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Ethnic networks in neighborhoods affect mental health: Evidence from a quasi-random assignment of applicants in the public social housing system

Bence Boje-Kovacs [a,*], Jane Greve [b], Cecilie D. Weatherall [c]

[a] Department of the Built Environment, Aalborg University, A.C. Meyers Vænge 15, 2450, Copenhagen SV, Denmark
[b] VIVE – the Danish Centre for Social Science Research, Herluf Trolles Gade 11, 1052, Copenhagen K, Denmark
[c] FOSS, Nils Foss Allé 1, 3400, Hilleroed, Denmark

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ABSTRACT

This paper examines the impact of residence-based ethnic networks on mental health; such networks are defined as the concentration of residents from the same country of origin in a neighborhood. To estimate the effect, we utilize administrative registry data, together with data on quasi-random assignment of apartments to non-Western households with housing needs to various neighborhoods. After controlling for individual characteristics, time-invariant neighborhood characteristics, and general practitioners (GP) fixed effects, we find that a 1–percentage-point increase in the concentration of residence-based co-ethnics (RBCEs) increases the probability of being treated with psychiatric medications by 0.7-percentage point over a 5-year period after the assignment. With 19% of the population being treated with psychiatric medications the year before assignment, the result translates into an effect size of 3.7%. The results indicate that relatively high concentrations of co-ethnics treated with psychiatric medications increase the probability of being treated with psychiatric medications. The positive impact on treatment with psychiatric medication reflects an increase in the demand for these drugs when moving into a neighborhood with neighbors of the same ethnicity. If new residents are in good mental health condition when moving, these results suggest that moving into a neighborhood with a high co-ethic concentration worsens mental health status. However, as the population in this study is a vulnerable group an increase in treatment with psychiatric medications likely reflects that untreated mental health problems are treated, and the mental health status improved. The group of non-Western immigrants in this study differs significantly from the population in general, thus, results may not be generalized to all non-Western immigrants.

1. Introduction

Mental illness is one of the leading causes of long-term disability and the global burden is considerable. In 2019, the economic value of global mental illness was estimated to USD 5 trillion (Arias et al., 2022). Across disciplines, research has documented the social and economic consequences of the growing population with mental health problems (OECD, 2016; Trautmann et al., 2016; Tucci and Moukaddam, 2017). Moreover, recent studies have shown a high incidence of mental health problems among several ethnic minorities (Bas-Sarmiento et al., 2017; Johansson et al., 2012; Levecque et al., 2007; Schrier et al., 2012; de Wit et al., 2008). Besides risk factors related to personal or family characteristics and the history of migration, the literature points to the role of social experiences and networks among residence-based co-ethnics as a major factor influencing mental health (Bécares et al., 2018; Pickett and Wilkinson, 2008). In many studies, the residence-based co-ethnic (RBCE) population is expected to hold ethnic minorities' social experience and networking (Shaw et al., 2012). However, few studies have examined the causal impact of RBCE networks on mental health (Awaworyi Churchill et al., 2019; Devillanova, 2008).

In this paper, we examine the causal impact of RBCE networks — measured as the concentration of residents having the same (non-Western) country of origin —on new residents' mental health. Moreover, we investigate which characteristics of the RBCE population influence mental health. To measure mental health, we use an indicator for whether the applicant was treated with psychiatric medications, which is a proxy for underlying mental health problems and not a direct measure of mental health. We define neighborhoods as physically contiguous housing blocks delimited by the four intersections that constitute corners of the block.

* Corresponding author.
E-mail addresses: bjbk@build.aau.dk (B. Boje-Kovacs), jagr@vive.dk (J. Greve), cdw@foss.dk (C.D. Weatherall).

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Fig. 1 presents the conceptual framework and illustrates potential factors and paths when estimating the causal impact of the concentration of RBCEs on mental health. The ethnic density hypothesis suggests that higher ethnic concentration in the neighborhood is beneficial for mental health as it provides a social network, social support, and community cohesion, which in turn offsets stress related to racial discrimination, socioeconomic disadvantage, and low social status (Bécares et al., 2018; Hong et al., 2014; Jun et al., 2020). However, social norms related to drug abuse or psychological imitation of ethnic peers may affect new residents' mental health either positively or negatively (Eisenberg et al., 2013; Hatfield et al., 1993). Also, lack of information about the health care system in the RBCE population might influence the demand for health care services, which again can affect mental health.

Since segregation by income is highly correlated with ethnic segregation (see Figs. A1–A3), living among disadvantaged neighbors can lead to poor social support and social cohesion and thereby worse mental health (Carpiano, 2007; Cattell, 2001; Echeverría et al., 2008; Fone et al., 2007; Silver et al., 2002). Moreover, characteristics of socioeconomically disadvantaged neighborhoods such as high crime rates can lead to anxiety and fear of victimization, which leads to social isolation and loneliness (Popkin et al., 2002). Likewise, social network theories suggest that the high concentration of unemployed peers may reduce job opportunities (Montgomery, 1994) and thereby increase mental health problems (Browning and Heinesen, 2012; Marcus, 2013).

Neglected building maintenance or scarce green and open spaces (Jones-Rounds et al., 2014), as well as the quality of local consumer goods and services can negatively affect mental health and are often correlated with other neighborhood characteristics such a high concentration of non-Western immigrants. Finally, variations in accessibility to mental health care, and the quality of health care services, in particular general practitioners (GPs), across neighborhoods can affect the quality of health care (Bissonnette et al., 2012).

To estimate the causal impact of RBCE networks on mental health, we use quasi-random assignment of non-Western households with housing needs into neighborhoods with different ethnic concentrations in Copenhagen between 2000 and 2006. Combined with Danish administrative registry data, this setup allows us to control for institutional and environmental time-invariant neighborhood characteristics affecting mental health, as well as for health care quality, by using neighborhood and GP fixed effects, that is, isolating the impact of RBCE networks and social interactions among co-ethnic neighbors.

We find that a 1–percentage-point increase in the concentration of RBCEs in the neighborhood increases the probability of being treated with psychiatric medications by 0.7 percentage points over a 5-year period after assignment. In our sample, 19% were treated with psychiatric medication the year before assignment; this translates to an effect size of 3.7%. Compared to not having co-ethnics at all in the neighborhood the highest probability of purchasing psychiatric medication is found among those who are exposed to co-ethnic concentration of at least 10%. Finally, we investigate which RBCE population characteristics influence mental health. We find that a 1–percentage-point increase in the share of RBCEs treated with psychiatric medications increases treatment with psychiatric medication by 0.14 percentage points. We examine the robustness of these main results.

1.1. Literature review

Previous literature contains mixed results of investigations into the relationship between RBCE concentration and mental health outcomes (and the ethnic density hypothesis). Applying an instrumental variable approach, Awaworyi Churchill et al. (2019) show that increased ethnic diversity in the neighborhood deteriorates mental health through a lower level of neighborhood trust. Several other studies using a multilevel approach and different definitions of community cohesion at the neighborhood level have investigated the ethnic density hypothesis and found a positive association between community cohesion within ethnic groups and mental health (Arévalo et al., 2015; Fone et al., 2007; Hong et al., 2014). Other literature finds that own-immigrant concentration, for some ethnic groups, is negatively associated with mental health (Echeverría et al., 2008; Mair et al., 2010).

