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Can a shift of neighborhoods affect mental health?

Evidence from a quasi-random allocation of applicants in the public social housing system

by

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Abstract

Mental health problems generate vast pecuniary and non-pecuniary costs for the individual, for relatives, and for society. Living in deprived neighborhoods has been shown to influence, among other things, labor market outcomes and crime. Therefore, we explore how living in a deprived neighborhood with different characteristics influences the mental health of the residents. We utilize a quasi-random allocation of applicants into different neighborhoods through the public social housing (PSH) office to estimate the effect on mental health of living in a deprived neighborhood. The applicants entitled to PSH are lower-income residents with both an urgent housing problem and social problems. Our results suggest that being exposed to a deprived neighborhood as an adult has a significant negative impact on mental health among vulnerable men. We find that besides the usual characteristics of a deprived neighborhood—i.e., high shares of people without employment and with low income—the share of people with mental health problems is an important characteristic of the neighborhood that has a negative impact on mental health among men.

Keywords: Deprived neighborhood, mental health, prescription of psychiatric medication, quasi-random allocation, administrative registry panel data, intention-to-treat, treatment on the treated, neighborhood characteristics

JEL-code: I1, R23

1. Introduction

Globally, almost one in every three individuals will experience mental problems during their lifetime (Steel et al., 2014). Mental health problems generate vast pecuniary and non-pecuniary costs for the people affected by them as well as for their relatives, and the global burden of mental health problems is significant (Lopez and Murray, 1998; Vigo et al., 2016). In Europe, the total estimated cost of mental health problems was 3.5% of the GDP in 2010 (OECD, 2016). Thus, tackling mental health problems in the population is becoming a key issue in social, health, and labor market policies in many countries.

Although researchers and politicians generally recognize that certain characteristics of neighborhoods may contribute to the development of mental health problems, empirical evidence of the causal effects of neighborhood characteristics is sparse. In this paper, we investigate the impact of neighborhood deprivation—defined by high rates of non-employment and low average gross income—on mental health among disadvantaged adults, here defined as lower-income residents with both an urgent housing problem and social problems.¹ We reveal more insight on the mechanism that drives the causal relationship between neighborhoods and mental health by examining which neighborhood characteristics (i.e., average income level, non-employment rate, rate of conviction for crimes, share of the residents purchasing psychiatric, and share of non-Western immigrants) have the greatest impact on the residents' mental health .

The composition of residents in a neighborhood can affect a person's mental health through different channels. First, through social interactions, neighbors' behavior may influence a person's own behavior and mental health, e.g., through higher acceptance of drug use or psychological imitation (Hatfield et al., 1993; Manski, 1995). Second, a specific composition of neighbors is often

¹ A description of the population entitled to social housing in 2002 shows that some of the problems indicated are mental health problems and drug addiction ((Christensen and Stax, 2002)).

related to the resources in or characteristics of the neighborhood, e.g., differences in access to health care or exposure to crime, which can affect the mental health of newly arrived residents.

In connection with a move, new neighbors also give rise to a new social comparison group, which—depending on the individual’s relative characteristics—may have a positive or negative impact on mental health. When, for example, people compare themselves to new and less successful neighbors, these comparisons may provide temporary relief and higher self-esteem when they can see that there are people living in poorer circumstances than they themselves are (Exline and Lobel, 1997). Thus, “downward” comparisons can have a positive impact on mental health. Conversely, “upward” comparisons can have a negative impact on mental health. Thus, the hypothesis about the mechanism by which neighborhood characteristics can affect mental health is not conclusive with regard to the direction and magnitude of the parameter estimate, and both the direction and magnitude may depend on the individual’s initial resources and mental health status.

The effects of social interaction and types of social interaction might also depend on gender. Results from a study of neighborhood characteristics on later labor income (Galster et al., 2008) suggest that, for males not fully employed, low-income neighbors provide negative role models, and middle-income (but not high-income) neighbors have a positive impact on earnings. These significant gender differences exist in adaptations into social contexts and health behaviors; therefore, we also examine heterogeneous effects between genders.

