balance tests showed that individual-level characteristics at arrival were well balanced across neighborhood disadvantage levels, with only one of 45 coefficients (Iran for high-income neighborhoods) statistically significant at the 0.05 level (Table S7). The imbalance of the country of origin by neighborhood disadvantage was expected since placement officers had access to this information, which may have informed placement decisions. However, refugees' educational attainment acquired before immigration (information placement

Table 1
Characteristics of the study population, by immigration status.

	Refugees (n = 9854)	Non-refugee immigrants (n = 12,259)	Matched native-born Danes (n = 45,789)
	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)
Female	50.2	51.1	50.8
Married	74.4	68.8	51.9
Age (years)	53.8 (10.6)	50.6 (9.9)	54.6 (7.3)
Number of family members			
1-2	57.0	68.3	69.9
3-4	29.1	24.6	26.5
5+	13.9	7.1	3.5
Country/region of origin			
Former Yugoslavia	50.3	–	–
Iraq	9.7	–	–
Iran	10.1	–	–
Afghanistan	2.5	–	–
Vietnam	9.9	–	–
Sri Lanka	4.9	–	–
Somalia	5.3	–	–
Lebanon (Palestinians)	7.5	–	–
Western	–	83.8	–
Non-Western	–	16.2	–
Education			
Basic education	14.4	10.5	44.3
Upper secondary education	22.4	19.7	36.3
Higher education	15.4	21.6	13.7
Unknown	47.8	48.2	5.7
Neighborhood disadvantage			
Low	33.6	53.8	33.7
Moderate	31.0	22.4	30.9
High	35.5	23.8	35.4
Follow-up years[a]	16.1 (7.7)	12.1 (9.7)	36 (20.4)
Emigration	30.4	55.7	11.3
Outcomes, incidence rate per 1000 person-years			
Dementia	2.4 (2.2,2.7)	2.04 (1.8,2.3)	1.8 (1.8,1.9)
Mortality[b]	15.3 (14.7,15.9)	13.6 (13.0,14.2)	11.1 (11.0,11.3)
Observed person-years	158,950	147,827	1,646,504

Abbreviations: SD, standard deviation; -, not applicable.
Notes: Characteristics shown other than health outcomes are those from arrival (or baseline, for native-born Danes). The cohorts included individuals 40 years or older who were 1) refugees at time of arrival to Denmark (1986–1998), 2) non-refugee immigrants, and 3) native-born Danes, matched to refugees by age, sex, parish, and year.
[a] These values represent years of follow-up using dementia as the outcome.
[b] These values are derived from the mortality analysis, where we do not censor individuals at dementia.

Table 2
Characteristics of the refugee cohort, by tertile of neighborhood disadvantage level.

	Neighborhood disadvantage		
	Low	Moderate	High
	(n = 3308)	(n = 3051)	(n = 3495)
	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)
Female	49.4	50	51.0
Married	72.5	74.9	75.7
Age (years)	53.7 (10.6)	53.7 (10.4)	53.9 (10.8)
Number of family members			
1-2	58	57.6	55.5
3-4	27.9	29.3	30.2
5+	14.1	13.1	14.3
Country of origin			
Former Yugoslavia	44.9	56.9	49.6
Iraq	10.6	7.1	11.0
Iran	13.3	9.1	7.9
Afghanistan	3.4	1.7	2.2
Vietnam	7.9	9.0	12.4
Sri Lanka	5.0	6.0	3.7
Somalia	5.5	3.9	6.4
Lebanon (Palestinians)	9.5	6.2	6.7
Education			
Basic education	13.1	15.8	14.4
Upper secondary education	22	22.9	22.4
Higher education	16.3	14.3	15.6
Unknown	48.6	47.0	47.6
Co-regional composition	1.3 (1.1)	1.6 (1.2)	3.4 (3.7)
Population density (person/ km^2)	2235 (3926)	1658 (3106)	3902 (6721)
Follow-up years[a]	15.9 (7.9)	16.2 (7.6)	16.2 (7.7)
Emigration	30.4	30.5	30.4
Outcomes, incidence rate per 1000 person-years			
Dementia	2.6 (2.21,3.09)	2.4 (2.0,2.9)	2.3 (1.9,2.7)
Mortality[b]	16.2 (15.2,17.3)	15.1 (14.1,16.2)	14.6 (13.6,15.6)

Abbreviations: SD, standard deviation.
Notes: The cohort included refugees 40 years or older at time of arrival to Denmark (1986–1998), and characteristics other than health outcomes are those from arrival (baseline). The classification of the disadvantage index into tertiles is based on year and parish.
[a] These values represent years of follow-up using dementia as the outcome.
[b] These values are derived from the mortality analysis, where we do not censor at dementia.

officers did not have) was not associated with neighborhood disadvantage level (Table S7), confirming the quasi-random distribution of refugees across neighborhoods. We adjusted for all observed variables in our Cox models to improve the precision of estimates.