There could be several reasons for these mixed results. First, most of the studies do not account for residents' self-selection into neighborhoods (Bécares et al., 2018). Consequently, the correlation between individual and neighborhood characteristics induces endogeneity problems, which in turn do not permit distinguishing whether the outcome is caused by individual or neighborhood characteristics (Bayer et al., 2008; Topa and Zenou, 2015). To control for self-selection, we exploit a public social housing program in the Copenhagen municipality that quasi-randomly assigns households into neighborhoods with various ethnic concentrations.

Second, previous studies do not distinguish between the effects of social interaction, and the institutional and structural environmental features of the neighborhood (Manski, 1993). From a policy perspective, it is relevant to distinguish between these effects to improve

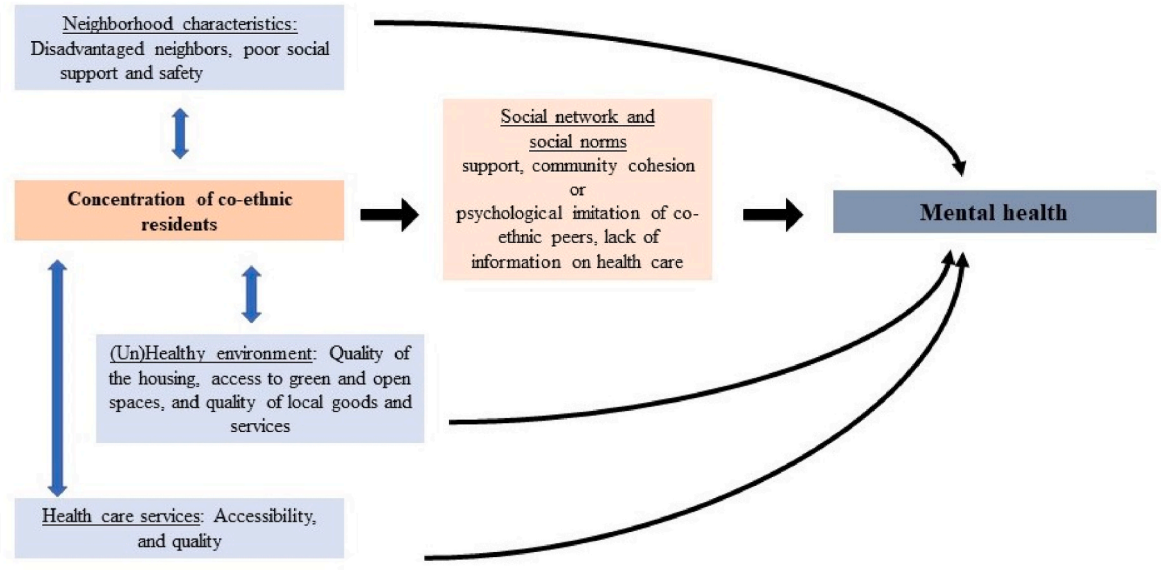


Fig. 1. Conceptual framework of variables affecting mental health.

understanding of influences on mental health. In this paper, we control for institutional and environmental time-invariant neighborhood characteristics as well as for health-care quality by using neighborhood and GP fixed effects.

Third, most studies rely on relatively large geographical units, such as census tracts (Bécares et al., 2014), political boundaries (Jun et al., 2020), census area units (Bécares et al., 2013), or counties (Choi et al., 2016) with neighborhood populations defined as over 1500 residents on average. However, such large areas do not necessarily correspond to social space where interaction takes place (Mezuk, et al., 2015). Recent studies on neighborhood effects suggest that social interaction occurs on a relatively small geographical scale, such as housing blocks (Damm, 2014; Grossman and Khalil, 2020; Rotger and Galster, 2019). In a Danish study, Hjorth et al. (2016) show that the median size of a self-perceived neighborhood in Denmark contains 479 residents. In this study, we define neighborhoods as physically contiguous housing blocks; an average 370 residents live in each block.

In our study, mental health is measured by an indicator for treatment with psychiatric. Previous literature has shown that a high degree of community cohesion can promote access to information about health-related behaviors as well as to services (Echeverría et al., 2008) and Devillanova (2008) shows that health care utilization increases through the information flow in the ethnic networks. Thus our result that an increase in the concentration of RBCEs increases the use of psychiatric medication may support the ethnic density hypothesis.

Our study contributes to the literature on RBCE concentration and mental health in several ways. First, we quantify the causal effect of the RBCE social network on mental health using quasi-random assignment of social housing in the Copenhagen municipality. Second, our estimates do not reflect effects of the physical environment and local institutional factors as we include neighborhood and GP fixed effects. Third, we demonstrate that the effect is mainly coming from neighborhoods with a concentration of co-ethnics of at least 10%. Fourth, our results point to which characteristics of co-ethnic neighbors, that is, previous psychiatric medication treatment and non-employed status, increase the risk of mental health problems.

2. Data and methods

2.1. Public social housing assignment

Our analysis is based on a dataset containing 3110 non-Western individuals (coming from various non-Western countries) who received a housing offer from the Public Social Housing (PSH) system in the Copenhagen municipality between 2000 and 2006. To be eligible for PSH, the applicant must have an urgent housing need as a result of socioeconomic problems, such as addiction, health issues, or financial issues.

The applicant is assigned to a local caseworker at one of the municipality's citizen service centers. The local caseworker collects information relevant to eligibility such as the applicant's financial situation, criminal record, health, and addiction issues. Also included is whether the applicant has exploited all other possible options to find an apartment on their own. Finally, the caseworker reviews the information and decides whether the applicant is eligible for housing; eligible persons' applications are forwarded to the municipal PSH office. Once the PSH office approves an application (i.e., agrees with caseworker's assessment), PSH matches the household's characteristics with the list of available apartments. When pairing apartments and applicants the PSH office accounts for the number of family members (and thereby rooms needed) and the applicant's financial means (the PSH office does not provide financial support to pay rent for eligible applicants). Vacant apartments are always matched with applicants according the oldest application determined eligible. Applicants have no influence on the matching process. While the group of applicants is a vulnerable group and many have addiction issues and mental health problems (see Christensen and Stax (2002) for a description of the entire group of applicants in Copenhagen in 2002), mental health issues are not taken into account during assignment of applicants to apartments and neighborhoods. Fig. A4 illustrates the process of assignment.