Our paper is in the same strand as the literature that uses the Moving to Opportunity program (MTO) experiment to identify the causal impact of neighborhood characteristics (Kling et al., 2007; Leventhal and Brooks-Gunn, 2003; Ludwig et al., 2013). However, while these studies examine the impact of residents choosing to *move into better* neighborhoods compared to a control group that received no assistance for moving, we add to the existing literature by examining the effect of *moving into a deprived neighborhood* as compared to moving into a non-deprived

neighborhood. We believe it is important to assess whether the findings in Kling et al. (2007), Leventhal and Brooks-Gunn (2003), and Ludwig et al. (2013) can be generalized to populations that move into deprived neighborhoods and to neighborhoods outside the United States (US). Previous literature suggests potential mental health benefits among adults and young females from moving to a better neighborhood (Kling et al., 2007; Leventhal and Brooks-Gunn, 2003; Ludwig et al., 2013). In these studies, no effects on mental health and risky behaviors are found among young males moving to a low-poverty neighborhood compared to staying in relatively high-poverty neighborhoods. These results are not directly comparable with ours, as they do not examine the effects for adults by gender. Furthermore, the impact of moving to a better neighborhood might not correspond to the impact of moving to a worse neighborhood. In this paper, we study the latter.

In order to overcome the limitations of selection bias and to determine the causal impact on mental health of being exposed to a deprived neighborhood, we exploit the quasi-random allocation of public social housing (hereafter PSH) in the Copenhagen Municipality from 2000 through 2007.² Since 1950, the Municipality of Copenhagen has provided affordable housing for lower-income persons who have both an urgent housing problem and social problems. Over the years, a scarcity of housing arose, and in 2000, the Municipality of Copenhagen made an agreement with all non-profit organizations owning public housing, which comprises 20% of the housing stock in Copenhagen Municipality, stating that these organizations were to make every third vacant apartment available

² This approach is similar to, for instance, Oreopoulos (2003), who uses assignment of public housing in Toronto to identify the effect of neighborhood characteristics on earnings and employment probabilities. Damm (2014) and Damm and Dustmann (2013) who use quasi-random assignment of refugee immigrants to different municipalities in Denmark to identify the effect of neighborhood crime on subsequent criminal behavior and neighborhood quality on employment and Rotger and Galster (2017) who use the quasi-random allocation of public housing in the municipality of Copenhagen, as we do in this paper, but uses data from 2009 through 2012 to investigate the impact of neighborhood effects on youth crime. Besides focusing on other outcomes, the previous studies from Denmark also apply different scale of neighborhoods than we do in this paper.

to the municipality (Christensen and Stax, 2002).³ The PSH in Copenhagen assigns residents to these apartments as they become available. During the allocation process, the PSH office evaluates the potential residents only with respect to resident income, family size, and pet ownership. As the availability of apartments used for PSH is often limited and waiting times are long, the people in need of housing often accept the first offer they receive, i.e., the compliance rate is as high as 88%.

PSH apartments are located in different neighborhoods in the municipality. While some of these neighborhoods are characterized by high rates of non-employment and crime, high proportions of people with no formal education, and immigrant-status and low-income families, other neighborhoods are similar to the average neighborhoods in Copenhagen (Weatherall et al., 2016). We use natural, geographically contingent and administrative units in the public housing sector as neighborhoods. Among the nearly 300 neighborhoods we look at, there are on average 333 residents living in each neighborhood. In previous literature, average income and employment levels in the local area often characterize the economic status of a location (Rosenthal and Ross, 2015). We characterize a neighborhood as deprived by looking at the distribution of non-employed individuals and the gross income distribution. Thus, a deprived neighborhood is defined by having a non-employment rate within the highest quartile of the non-employment distribution (i.e., 45% of its residents are non-employed), and the average gross income is in the lowest quartile of the income distribution (i.e., income level is below DKK 188,359/\$30,778, measured in 2014 prices) among residents living in the public housing block in 2013. We use different definitions and scales of neighborhood composition to test the sensitivity of the thresholds of the non-employment rate and income.