Descriptive statistics for non-refugee immigrant cohorts showed some differences in individual characteristics by neighborhood disadvantage levels (e.g., family size) (Table S8). A greater number of non-refugee immigrants (~57%) resided in less disadvantaged neighborhoods at arrival than the refugee cohort (~33%) (Table S8 & Fig. S3). Descriptive characteristics by disadvantage level in matched Danish-born cohort were almost identical to those of the refugee population (Table S9).

Finally, emigration risk did not differ by neighborhood disadvantage levels for refugee cohorts (Table S10).

3.2. *Association of neighborhood disadvantage with dementia and mortality: refugee cohort*

Neighborhood disadvantage was not associated with dementia risk in the refugee sample (Fig. 1 & Table 3). However, it was associated with *lower* mortality risk among refugees (HR 0.96, 95% CI: 0.93, 0.99; Fig. 1). In models using a categorical exposure with the low-disadvantage neighborhood as a reference, mortality risk was similarly lower for refugees in moderate-disadvantage neighborhoods (HR 0.90, 95% CI: 0.78, 1.03) and high-disadvantage neighborhoods (HR 0.90, 95% CI: 0.79, 1.01), although confidence intervals included the null (Table 3).

3.3. *Secondary analyses for refugee cohort*

In subgroup analyses, we found some evidence that disadvantage effects differed by sex, age group, and family size for mortality outcome. The continuous measure of neighborhood disadvantage was not associated with mortality risk in subgroup analyses by sex. Yet, we found some gender differences in models using a categorical neighborhood exposure; women in moderate disadvantage neighborhoods had a lower mortality risk than women in neighborhoods with low disadvantage (HR

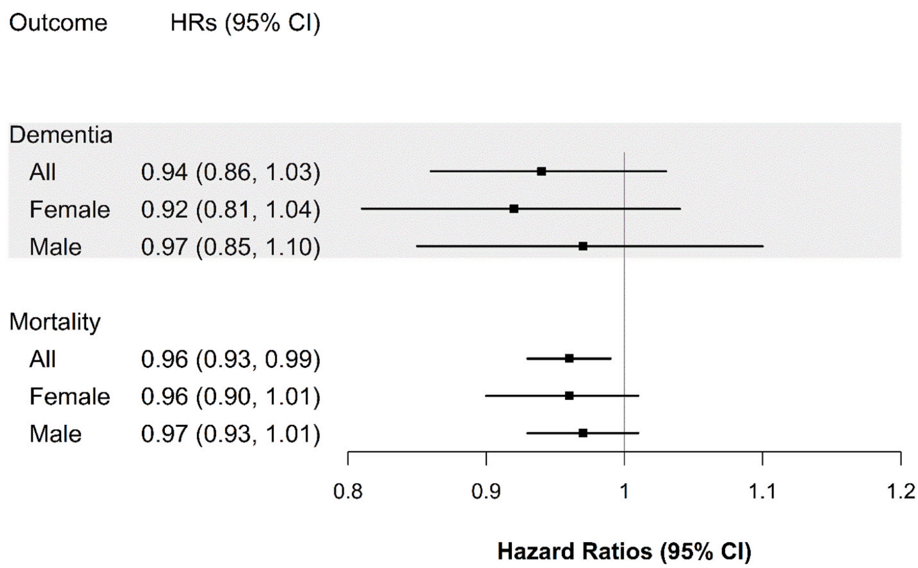

Fig. 1. Association between neighborhood disadvantage (continuous) and dementia and mortality risks among refugees to Denmark, overall and stratified by sex

Abbreviations: HR, Hazard ratio; CI, Confidence interval

Notes: N = 9854 (4943 females; 4911 males) individuals aged 40 and older at arrival during 1986–1998. Estimates are from Cox proportional hazards models with neighborhood disadvantage as a *continuous* exposure. All models are adjusted for age, sex, country/region of origin (only for non-refugee immigrants), number of family members, marital status, and fixed effects (i.e., indicator variables) for the year of arrival and municipality.

Table 3
Association of neighborhood disadvantage (tertiles) with dementia and mortality risk, overall and stratified by sex.

Neighborhood disadvantage level	Total		Female		Male	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Dementia						
Moderate	0.94	(0.70, 1.26)	0.80	(0.53, 1.22)	1.08	(0.68, 1.71)
High	0.82	(0.61, 1.11)	0.69	(0.43, 1.10)	0.91	(0.59, 1.40)
Mortality						
Moderate	0.90	(0.78, 1.03)	0.78	(0.63, 0.97)	1.04	(0.87, 1.25)
High	0.90	(0.79, 1.01)	0.90	(0.74, 1.09)	0.93	(0.78, 1.10)

Abbreviations: HR, Hazard ratio; CI, Confidence interval.
Notes: N = 9854 (4943 females; 4911 males) individuals aged 40 and older at arrival during 1986–1998. Estimates are from Cox proportional hazards models with *low-disadvantage* neighborhoods as the reference. All models are adjusted for age, sex, country of origin, number of family members, marital status, and fixed effects (i.e., indicator variables) for year of arrival and municipality.