The public housing sector is owned by non-profit housing associations and accounts for 20% of total housing stock in the municipality. Since 2000, every third vacant apartment within each housing association is automatically assigned to the PSH office. Consequently, the PSH office has no influence on the order and location of incoming apartments. Fig. A5 shows the locations of offered housing in Copenhagen municipality over the 2000–2006 period. To test the randomness of vacant apartments assigned to PSH, we compare housing characteristics between vacant apartments assigned to public social housing and those that were not. Table A1 reveals that there is no significant relationship between apartment size nor number of rooms and those assigned to the PSH office. However, vacant apartments assigned to the PSH office are on average 5 years older compared to vacant apartments not assigned to the PSH office.

Furthermore, one might expect higher vacancy rates for apartments in low-income neighborhoods. If this were the case, the parameter estimate could be biased if available apartments assigned to PSH correlate with ethnic concentration. In Table A2, we show that there is only one significant relationship between the share of apartments assigned to PSH and the characteristics of the neighborhood. In general, the parameter estimates point in different directions and do not show a clear picture of selection in terms of the neighborhood's socioeconomic characteristics. In our main results, we control for these neighborhood characteristics. Overall, Tables A1 and A2 suggest that there is no systematic selection bias regarding incoming housing stock that PSH uses to assign households to public housing.

Applicants who have received a housing offer have the right to reject the first offer. If the offer is rejected, the PSH office requires a detailed description of the reasons for the refusal before the application procedure can start again. In case of a rejection, the average waiting time for an offer in the period of analysis is 7–10 months. The PSH office allows two offers; however, our data includes only information on the final housing offer. As using the final offer as indicator for neighborhood can introduce potential bias in results we examine the question of bias in Section 2.4 by conducting several balance tests.

We observe that 9% reject the PSH offer. A total of 13% of assigned households, including those who rejected the offer, never moved into the assigned apartments, or lived at the address for less than a year. Of those who did move into respective assigned apartments, 59% stayed in such housing for five years after the year of assignment.

Overall, given the procedure in which apartments were assigned to applicants, we consider the distribution of apartments across neighborhoods to be quasi-random.

2.2. Population

The administrative registry data from the Copenhagen municipal PSH system for 2000–2006 include records of each applicant's date of assignment, acceptance or rejection of a housing offer, the person's unique identification (ID) number and the full address of the apartment offered.

By using the applicant's unique ID number, we merge a long list of Danish administrative registries from 1996 through 2011 to the PSH records. Since the PSH records only contain the identification number of the main applicant, we identify family members as those who share the same household with the main applicant before and after an apartment was offered corresponding to 24% of the final sample number. The administrative registries provide information for the population aged 18 to 60 annually on both health-care use — that is, prescribed and purchased psychiatric medications and non-psychiatric hospital admissions — and individual demographic and socioeconomic characteristics, such as age, current residence, moving patterns, country of origin, income,

employment status, and level of education.

Our main sample includes applicants and their family members with non-Western ethnic backgrounds who were offered an apartment through the PSH office in Copenhagen from 2000 to 2006. The following protocols were applied when creating the main sample: (1) The latest observation is kept if a household was assigned to more than one address in the same year. In our final dataset, there are 33 individuals who are assigned to more than one address during the same year. We repeated our main analysis including only the first assigned address. Table A3 shows the same result as for our main specification. (2) Individuals aged 23 to 55 in the year of assignment are included. (3) Applicants who died or immigrated during the study period were excluded because we could not follow them over time. The total number of applicants — including family members — with non-Western ethnic backgrounds aged 23–55 offered housing through the Copenhagen PSH office in the 2000–2006 period is 3110.

We define neighborhoods as physically contiguous housing blocks delimited by the four intersections that constitute the corners of the block. In our sample, there are 259 neighborhoods with an average of 370 residents in each block.

The mental health outcome that we examine is a binary indicator (0/1) that equals 1 if the person purchases prescribed psychiatric medication, that is, anti-depressants, anti-psychotics, anti-anxiety drugs, psychostimulant medication, analgesics, and drugs used in addictive disorders in a given year. We define RBCE networks as the proportion of residents having the same country of origin in the neighborhood.

Table 1 compares baseline characteristics of the main sample with the full population of non-Western immigrants in Copenhagen municipality between 2000 and 2006. As expected, the population of non-Western immigrants who receives a housing offer from PSH has significantly worse socioeconomic characteristics and mental health indicators compared to the non-Western population in Copenhagen. In particular, three out of four in the main sample are non-employed, and one out of four are treated with psychiatric medications.

Table A4 presents descriptive statistics (mean, standard deviation, min/max) of the neighborhood characteristics measured the year before assignment. Overall, the table demonstrates substantial variation among neighborhoods. The average share of co-ethnics in the neighborhood corresponds to 2.4 percent. Fig. A6 shows that the measure of ethnic density is skewed to the right.

Table 1
Sample means and standard deviations (SDs) of individual characteristics for assigned non-Western population and total non-Western population living in Copenhagen, 2000–2006.

	Assigned Non-Western population		Non-Western population in Copenhagen	
	Mean	SD	Mean	SD
Age (years)	34.72***	7.64	35.88	8.69
Women (0/1)	1.51*	0.50	1.49	0.50
<10 years of formal education (0/1)	0.35***	0.48	0.32	0.47
Total annual income (in DKK)	151,12***	74,31	191,51	149,74
Employed (0/1)	0.26***	0.44	0.51	0.50
Convicted of crime(s) (0/1) [a]	0.06***	0.24	0.02	0.15
Number of family members	2.60***	1.62	4.79	2.95
Psychiatric medications (0/1) [b]	0.26***	0.44	0.14	0.35
Non-psychiatric hospitalization (0/1)	0.01	0.08	0.01	0.08
Observations	3110		272,879	

Note: The sample includes non-Western immigrants aged 23–55. For the sample of assigned non-Western immigrants, all variables are measured the year before assignment.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.
[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.
[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02.

2.3. Empirical strategy

As 91% of the applicants accept the offer, we estimate an intention-to-treat (ITT) effect. ITT is an average of the causal impact of RBCE networks on new residents' mental health for applicants who received and accepted an offer from the PSH office and for applicants who received the offer but did not accept it. Consequently, the ITT approach shows the impact of being offered public social housing regardless of acceptance and how long applicants stay in the offered apartment. Our model follows:

$$y_{int} = \alpha + \beta_t + X_{it}\gamma + \delta I_{nt-1} + \zeta A_{nt-1} + \mu_n + \mu_{gp} + \epsilon_{int} \quad \text{(Eq. 1)}$$

where y_{int} is the mental health outcome (i.e., treatment with psychiatric medication for individual I assigned to neighborhood n in year t). I_{nt-1}, the main variable of interest, is the concentration of co-ethnics in neighborhood n, the year before assignment $t-1$.

We isolate the impact of the concentration of co-ethnics from other neighborhood characteristics by adding a vector, A_{nt-1}, that includes neighborhood characteristics the year before assignment $t-1$, such as the percentage of non-employed residents, average gross income, average crime rate, percentage of residents treated with psychiatric medication, and number of people living in the neighborhood. X_{it} is a vector of control variables in the year of assignment that can potentially affect mental health status: age, gender, an indicator for less than 10 years of education, an indicator for being employed, an indicator for whether the individual has been convicted of a crime, number of family members, gross household income, and an indicator for whether the individual has been treated with psychiatric medication.