0.78, 95% CI: 0.63, 0.97), while this association was not persisted for men (HR 1.04, 95% CI: 0.87, 1.25) (Table 3). Also, the association persisted only for refugee older adults aged 60 and over on arrival (HR 0.95, 95% CI: 0.91, 0.99; Table S11), while the confidence intervals included the null for those aged 40–59 years (HR 0.97, 95% CI: 0.92, 1.02). In addition, greater neighborhood disadvantage in continuous measure was associated with lower mortality risk among refugees with two or more family members at arrival (HR 0.92, 95% CI: 0.89, 0.96; Table S12), while those who arrived alone showed no association (HR 1.04, 95% CI: 0.98, 1.11).

In models adjusting for other relevant neighborhood-level factors (i.e., ethnic enclaves and population density), the size of the effect estimate for the association of neighborhood disadvantage with mortality was attenuated, and confidence intervals included the null (HR 0.97, 95% CI: 0.93, 1.01; Table S13).

3.4. Association of neighborhood disadvantage with dementia and mortality: comparison cohorts

As with refugees, we did not find associations between neighborhood disadvantage and dementia among non-refugee immigrants or native-born Danes (Table 4 and S14). However, disadvantaged neighborhoods on arrival were associated with higher mortality (HR 1.06, 95% CI: 1.02, 1.10) for non-refugee immigrants (Table 4). This was generally similar across subgroups according to Western vs. non-Western country of origin and sex, except for a null association among Western women immigrants (HR 0.99, 95% CI: 0.92, 1.07; Table 4). Models using a categorical neighborhood disadvantage exposure indicated that increased mortality risk in high-disadvantage neighborhoods largely drove the association (Table S15).

For native-born Danes, we observed an association between living in disadvantaged neighborhoods and increased mortality (HR 1.11, 95% CI 1.06, 1.17), with no difference by sex (Table 4). A gradient effect was seen in categorical exposure models (Table S15).

Table 4
Association of neighborhood disadvantage (continuous) with dementia and mortality risks in comparison cohorts, overall and stratified by sex.

Cohort	Total		Female		Male	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Dementia						
Non-refugee immigrants	0.94	(0.84, 1.05)	0.98	(0.85, 1.13)	0.87	(0.71, 1.06)
Western	1.03	(0.90, 1.18)	1.12	(0.93, 1.34)	0.94	(0.75, 1.18)
Non-Western	0.97	(0.81, 1.16)	0.99	(0.79, 1.23)	0.88	(0.61, 1.27)
Native-born Danes	1.06	(1.00, 1.14)	1.07	(1.00,1.14)	1.07	(0.98,1.16)
Mortality						
Non-refugee immigrants	1.06	(1.02, 1.10)	1.03	(0.98, 1.09)	1.10	(1.05, 1.16)
Western	1.07	(1.02, 1.12)	0.99	(0.92, 1.07)	1.12	(1.04, 1.20)
Non-Western	1.09	(1.03, 1.16)	1.09	(1.01, 1.17)	1.10	(1.01, 1.20)
Native-born Danes	1.11	(1.06, 1.17)	1.10	(1.05, 1.16)	1.12	(1.07, 1.18)

Abbreviations: HR, Hazard ratio; CI, Confidence interval.
Notes: N = 12,259 non-refugee immigrants aged 40 and older at arrival during 1986–1998 and N = 45,789 matched native-born Danes. Estimates are from Cox proportional hazards models with neighborhood disadvantage as a *continuous* exposure. All models are adjusted for age, sex, country/region of origin (only for non-refugee immigrants), number of family members, marital status, and fixed effects (i.e., indicator variables) for the year of arrival and municipality.

4. Discussion

This study examined the association of neighborhood disadvantage with dementia and mortality among older refugees by taking advantage of a natural experiment created by a refugee dispersal policy in Denmark that quasi-randomly distributed refugees across neighborhoods. We did not observe an association between increased disadvantage and dementia risk among refugees, non-refugee immigrants, or native-born Danes. Contrary to our initial hypothesis, we found that neighborhood disadvantage was associated with lower mortality risk in the refugee cohort. This lowered risk of living in disadvantaged neighborhoods was persistent among female refugees assigned to moderate-disadvantage neighborhoods, older refugees, and those in families of two or more. Among non-refugee immigrants and the matched cohort of native-born Danes, we observed the expected association of higher disadvantage with greater mortality risk, with some variation by sex and country/region of origin of immigrants.

The findings among refugees contrast with prior observational studies linking neighborhood disadvantage with dementia-related biomarkers (Hunt, Buckingham, et al., 2020; Hunt, Vogt, et al., 2020), dementia incidence (Mobley et al., 2022), and increased mortality risk (Meijer, Röhl, et al., 2012). They also contrast with studies using the refugee dispersal policy as a natural experiment that found that neighborhood disadvantage increased cardiovascular risk factors (Hamad et al., 2020; White et al., 2016)—key contributors to dementia and mortality. However, previous evidence on neighborhood disadvantage-dementia association was also inconclusive, in part due to methodological limitations (e.g., biases stemming from selection into neighborhood or selective survival), and somewhat patterned by country characteristics. The association has been found in the United States for the non-immigrant population (Hunt, Buckingham, et al., 2020; Hunt, Vogt, et al., 2020; Mobley et al., 2022). The weak U.S. social safety net and strong area-level disadvantage may play a role, however, as countries that have a stronger safety net do not display this association (Cadar et al., 2018; Ouvrard et al., 2020).

One set of explanations of our findings is methodological. We leveraged quasi-experimental neighborhood assignments that reduce confounding from neighborhood selection. Thus, our findings on dementia and mortality outcomes for non-refugee immigrants and native-born Danes—to whom the dispersal policy did not apply—likely reflect some degree of unmeasured confounding and the selection bias common in observational studies (Diez Roux, 2004; Oakes, 2004). For example, non-refugee immigrants with low health status (or chronic health problems developed before they immigrated to Denmark) may have been more likely to live in disadvantaged neighborhoods, and low health status may have also affected increased mortality risk. Alternately, those with lower socioeconomic status may have sorted into disadvantaged neighborhoods because they could only afford housing prices in such neighborhoods, and their socioeconomic status may have increased mortality risk through a variety of pathways, including increased chronic stress. Null association of dementia outcome in the refugee cohort could be due to a smaller number of dementia cases and the use of conservative models with the inclusion of multiple covariates (e.g., municipality fixed effects), which may have hindered the detection of the neighborhood effect. The effect of neighborhood disadvantage on dementia would be underestimated if death makes survival to dementia incidence less likely. Still, given lower mortality risks in the refugee cohort in high-disadvantaged neighborhoods, early mortality likely does not play a role in our dementia results.

Another set of explanations is substantive. The unique social conditions of refugees, who differ from other immigrant groups due to their prior experiences of trauma, different labor market experiences, and potentially different welfare access (Blume & Verner, 2007) may explain our counterintuitive finding for mortality. Also, high-disadvantage neighborhoods may have beneficial features for older refugees. For example, discrimination and exclusion may be lower in such neighborhoods due to the presence of more racial/ethnic minority groups. This may have lowered mortality risk by lowering accumulated stress (e.g., dysregulated metabolism and immunity; Rodgers, Cuevas, Williams, Kawachi, & Subramanian, 2021). It also may offer more opportunities for a strong social network which is a protective factor for mortality (Holt-Lunstad, Smith, & Layton, 2010). Indeed, the implementation of the dispersal policy may have deterred the creation of strong social networks among refugees (Wren, 2003), and those in low-disadvantage neighborhoods may bear the brunt of this impact. Our secondary analysis, finding that the estimated effect of living in high-disadvantage neighborhoods was attenuated when we adjusted for other neighborhood-level factors (i.e., ethnic enclave and population density), supports this interpretation.

In subgroup analyses, we found heterogeneous neighborhood effects by sex, age, and family size; they provide additional insight into how social integration mechanisms may link the associations between greater disadvantage and lower mortality risk. In sex-stratified models, when we used a categorical exposure, moderate-disadvantage was associated with lower mortality risk among women compared with low-disadvantage neighborhoods. The aforementioned protective mechanisms (e.g., social networks) in the moderate-disadvantage may have been more salient for women refugees. The protective effect of disadvantage was also persistent for refugees aged 60 and over at arrival. This may be because older adults are less likely to encounter normative expectations for formal socioeconomic activities (i.e., work). Thus, high-disadvantage neighborhoods with few opportunities for labor market participation may not be particularly harmful. Similarly, the protective effect of disadvantage was persistent for those who arrived with families. We think this reflects different socialization patterns of women and those aged 60 and over, who tended to come with families. Future qualitative and quantitative research on the effects of various aspects of neighborhoods (e.g., social and built environmental context) and mediating pathways may help disentangle distinct etiological mechanisms between neighborhood disadvantage and mortality.

Our study has several strengths. We leveraged a natural experiment to generate more rigorous estimates of the health effects of neighborhood disadvantage among older adults compared with prior correlational studies. This study design reduces the selection bias that typically confounds analyses in the neighborhood health effects literature. Furthermore, using health registers to capture relevant clinical diagnoses and medications minimized the reporting biases common in surveys and enabled the inclusion of a relatively large sample of affected individuals.