We also include year of assignment fixed effects (β_t) and neighborhood of assignment fixed effects (μ_n), which represent their time-constant structural and institutional characteristics at the neighborhood level. Finally, we include post-assignment GP fixed effects (μ_{gp}) measuring health-related institutional factors that can influence mental health. When we control for post-assignment GP fixed effects, we include an identification number for the GP of each individual in the year after assignment. Consequently, we explore variation in differences in the concentration of co-ethnics within neighborhoods and post-assignment GPs across different cohorts. Table A5 shows that when controlling for time-invariant neighborhood characteristics, there is no significant time trend in the proportion of co-ethnics compared to the base year 2000. Consequently, by applying cohort and neighborhood fixed effects, we control for unobserved and time-constant characteristics affecting mental health in each cohort within each neighborhood. ϵ_{int} is the idiosyncratic error term. Since eligible applicants for public social housing are matched with available apartments, which the PSH receives on the neighborhood level, we cluster the standard error on the neighborhood level. All versions of the model are estimated using ordinary least squares (OLS). The results are virtually the same when we use a logistic regression model. These results are available upon request. We also estimate the treatment effects on the treated (TOT) using a two-stage-least square (2SLS) approach. In the 2SLS approach we use the quasi-random assignment of an apartment in a neighborhood (with a given proportion of co-ethnics) as an instrument for the proportion of co-ethnics in the neighborhood where the applicant actually lives (in the year after assignment). The results are virtually the same when we use a 2SLS model. These results are available upon request.

2.4. Exogeneity of neighborhood assignment

In Section 2.1, we describe how the PSH quasi-randomly assigns disadvantaged households to public social housing in different neighborhoods. Thus, conditional on household size and applicant's income, other combined individual characteristics should not be able to predict the characteristics of the neighborhood to which the applicant is assigned.

To test this prediction, we regress several neighborhood characteristics prior to assignment on applicants' pre-assignment characteristics. For all calculations, we include year of assignment fixed effects. The balance tests provide support for our assumption of quasi-random assignment of residents if combined individual characteristics are not significantly correlated with neighborhood characteristics before assignment.

Table 2 shows seven balance tests for the main sample. For the main sample, the F-test on joint insignificance of the explanatory variables is rejected only once when we regress the crime rate on individual characteristics. Consequently, women on average are assigned to neighborhoods with a 0.1 percentage-point lower crime rate than men.

Table A6 shows additional balance tests, where we regress neighborhood characteristics, specifically of non-Western immigrants in the full sample (i.e., non-Western applicants' characteristics). Again, the F-test on joint insignificance is rejected once. Women are on average assigned to neighborhoods with a 0.3-percentage point lower crime rate compared to men. In each case the parameter estimate is effectively insignificant due to its negligible size. Moreover, we control for gender in the principal estimates. Thus, based on these tests and the way the policy was implemented, we believe that assignment of vulnerable non-Western households to public housing in Copenhagen municipality was quasi-random, conditional on characteristics known to the PSH office at the time of assignment.

3. Results

3.1. The impact of residence-based co-ethnic concentration on mental health

In Table 3, we present the impact of the residence-based co-ethnic (RBCE) concentration (measured the year before assignment) on the probability of being treated with psychiatric medications. Based on a compliance rate of 91%, we present the intention-to-treat (ITT) effects. Column 1 in Table 3 shows that a 1–percentage-point increase in the proportion of co-ethnics increases the probability of being treated with psychiatric medication by 0.7 percentage points. A 1–percentage-point increase in our treatment variable from the mean comprises 262 individuals corresponding to 8.4 percent of the population of interest. With 19% of the population being treated with psychiatric medications the year prior to assignment, the result translates into an effect size of 3.7%.

Our outcome variable includes psychiatric medication for treating various mental health problems. Table 3 shows the results where we examine the impact of ethnic concentration on each group of medications. We find a positive impact of ethnic concentration on treatment with all subgroups of medication except anxiolytics and drugs used in alcohol dependence (parameter estimates are close to zero). The results on analgesics, and antipsychotics are statistically significant at the 10- and 5-% level, respectively.

To examine whether the impact of RBCE concentration depends on the neighborhood being characterized by a high or low level of co-ethnic concentration we divide the measure of co-ethnic concentration into four groups and regress these on mental health. Overall, Table A7 reveals that having co-ethnics in the neighborhood compared to not having any co-ethnics increases the probability of purchasing psychiatric medication. Moreover, Table A7 shows that the parameter estimate is highest at a co-ethnic concentration of at least 10%. Thus, the effect of RBCE concentration comes mainly from living in a neighborhood with a very high co-ethnic concentration. When we estimate the main model including a diversity index (following Awaworyi Churchill et al., 2019), instead of RBCE concentration, we find no significant effect. These results are available upon request.

Several studies emphasize the residence-based ethnic population as a major environmental factor influencing mental health (Bécares et al., 2018; Pickett and Wilkinson, 2008). However, little is known about which characteristics of the residence-based ethnic population influence mental health. Previous studies argue that living among disadvantaged neighbors can lead to poor social support and social cohesion and thereby worsen mental health (Carpiano, 2007; Cattell, 2001; Echeverría et al., 2008; Fone et al., 2007; Silver et al., 2002). In this section we examine several characteristics of the co-ethnic population (measured the year before assignment) and estimate the impact of being exposed to a higher proportion of neighbors with the same ethnicity who are in vulnerable positions. In particular, we examine the extent to which the concentration of co-ethnics with (1) previous treated with psychiatric medication (Eisenberg et al., 2013), (2) crime convictions (Popkin et al., 2002), and (3) non-employment status (Browning and

Table 2
Balance tests: Assignment location attributes and individual characteristics of assignees. Linear probability model. Robust standard errors (SE) appear in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Psychiatric medications (%)	Appointment with psychiatrist (%)	Non-psychiatric Hospitalization (%)	Non-Western immigrants (%)	Non-employed (%)	Crime (%)	Average gross income (in DKK)
Age (years)	0.000	0.000	−0.000	−0.001*	−0.000	−0.000	109.318
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(121.508)
Women (0/1)	0.002	0.000	−0.001	−0.004	−0.002	−0.001**	773.443
	(0.001)	(0.000)	(0.000)	(0.007)	(0.003)	(0.000)	(1006.203)
<10 years of formal education (0/1)	0.001	−0.000	0.000	0.001	0.007**	0.001	−836.722
	(0.002)	(0.000)	(0.000)	(0.007)	(0.004)	(0.000)	(1076.179)
Employed (0/1)	0.000	−0.000	0.001	−0.011	−0.004	−0.001	1169.526
	(0.002)	(0.000)	(0.001)	(0.009)	(0.004)	(0.001)	(1262.230)
Convicted of crime(s) (0/1) [a]	−0.001	0.000	−0.000	−0.016	−0.006	0.002**	2415.512
	(0.003)	(0.001)	(0.001)	(0.013)	(0.006)	(0.001)	(1953.621)
Psychiatric medication (0/1) [b]	−0.002	0.000	0.000	0.003	−0.001	0.000	−240.712
	(0.002)	(0.000)	(0.000)	(0.007)	(0.003)	(0.000)	(1201.240)
Non-psychiatric hospitalization (0/1)	−0.006	0.000	−0.003	0.007	−0.002	−0.001	654.365
	(0.007)	(0.001)	(0.002)	(0.039)	(0.017)	(0.003)	(4974.479)
Observations	3110	3106	3106	3110	3110	3110	3110
R-squared	0.142	0.014	0.070	0.119	0.025	0.079	0.028
Prob > F	0.746	0.295	0.182	0.511	0.370	0.0435	0.812