The study also has several limitations. First, dementia diagnoses may have been misclassified or missed due to potential barriers to access to quality diagnostic tools among ethnic minorities (Nielsen, Vogel, Phung, Gade, & Waldemar, 2011). Our estimates could be biased if detection rates varied by neighborhood disadvantage. Second, if sickness triggered emigration, leading to mortality undetected in Cox models, the disadvantage-mortality estimate for refugees would be biased downward. Yet this is unlikely since refugees generally have little opportunity to choose to emigrate for health reasons, and we were reassured that we did not find that neighborhood disadvantage was associated with the emigration risk among refugees (Table S10). Third, some aspects of the analysis may have more limited power to detect smaller effect estimates, including subgroup analyses and those in which the exposure was modeled as a categorical (rather than a continuous) variable. Fourth, studies have shown that estimates of neighborhood effects may be sensitive to how neighborhood boundaries are defined (Flowerdew, Manley, & Sabel, 2008; Jakobsen, 2021; Lund, 2018). Neighborhood effect estimates are influenced by the particular spatial scale used for exposure data aggregation, known as the modifiable areal unit problem (Openshaw & Taylor, 1981), or the way neighborhoods are delineated, known as the uncertain geographic context problem (Kwan, 2012). While parishes reflect historical and contemporary social and economic features (Meijer, Kejs, et al., 2012), they nevertheless may not perform as well as smaller geographic areas (Jakobsen, 2021). A final concern is that our study findings may not be generalizable to other outcomes or older refugees in different countries or more recent periods. Nevertheless, this natural experiment provides a unique opportunity to estimate neighborhood disadvantage effects while reducing confounding by self-selection.

In conclusion, we found no evidence of neighborhood disadvantage associated with dementia, but also found that living in socioeconomically disadvantaged neighborhoods provided mortality benefits to older refugees. Amid new and continuing waves of refugees worldwide, understanding conditions that support or harm older adults' health and well-being is important. Future studies replicating these analyses in more recent cohorts in different geographical settings are needed. Also, studies assessing mechanistic pathways through which disadvantaged neighborhoods lower mortality may strengthen our theoretical understanding and inform ways to support refugee populations.

Declarations of interest

None.

Funding

This work was supported by grants from the National Institute of Aging (R01AG063385).

Author statement

Min Hee Kim: Conceptualization; Formal analysis; Investigation; Methodology; Software; Validation; Visualization; Writing - original draft; Writing - review & editing, Investigation, Methodology, Validation, Writing – review & editing.

Else Foverskov: Conceptualization, Data curation, Investigation, Methodology, Validation, Writing – review & editing.

Trine Frøslev: Data curation, Formal analysis, Software, Investigation, Writing – review & editing.

Justin S. White: Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

M. Maria Glymour: Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

Jens Hainmueller: Conceptualization, Methodology, Writing – review & editing.

Lars Pedersen: Conceptualization, Supervision, Methodology, Writing – review & editing.

Henrik T. Sørensen: Conceptualization, Supervision, Methodology, Writing – review & editing.

Rita Hamad: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2022.101312.

References

Agyemang, C., & Norredam, M. (2020). Neighborhood environment has a profound association with refugees' health. *JAMA Network Open, 3*(8). https://doi.org/10.1001/jamanetworkopen.2020.14355. e2014355-e2014355.

Al-Rousan, T., AlHeresh, R., Saadi, A., El-Sabrout, H., Young, M., Benmarhnia, T., et al. (2022). Epidemiology of cardiovascular disease and its risk factors among refugees and asylum seekers: Systematic review and meta-analysis. *International Journal of Cardiology Cardiovascular Risk and Prevention.* , Article 200126. https://doi.org/10.1016/j.ijcrp.2022.200126

Barnes, D. E., & Yaffe, K. (2011). The projected effect of risk factor reduction on Alzheimer's disease prevalence. *The Lancet Neurology, 10*(9), 819–828. https://doi.org/10.1016/S1474-4422(11)70072-2

Berry, S. D., Ngo, L., Samelson, E. J., & Kiel, D. P. (2010). Competing risk of death: An important consideration in studies of older adults. *Journal of the American Geriatrics Society, 58*(4), 783–787. https://doi.org/10.1111/j.1532-5415.2010.02767.x

Besser, L. M., McDonald, N. C., Song, Y., Kukull, W. A., & Rodriguez, D. A. (2017). Neighborhood environment and cognition in older adults: A systematic review. *American Journal of Preventive Medicine, 53*(2), 241–251. https://doi.org/10.1016/j.amepre.2017.02.013

Blume, K., & Verner, M. (2007). Welfare dependency among Danish immigrants. *European Journal of Political Economy, 23*(2), 453–471. https://doi.org/10.1016/j.ejpoleco.2006.08.005

Braak, H., Thal, D. R., Ghebremedhin, E., & Del Tredici, K. (2011). Stages of the pathologic process in alzheimer disease: Age categories from 1 to 100 years. *Journal of Neuropathology & Experimental Neurology, 70*(11), 960–969. https://doi.org/10.1097/NEN.0b013e318232a379

Cadar, D., Lassale, C., Davies, H., Llewellyn, D. J., Batty, G. D., & Steptoe, A. (2018). Individual and area-based socioeconomic factors associated with dementia incidence in England: Evidence from a 12-year follow-up in the English longitudinal study of ageing. *JAMA Psychiatry, 75*(7), 723–732. https://doi.org/10.1001/jamapsychiatry.2018.1012