Notes: All variables are measured the year before assignment. All regressions include year of assignment fixed effects and assignment characteristics known to the PSH such as gross household income and number of family members. The F-test for joint insignificance includes all variables except gross household income, number of family members, and year of assignment. Standard errors are clustered at the neighborhood level.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.

[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02.

Table 3
Impact of concentration of co-ethnics in the neighborhood on mental health (treated with psychiatric medications) outcomes, intention-to-treat effects.

	Psychiatric medications	Subgroups of psychiatric medications					
		Antidepressants	Analgesics	Antipsychotics	Anxiolytics	Hypnotics & sedatives	Drugs used in alcohol dependence
Concentration of co-ethnics	0.007**	0.002	0.005*	0.004**	−0.000	0.003	−0.000
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
Observations	3110	3110	3110	3110	3110	3110	3110
Sample outcome means (%)	19.36	7.52	8.39	4.05	4.57	5.85	1.13

Notes: See Table 2 for set of control variables included. All regressions control for number of family members, gross income, year of assignment, assigned neighborhood identifier, post-assignment GP identifier, and the following neighborhood characteristics: proportion residents without employment, average gross income, average crime rate, proportion of residents treated with psychiatric medications, and number of people living in the neighborhood. All control variables are measured 1 year before assignment. Standard errors are clustered at the neighborhood level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

Heinesen, 2012; Marcus, 2013; Montgomery, 1994) has an impact on new residents' mental health. In particular, we added these three characteristics of co-ethnics to our model (Eq. (1)).

As seen in Table 4, column 1, a 1-percentage–point increase in the concentration of unemployed co-ethnics significantly increases the probability of being treated with psychiatric medication by 0.07 percentage points. Column 3 shows that a 1-percentage–point increase in the concentration of co-ethnics with previous use of psychiatric medication increases the probability of being treated with psychiatric medication by 0.17 percentage points. The concentration of criminal co-ethnics in the assigned neighborhood has no significant effect on mental health outcomes (column 2). When we simultaneously enter the characteristics of co-ethnics into the regression, the impact of co-ethnics with previous use of psychiatric medication remains roughly the same whereas the size of the coefficient for non-employed co-ethnics drops by almost one-third and loses statistical power. We have also tested our results from Table 4 using categorical variables for the co-ethnic characteristics. In particular, we examined the effect of the share of co-ethnic characteristics below and above the median of the concentration, compared to no co-ethnics with a given characteristic. These results largely confirm the findings from Table 4. We find a significant increase in the probability of being treated with psychiatric medication when being exposed to co-ethnics with previous use of psychiatric medications in the neighborhood. Moreover, we find the highest probability among those who are exposed to co-ethnics with previous use of psychiatric medications above the median. The same holds for the exposure to non-employed co-ethnics (significant at the ten percent level). These results are available from the author upon request.

Table 4
Impact of concentration of co-ethnics' characteristics in the neighborhood on mental health (treated with psychiatric medications) outcomes, intention-to-treat effects.

	(1)	(2)	(3)	(4)
Concentration of non-employed co-ethnics	0.0007***			0.0005*
	(0.0003)			(0.0003)
Concentration of co-ethnics convicted of crime(s) [a]		0.0006		0.0000
		(0.0011)		(0.0011)
Concentration of co-ethnics with previous use of psychiatric medications [b]			0.0017***	0.0014**
			(0.0006)	(0.0006)
Observations	3110	3110	3110	3110

Notes: See Table 2 for set of control variables included. All regressions control for number of family members, gross income, year of assignment, assigned neighborhood identifier, post-assignment GP identifier, and the following neighborhood characteristics: proportion residents without employment, average gross income, average crime rate, proportion of residents treated with psychiatric medications, and number of people living in the neighborhood. All control variables are measured 1 year before assignment. Standard errors are clustered at the neighborhood level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.
[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.
[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02.

3.2. Robustness checks

We tested the main results in Table 3 in several ways. First, we estimated the main model (Eq. (1)) on a balanced sample, that is, we excluded observations that we cannot track 5 years prior to the assignment. Second, we estimated the main results on a sample including only the principal applicant. Third, we include applicants with Western backgrounds and their concentration of co-ethnics by neighborhood in the sample. Fourth, we estimated Eq. (1) for a sample including deaths and emigrants with at least one observation after assignment. Fifth, we tested the definition of neighborhood by using physically contiguous residential areas with at least 150 households as neighborhoods by Damm and Schultz-Nielsen (2008). Sixth, we ran a placebo test, where we assigned each applicant to a random neighborhood and calculated the effect of co-ethnics of the random neighborhood on treatment with psychiatric medications. Finally, to assess the validity of our interpretation of co-ethnic concentration as social network, we assigned to each applicant a random ethnic group in the assigned neighborhood and regressed it on mental health.

Table 5 presents the results for the seven alternative specifications. Changing the sample as well as the definition of neighborhood (results in columns 1–5) do not change the conclusions derived from the main results in Table 3. As expected, the parameter estimates from the placebo regressions, presented in columns 6 and 7, are not statistically significant. The results in Table 5, column 7, support the assumption that the concentration of co-ethnics matters for mental health, and not the concentration of immigrants in general.

4. Conclusions

This paper estimates the impact of residence-based co-ethnic (RBCE) networks on new residents' mental health. The average estimated effect over the 5-year period after assignment on being treated with psychiatric medications is 0.7 percentage points. This translates into an effect size of 3.7%. We find that compared to not having co-ethnics at all in the neighborhood the highest probability of purchasing psychiatric medication is found among those who are exposed to a high co-ethnic concentration, i.e., of at least 10% or more co-ethnic neighbors. Our main empirical approach allows us to rule out institutional and environmental time-invariant neighborhood characteristics affecting mental health, as well as the quality of health care received by using neighborhood and GP fixed effects. The main result is robust to several alternative sample and model specifications. We find that concentrations of co-ethnics treated

Table 5
Impact of co-ethnic concentration in neighborhood on mental health (treated with psychiatric medications) outcomes using alternative sample and model specifications, intention-to-treat effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Balanced panel	Only main applicant	All immigrants	With emigration and death	Different neighborhood	Random neighborhood, same co-ethnics	Same neighborhood, random ethnic group
Concentration of co-ethnics	0.006*	0.009**	0.005*	0.006*	0.007**	0.001	0.004
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.004)
Observations	2236	2365	3489	3303	2982	3046	3110

Notes: See Table 2 for set of control variables included. All regressions control for number of family members, gross income, year of assignment, assigned neighborhood identifier, post-assignment GP identifier, and the following neighborhood characteristics: proportion residents without employment, average gross income, average crime rate, proportion of residents treated with psychiatric medications, and number of people living in the neighborhood. All control variables are measured 1 year before assignment. Standard errors are clustered at the neighborhood level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

with psychiatric medications and of non-employed co-ethnics have a significant and increasing effect on newer residents' probability of being treated with psychiatric medications.

Our paper contributes in several ways to the growing body of studies on the importance of place for immigrants' socioeconomic and, in particular, health characteristics. First, we made use of a unique quasi-experiment that assigns immigrants in urgent need of housing to public social housing in diverse neighborhoods to control for the self-selection of residents into neighborhoods. Consequently, our parameter estimates can be interpreted as causal effects. Second, as all applicants are movers, our parameter estimates present the effect of neighborhood characteristics and do not reflect disruption costs, that is, the cost of moving into a new neighborhood. Third, we control for institutional and structural factors by including neighborhood and GP fixed effects. Consequently, we interpret the effect of RBCE concentration as a measure of social interaction with new neighbors from the same country of origin. Finally, we examine the type of characteristics of residence-based ethnic populations that affect mental health and find that a higher concentration of co-ethnics treated with psychiatric medications and a higher concentration of non-employed co-ethnics has an impact on mental health. The group of applicants includes a high share of people with mental health problems and without employment, thus, these later results suggest that being placed in a neighborhood with a high concentration of neighbors with the same country of origin and the same social indicators increases social interaction and affects the mental health outcomes of new residents.

The positive impact of RBCE concentration on our mental health outcome, that is, treatment with psychiatric medication, may reflect a negative effect on new residents' mental health. However, it might also be that the social network with co-ethnics provides the new residents with information about treatment possibilities and access to health care services. The population using the PSH system is a group that could potentially have untreated mental health problems. If this is the case, the positive parameter estimate on our proxy for mental health reflects a positive effect on mental health and our results support the ethnic density hypothesis.

Our finding that RBCE concentration impacts treatment with psychiatric medications is estimated on a vulnerable group with both financial and social problems. This group might not be able to participate in social activities and to benefit from proximity to their co-ethnics. Still, we find a significant effect of being exposed to a higher concentration of co-ethnics for this group. Thus, while the group of non-Western immigrants who are offered an apartment through the PSH office is not representative of the entire group of non-Western immigrants in Denmark, our findings point to the importance of RBCE network and, in particular, that the characteristics of co-ethnic neighbors can have a significant impact on mental health.

CRediT authorship contribution statement

Bence Boje-Kovacs: Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing, Methodology. **Jane Greve:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Cecilie D. Weatherall:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – original draft.

Data availability

The results are based on Danish administrative registry data. We are not able to make these data publicly available. Anyone can apply for data when affiliated with a Danish-authorized institute.

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Appendix

Table A1
Correlation between housing attributes and apartments assigned to public social housing.

	(1)	(2)	(3)
	Size of apartment in m^2	Number of rooms	Year of construction
Assigned to PSH	1.167	0.052	−4.969***

(*continued on next page*)

Table A1 (*continued*)

	(1)	(2)	(3)
	Size of apartment in m^2	Number of rooms	Year of construction
	(0.808)	(0.037)	(1.023)
Observations	35,636	35,636	35,631
R-squared	0.002	0.002	0.006

Notes: We estimate the following regression: $y_{ant} = \alpha + \beta_t + \gamma assigned_{ant} + \epsilon_{ant}$. y_{nt} contains housing attributes of available apartment a in neighborhood n in year of assignment t. $assigned_{ant}$ is a dummy variable equals one if the available apartment a in neighborhood n in year of assignment t. is assigned to PSH neighborhood. β represents year of assignment dummies. The sample includes all available apartments in the public housing sector in Copenhagen municipality during the 2000–2006 period. Robust standard errors are clustered at the estate level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

Table A2
Correlation between average housing estate characteristics and proportion of apartments assigned to public social housing in neighborhoods.

	(1)	(2)	(3)	(4)	(5)	(6)
	Available apartments assigned to PSH (%)	Available apartments assigned to PSH (%)	Available apartments assigned to PSH (%)	Available apartments assigned to PSH (%)	Available apartments assigned to PSH (%)	Available apartments assigned to PSH (%)
Average gross income (in DKK)	−0.000					
	(0.000)					
Non-Western immigrants (%)		0.007				
		(0.004)				
Non-employed (%)			−0.016			
			(0.011)			
Crime (%) [a]				0.279***		
				(0.074)		
Psychiatric medications (%) [b]					−0.020	
					(0.012)	
Non-psychiatric hospitalization (%)						−0.007
						(0.020)
Observations	2905	2905	2905	2905	2905	2905
R-squared	0.006	0.004	0.011	0.011	0.011	0.003

Notes: We estimate the following regression: $y_{nt} = \alpha + \beta_t + share_assigned_{nt}\gamma + \epsilon_{nt}$. y_{nt} contains average socioeconomic characteristics of neighborhood n in year of assignment t. $share_assigned_{nt}$ contains the proportion of assigned apartments to public social housing in neighborhood n in year of assignment t. β represents year of assignment dummies. The sample includes all apartments in Copenhagen municipality's public housing sector during 2000–2006 period. All regressions include year of assignment fixed effects. Robust standard errors are clustered at housing estate level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.
[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.
[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02

Table A3
Impact of concentration of co-ethnics in the neighborhood on mental health (treated with psychiatric medications) outcomes, intention-to-treat effects, using first offer.

	(1)
Concentration of co-ethnics	0.007**
	(0.003)
Observations	3110

Notes: See Table 2 for set of control variables included. The regression controls for number of family members, gross income, year of assignment, assigned neighborhood identifier, post-assignment GP identifier, and the following neighborhood characteristics: proportion residents without employment, average gross income, average crime rate, proportion of residents treated with psychiatric medications, and number of people living in the neighborhood. All control variables are measured 1 year before assignment. Standard errors are clustered at the neighborhood level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

Table A4
Sample means, standard deviations (SDs), Min, Max of neighborhood characteristics for assigned non-Western population in Copenhagen.