Chenoweth, J., & Burdick, L. (2001). The path to integration: Meeting the special needs of refugee elders in resettlement. *Refuge: Canada's Journal on Refugees, 20*(1), 20–29. https://doi.org/10.25071/1920-7336.21244

Clarke, P. J., Ailshire, J. A., House, J. S., Morenoff, J. D., King, K., Melendez, R., et al. (2012). Cognitive function in the community setting: The neighbourhood as a source of 'cognitive reserve. *Journal of Epidemiology & Community Health, 66*(8), 730–736. https://doi.org/10.1136/jech.2010.128116

Damm, A. P. (2005). The Danish dispersal policy on refugee immigrants 1986-1998: A natural experiment?. Retrieved from https://pure.au.dk/ws/files/32305246/05-3_apd.pdf.

Damm, A. P. (2009). Ethnic enclaves and immigrant labor market outcomes: Quasi experimental evidence. *Journal of Labor Economics, 27*(2), 281–314. https://doi.org/10.1086/599336, 10.1086/599336.

DesMeules, M., Gold, J., McDermott, S., Cao, Z., Payne, J., Lafrance, B., et al. (2005). Disparities in mortality patterns among Canadian immigrants and refugees, 1980-1998: Results of a national cohort study. *Journal of Immigrant and Minority Health, 7*(4), 221–232. https://doi.org/10.1007/s10903-005-5118-y

Diez Roux, A. V. (2001). Investigating neighborhood and area effects on health. *American Journal of Public Health, 91*(11), 1783–1789. https://doi.org/10.2105/AJPH.91.11.1783

Diez Roux, A. V. (2004). Estimating neighborhood health effects: The challenges of causal inference in a complex world. *Social Science & Medicine, 58*(10), 1953–1960. https://doi.org/10.1016/S0277-9536(03)00414-3

Diez Roux, A. V., & Mair, C. (2010). Neighborhoods and health. *Annals of the New York Academy of Sciences, 1186*(1), 125–145.

Flowerdew, R., Manley, D. J., & Sabel, C. E. (2008). Neighbourhood effects on health: Does it matter where you draw the boundaries? *Social Science & Medicine, 66*(6), 1241–1255. https://doi.org/10.1016/j.socscimed.2007.11.042

Fonseca, X., Lukosch, S., & Brazier, F. (2019). Social cohesion revisited: A new definition and how to characterize it. *Innovation: The European Journal of Social Science Research, 32*(2), 231–253. https://doi.org/10.1080/13511610.2018.1497480

Foverskov, E., White, J. S., Norredam, M., Frøslev, T., Kim, M. H., Glymour, M. M., et al. (2022). Neighbourhood socioeconomic disadvantage and psychiatric disorders among refugees: A population-based, quasi-experimental study in Denmark. *Social Psychiatry and Psychiatric Epidemiology*. https://doi.org/10.1007/s00127-022-02300-3

Gautam, R., Mawn, B. E., & Beehler, S. (2018). Bhutanese older adult refugees recently resettled in the United States: A better life with little sorrows. *Journal of Transcultural Nursing, 29*(2), 165–171. https://doi.org/10.1177/1043659617696975

GBD Dementia Forecasting Collaborators. (2022). Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: An analysis for the global burden of disease study 2019. *The Lancet Public Health, 7*(2), Article e105. https://doi.org/10.1016/S2468-2667(21)00249-8

Groenwold, R. H., Palmer, T. M., & Tilling, K. (2021). To adjust or not to adjust? When a "confounder" is only measured after exposure. *Epidemiology, 32*(2), 194. https://doi.org/10.1097/EDE.0000000000001312

Hamad, R., Öztürk, B., Foverskov, E., Pedersen, L., Sørensen, H. T., Bøtker, H. E., et al. (2020). Association of neighborhood disadvantage with cardiovascular risk factors and events among refugees in Denmark. *JAMA Network Open, 3*(8). https://doi.org/10.1001/jamanetworkopen.2020.14196. e2014196-e2014196.

van Ham, M., & Manley, D. (2012). Neighbourhood effects research at a crossroads. Ten challenges for future research introduction. *Environment & Planning A, 44*(12), 2787–2793. https://doi.org/10.1068/a45439

Hasager, L., & Jørgensen, M. H. (2021). *Sick of your poor neighborhood?: Quasi-experimental evidence on neighborhood effects on health.* February. https://doi.org/10.2139/ssrn.3782634 *(CEBI Working Paper Series)*.