	Mean	SD	Min	Max
Percent of co-ethnic neighbors	0.02	0.03	0	0.29
Three largest groups of co-ethnics by country of origin				
Percent of co-ethnic neighbors (Turkey)	0.04	0.04	0	0.2
Percent of co-ethnic neighbors (Iraq)	0.02	0.02	0	0.25
Percent of co-ethnic neighbors (Somalia)	0.05	0.04	0	0.15
Percent of non-Western immigrant neighbors	0.40	0.09	0.13	0.88
Percent of neighbors convicted of crime(s) [a]	0.02	0.01	0	0.11
Percent of neighbors treated with psychiatric medications [b]	0.20	0.04	0.05	0.69
Average gross income (in 1000 DKK)	206	28	106	326
Percent of neighbors admitted to non-psychiatric hospital	0.01	0.01	0	0.09
Percent of non-employed neighbors	0.40	0.10	0.13	0.86
Percent of co-ethnics convicted of crime(s)[a]	0.03	0.09	0	1
Percent of co-ethnics treated with psychiatric medications[b]	0.11	0.19	0	1
Percent of non-employed co-ethnics	0.42	0.37	0	1
Observations		3110		

Note: All variables are measured the year before assignment.
[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.
[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02.

Table A5
Correlation between proportion of co-ethnics and year of assignment.

	(1)
2000 year of assignment	(REF)
2001 year of assignment	−0.020
	(0.055)
2002 year of assignment	0.003
	(0.055)
2003 year of assignment	−0.003
	(0.052)
2004 year of assignment	0.016
	(0.053)
2005 year of assignment	0.017
	(0.050)
2006 year of assignment	0.020
	(0.051)
Observations	26,446
R-squared	0.179

Notes: The regression is based on neighborhoods that persons in our population were assigned to. The regression includes assigned neighborhood identifier. Robust standard errors are reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

Table A6
Assignment location attributes among non-Western immigrants and individual characteristics of assignees: Linear probability model, robust standard errors (SEs) in parentheses.

	(1)	(2)	(3)	(4)	(5)
	Non-employed (%)	Average gross income (in DKK)	Crime (%)	Psychiatric medications (%)	Non-psychiatric Hospitalization (%)
Age (years)	0.000	−52.561	−0.000	−0.000	0.000
	(0.000)	(54.447)	(0.000)	(0.000)	(0.000)
Women (0/1)	−0.006*	301.439	−0.003***	0.000	0.001
	(0.003)	(627.058)	(0.001)	(0.002)	(0.000)
<10 years of formal education (0/1)	0.006*	−1168.683*	−0.001	0.003	0.001*
	(0.004)	(699.327)	(0.001)	(0.002)	(0.001)
Employed (0/1)	0.002	273.911	0.000	−0.002	0.001
	(0.004)	(880.262)	(0.001)	(0.003)	(0.001)
Convicted of crime(s) (0/1) [a]	−0.003	749.196	0.002	−0.002	−0.001
	(0.007)	(1461.671)	(0.002)	(0.005)	(0.001)
Psychiatric medications (0/1) [b]	0.002	−824.780	0.001	0.003	0.001*
	(0.003)	(646.510)	(0.001)	(0.002)	(0.001)
Non-psychiatric hospitalization (0/1)	−0.009	4694.202	0.010	−0.009	−0.000
	(0.017)	(3515.221)	(0.007)	(0.012)	(0.002)

(continued on next page)

Table A6 (*continued*)

	(1)	(2)	(3)	(4)	(5)
	Non-employed (%)	Average gross income (in DKK)	Crime (%)	Psychiatric medications (%)	Non-psychiatric Hospitalization (%)
Constant	0.513***	164,480.784***	0.036***	0.159***	0.007***
	(0.016)	(3112.670)	(0.004)	(0.009)	(0.002)
Observations	3101	3101	3101	3101	3101
R-squared	0.030	0.095	0.048	0.089	0.009
Prob > F	0.284	0.193	0.0232	0.435	0.238

Notes: See Table 2 for set of control variables included. All regressions include year of assignment fixed effects and assignment characteristics known to the PSH such as gross household income and number of family members. The F-test for joint insignificance includes all variables except gross household income, number of family members, and year of assignment. Standard errors are clustered at the neighborhood level.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

[a] Convicted of violating criminal laws, firearm or narcotics control laws, or some combination of these.

[b] Psychiatric medications bear the following Anatomical Therapeutic Chemical codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02.

Table A7
Impact of different percentages of co-ethnic concentration in neighborhood on mental health (treated with psychiatric medications) outcomes, intention-to-treat effects.

	(1)
Share co-ethnics = 0	(REF.)
0> Share co-ethnics <5	0.097***
	(0.021)
5 ≥ Share co-ethnics <10	0.068*
	(0.036)
Share co-ethnics ≥ 10	0.174***
	(0.044)
Observations	3110

Notes: See Table 2 for set of control variables included. The regression controls for number of family members, gross income, year of assignment, assigned neighborhood identifier, post-assignment GP identifier, and the following neighborhood characteristics: proportion residents without employment, average gross income, average crime rate, proportion of residents treated with psychiatric medications, and number of people living in the neighborhood. All control variables are measured 1 year before assignment. Standard errors are clustered at the neighborhood level and reported in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.10$.

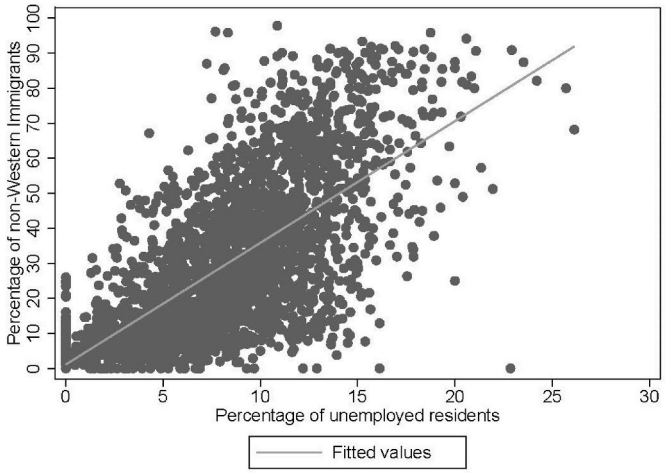


Fig. A1. Relationship between shares of non-Western immigrants and unemployed residents in neighborhoods in Copenhagen during the 2000–2006 period.

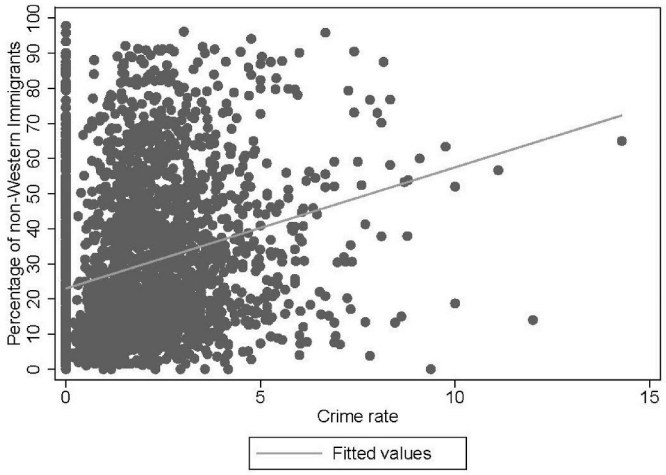


Fig. A2. Relationship between proportion of non-Western immigrants and crime rates in neighborhoods in Copenhagen during the 2000–2006 period.