Heide-Jørgensen, U., Adelborg, K., Kahlert, J., Sørensen, H. T., & Pedersen, L. (2018). Sampling strategies for selecting general population comparison cohorts. *Clinical Epidemiology, 10*, 1325. https://doi.org/10.2147/CLEP.S164456

Hollander, A.-C. (2013). Social inequalities in mental health and mortality among refugees and other immigrants to Sweden-epidemiological studies of register data. *Global Health Action, 6*(1), Article 21059. https://doi.org/10.3402/gha.v6i0.21059

Hollander, A.-C., Bruce, D., Ekberg, J., Burström, B., Borrell, C., & Ekblad, S. (2012). Longitudinal study of mortality among refugees in Sweden. *International Journal of Epidemiology, 41*(4), 1153–1161. https://doi.org/10.1093/ije/dys072

Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: A meta-analytic review. *PLoS Medicine, 7*(7), Article e1000316. https://doi.org/10.1371/journal.pmed.1000316

Hunt, J. F., Buckingham, W., Kim, A. J., Oh, J., Vogt, N. M., Jonaitis, E. M., … Norton, D. (2020). Association of neighborhood-level disadvantage with cerebral and hippocampal volume. *JAMA Neurology, 77*(4), 451–460. https://doi.org/10.1001/jamaneurol.2019.4501

Hunt, J. F., Vogt, N. M., Jonaitis, E. M., Buckingham, W. R., Koscik, R. L., Zuelsdorff, M., et al. (2020). Neighborhood disadvantage is associated with accelerated cortical thinning and cognitive decline in cognitively unimpaired adults: Public health: ADRD risk and protective factors: Brain changes and mechanisms. *Alzheimer's and Dementia, 16*, Article e043170. https://doi.org/10.1002/alz.043170

Jacob, B. A., Ludwig, J., & Miller, D. L. (2013). The effects of housing and neighborhood conditions on child mortality. *Journal of Health Economics, 32*(1), 195–206. https://doi.org/10.3386/w17369

Jakobsen, A. L. (2021). Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study. *Health & Place, 72*, Article 102675. https://doi.org/10.1016/j.healthplace.2021.102675

Kwan, M. P. (2012). The uncertain geographic context problem. *Annals of the Association of American Geographers, 102*(5), 958–968. https://doi.org/10.1080/00045608.2012.687349

Livingston, G., Huntley, J. G., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., & Cooper, C. (2020). Dementia prevention, intervention, and care: 2020 report of the lancet commission. *The Lancet, 396*(10248), 413–446. https://doi.org/10.1016/S0140-6736(20)30367-6

Lund, R. L. (2018). From the dark end of the street to the bright side of the road: Automated redistricting of areas using physical barriers as dividers of social space. *Methodological Innovations, 11*(3). https://doi.org/10.1177/2059799118814386

Martén, L., Hainmueller, J., & Hangartner, D. (2019). Ethnic networks can foster the economic integration of refugees. *Proceedings of the National Academy of Sciences, 116*(33), 16280–16285. https://doi.org/10.1073/pnas.1820345116

Meijer, M., Kejs, A. M., Stock, C., Bloomfield, K., Ejstrud, B., & Schlattmann, P. (2012). Population density, socioeconomic environment and all-cause mortality: A multilevel survival analysis of 2.7 million individuals in Denmark. *Health & Place, 18*(2), 391–399. https://doi.org/10.1016/j.healthplace.2011.12.001

Meijer, M., Röhl, J., Bloomfield, K., & Grittner, U. (2012). Do neighborhoods affect individual mortality? A systematic review and meta-analysis of multilevel studies. *Social Science & Medicine, 74*(8), 1204–1212. https://doi.org/10.1016/j.socscimed.2011.11.034

Messer, L. C., Laraia, B. A., Kaufman, J. S., Eyster, J., Holzman, C., Culhane, J., … O'campo, P. (2006). The development of a standardized neighborhood deprivation index. *Journal of Urban Health, 83*(6), 1041–1062. https://doi.org/10.1007/s11524-006-9094-x

Mobley, T. M., Shaw, C., Hayes-Larson, E., Fong, J., Gilsanz, P., Gee, G. C., … Mayeda, E. R. (2022). *Neighborhood disadvantage and dementia incidence in a cohort of Asian American and non-Latino White older adults in Northern California. Alzheimer's & Dementia*. Advance online publication. https://doi.org/10.1002/alz.12660

Morello-Frosch, R., Zuk, M., Jerrett, M., Shamasunder, B., & Kyle, A. D. (2011). Understanding the cumulative impacts of inequalities in environmental health: Implications for policy. *Health Affairs, 30*(5), 879–887. https://doi.org/10.1377/hlthaff.2011.0153

Nielsen, T., Vogel, A., Phung, T., Gade, A., & Waldemar, G. (2011). Over-and under-diagnosis of dementia in ethnic minorities: A nationwide register-based study. *International Journal of Geriatric Psychiatry, 26*(11), 1128–1135. https://doi.org/10.1002/gps.2650

Oakes, J. M. (2004). The (mis) estimation of neighborhood effects: Causal inference for a practicable social epidemiology. *Social Science & Medicine, 58*(10), 1929–1952. https://doi.org/10.1016/j.socscimed.2003.08.004

Openshaw, S., & Taylor, P. J. (1981). The modifiable areal unit problem. In N. Wrigley, & R. Bennett (Eds.), *Quantitative geography: A British view* (pp. 60–69) (Routledge and Kegan Paul, London).

Ouvrard, C., Meillon, C., Dartigues, J.-F., Ávila-Funes, J. A., & Amieva, H. (2020). Do individual and geographical deprivation have the same impact on the risk of dementia? A 25-year follow-up study. *The Journals of Gerontology: Series B, 75*(1), 218–227. https://doi.org/10.1093/geronb/gbx130

Phillips, D. (2007). Ethnic and racial segregation: A critical perspective. *Geography Compass, 1*(5), 1138–1159. https://doi.org/10.1111/j.1749-8198.2007.00051.x

Phung, T. K. T., Andersen, B. B., Høgh, P., Kessing, L. V., Mortensen, P. B., & Waldemar, G. (2007). Validity of dementia diagnoses in the Danish hospital registers. *Dementia and Geriatric Cognitive Disorders, 24*(3), 220–228. https://doi.org/10.1159/000107084

Rodgers, J., Cuevas, A. G., Williams, D. R., Kawachi, I., & Subramanian, S. (2021). The relative contributions of behavioral, biological, and psychological risk factors in the association between psychosocial stress and all-cause mortality among middle-and older-aged adults in the USA. *GeroScience, 43*(2), 655–672. https://doi.org/10.1007/s11357-020-00319-5

Rosella, L., Kornas, K., Huang, A., Bornbaum, C., Henry, D., & Wodchis, W. P. (2018). Accumulation of chronic conditions at the time of death increased in Ontario from 1994 to 2013. *Health Affairs, 37*(3), 464–472. https://doi.org/10.1377/hlthaff.2017.1150

Sadarangani, T. R., & Jun, J. (2015). Newly arrived elderly immigrants: A concept analysis of "aging out of place". *Journal of Transcultural Nursing, 26*(2), 110–117. https://doi.org/10.1177/1043659614549074

Sampson, R. J. (2012). Neighborhood inequality, violence, and the social infrastructure of the American city. In W. F Tate (Ed.), *Research on schools, neighborhoods, and communities: Toward civic responsibility* (pp. 11–28). Lanham, MD: Rowman & Littlefield.

Schmidt, M., Schmidt, S. A. J., Adelborg, K., Sundbøll, J., Laugesen, K., Ehrenstein, V., et al. (2019). The Danish health care system and epidemiological research: From health care contacts to database records. *Clinical Epidemiology, 11*, 563. https://doi.org/10.2147/CLEP.S179083

Syse, A., Dzamarija, M. T., Kumar, B. N., & Diaz, E. (2018). An observational study of immigrant mortality differences in Norway by reason for migration, length of stay and characteristics of sending countries. *BMC Public Health, 18*(1), 1–12. https://doi.org/10.1186/s12889-018-5435-4

Taudorf, L., Nørgaard, A., Waldemar, G., & Laursen, T. M. (2021). Mortality in dementia from 1996 to 2015: A national registry-based cohort study. *Journal of Alzheimer's Disease, 79*(1), 289–300. https://doi.org/10.3233/JAD-200823

Treas, J. (2015). Incorporating immigrants: Integrating theoretical frameworks of adaptation. *The Journals of Gerontology: Series B, 70*(2), 269–278. https://doi.org/10.1093/geronb/gbu067

UNHCR. (2021). *Working with older persons in forced displacement*. Geneva, Switzerland: UN High Commissioner for Refugees. Retrieved from https://www.refworld.org/docid/4ee72aaf2.html. (Accessed 13 May 2022).

Weiss, J. (2021). Contribution of socioeconomic, lifestyle, and medical risk factors to disparities in dementia and mortality. *SSM-Population Health, 16*, Article 100979. https://doi.org/10.1016/j.ssmph.2021.100979

White, J. S., Hamad, R., Li, X., Basu, S., Ohlsson, H., Sundquist, J., et al. (2016). Long-term effects of neighbourhood deprivation on diabetes risk: Quasi-experimental evidence from a refugee dispersal policy in Sweden. *Lancet Diabetes & Endocrinology, 4*(6), 517–524. https://doi.org/10.1016/S2213-8587(16)30009-2

Wren, K. (2003). Refugee dispersal in Denmark: From macro-to micro-scale analysis. *International Journal of Population Geography, 9*(1), 57–75. https://doi.org/10.1002/ijpg.273

Zuelsdorff, M., Larson, J. L., Hunt, J. F., Kim, A. J., Koscik, R. L., Buckingham, W. R., … Rissman, R. A. (2020). The area deprivation index: A novel tool for harmonizable risk assessment in Alzheimer's disease research. *Alzheimer's and Dementia: Translational Research & Clinical Interventions, 6*(1), Article e12039. https://doi.org/10.1002/trc2.12039