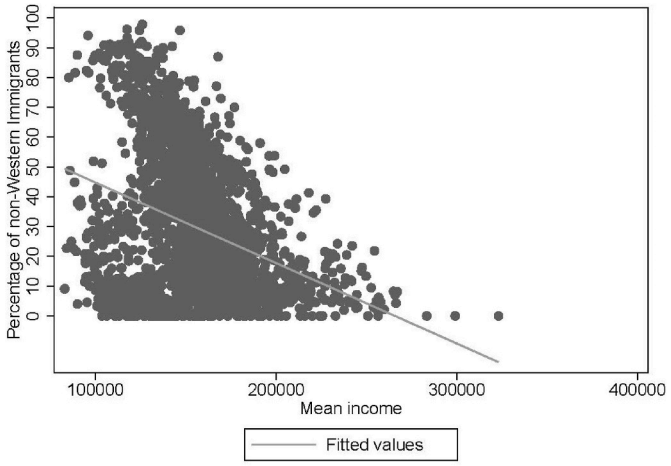


Fig. A3. Relationship between proportion of non-Western immigrants and neighborhood average income in Copenhagen during the 2000–2006 period.

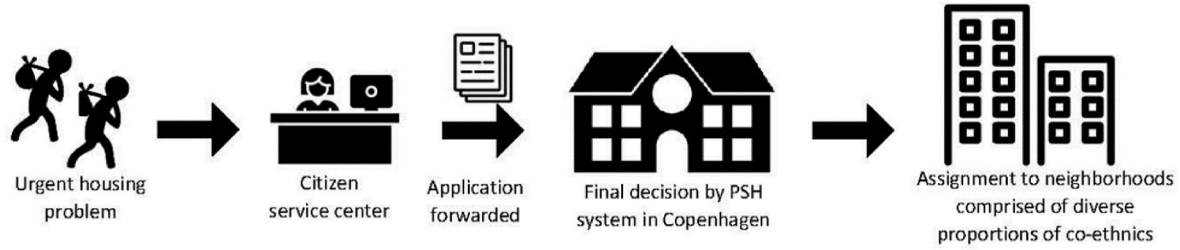


Fig. A4. Visualization of assignment process in Copenhagen municipality.

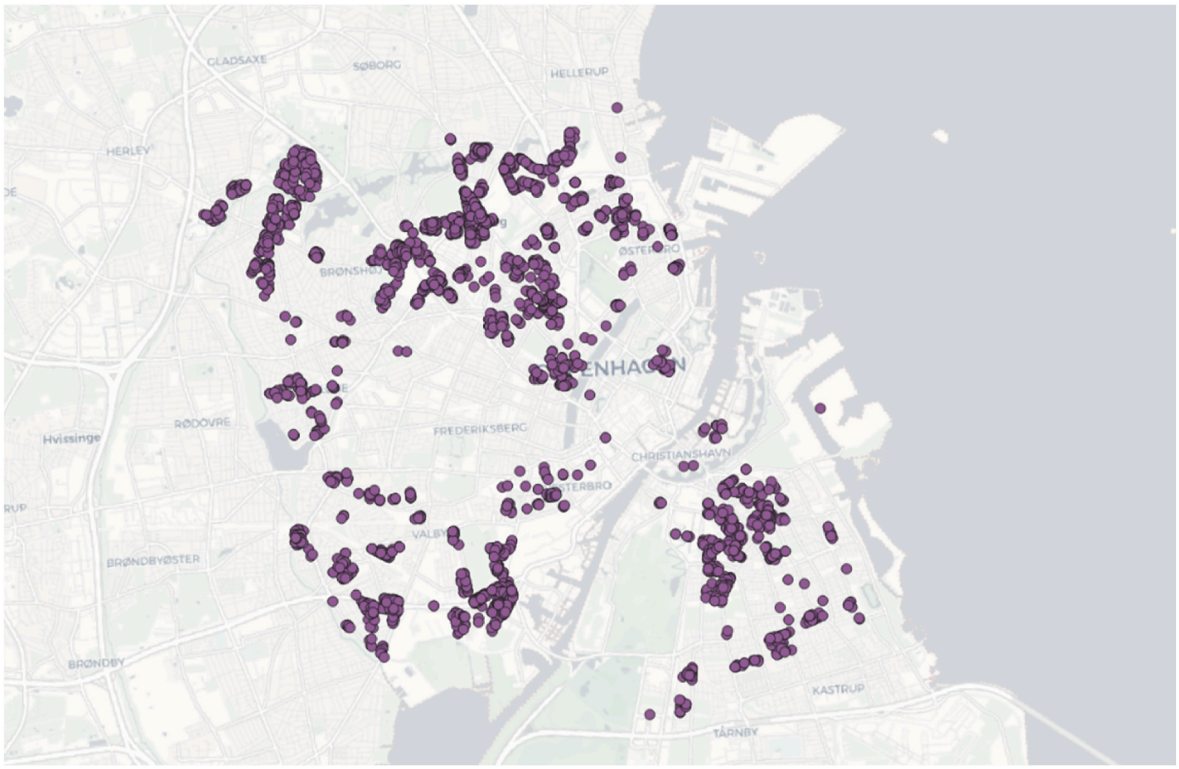


Fig. A5. Map of Copenhagen municipality and location of apartments assigned by PSH in 2000–2006. Addresses of locations not precise due to European Union General Data Protection Regulation. The empty space in the middle of the map is Frederiksberg, which is not part of Copenhagen municipality.

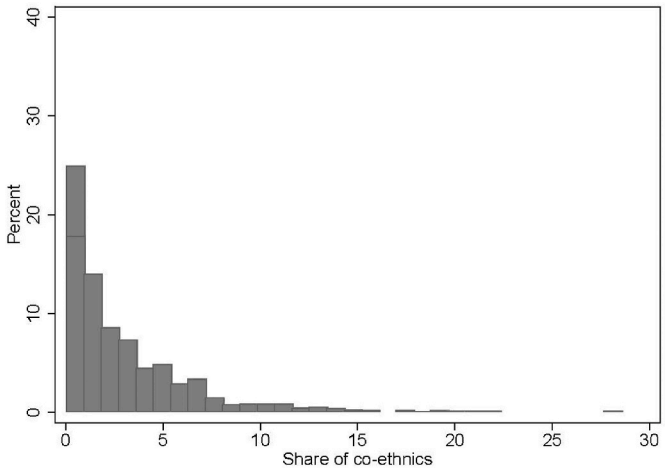


Fig. A6. The distribution of co-ethnics in the neighborhood of assignment. Note: Due to confidentiality requirements by Statistics Denmark, the bins must contain at least 4 individual observations.

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