To identify the effect of a deprived neighborhood on mental health, we use the combination of the data on the quasi-random allocation of applicants in the PSH system and the administrative

³ For more details see Section 3.2.

registry data, which is expected to reduce selection and attrition (Duranton et al., 2015). In addition to information on mental health services and prescription drug purchases from 1996 to 2013 (particularly useful in studies of fragile and disadvantaged groups, as measurement problems from both self-reporting and attrition biases are eliminated), the Danish administrative registry data contains information on socio-economic characteristics, demographics, housing, and moving patterns, all of which allow us to follow all individuals over time. Our main outcome of mental health is based on information on purchases of psychiatric medication and hospitalizations in psychiatric hospitals.

We estimate an intention-to-treat (ITT) effect, where we do not have to rely on whether people move into the assigned apartment or not, and compare people assigned to housing in deprived and non-deprived areas of the city. Our identifying assumption is that the assignment of an apartment in a given area is unrelated to the unobserved characteristics of an individual. Adopting an ITT approach allows us to avoid the very difficult problem of the endogeneity in people's decision of where to live, while we obtain a lower bound of the estimate of the true effect of living in a neighborhood. Furthermore, we estimate a treatment on the treated (TOT) effect, using the first assignment as the instrument for actual residence.

Our results show that, among men, being allocated to a deprived area increases the probability of purchasing psychiatric medication by five percentage points on average. Among women, the effect is not significant. We argue that the gender differences in the results are partly due to the different characteristics of the men and women who apply for PSH. We find that the mechanism behind the negative impact of the neighborhood on mental health can be explained by the usual characteristics of a deprived neighborhood—i.e., high shares of non-employed and low income— but also that the share of people with mental health problems is an important characteristic of the neighborhood that has a negative impact on mental health among men. Thus,

we conclude that neighborhood-based interventions could have a significant impact on mental health for some of the most disadvantaged groups of the population. Our results thus highlight the importance of neighborhood interventions designed for fragile and disadvantaged people.

The rest of the paper is structured as follows. Section 2 presents hypotheses and previous literature. Section 3 describes the public social housing system and our definition of a neighborhood. Sections 4 and 5 describe the empirical strategy and data. Section 6 presents the results, and Section 7 discusses the results and concludes the paper.

2. Hypotheses and previous literature

A central issue in estimating the effect of neighborhood characteristics on mental health lies in separating the effect of individual factors from that of contextual factors. People might choose where to live based on individual factors. For example, people with certain characteristics, such as having a mental health problem, might choose to live in neighborhoods where others have similar characteristics, or they might choose to live in cheap housing neighborhoods because of their limited financial means (Cheshire et al., 2014; Topa and Zenou, 2015). Assuming that we are able to solve the problem of selection with our quasi-random allocation in the PSH system, how can we interpret the effect of living in a deprived neighborhood as compared to a non-deprived neighborhood on mental health problems?

One hypothesis is that mental health problems are spread through social networks. This phenomenon is often referred to as a “peer effect” and refers to the mechanism by which being near or interacting with people in a deprived neighborhood influences the behavior of the individual. An instance of this would be a higher acceptance of drug abuse or the psychological imitation of a group of peers living nearby (Hatfield et al., 1993). Other instances could be an increased level of anxiety and fear of being victimized by new neighbors or a change in the social comparisons with

new neighbors, either making the mover feel relieved (when they make downward comparisons) or stressed (when they make upward comparisons) (Exline and Lobel, 1997).

Previous literature finds a high degree of correlation in depression and happiness among peers (Fowler and Christakis, 2008; Rosenquist et al., 2011).⁴ However, as these studies are based on correlations, one cannot unambiguously conclude that the estimates reflect causal effects and not self-selection, exposure to common factors, or the reflection problem (Manski, 1993).⁵ To identify the effect of peers, Eisenberg et al. (2013) used surveys on first-year college students who were randomly assigned a roommate. Eisenberg et al. (2013) found no overall effect on mental health but found a small effect for specific mental health measures. The effects differed significantly by gender; while the authors found large, significant contagion effects among men with pre-existing depression, women with pre-existing depression seemed to become less depressed if their roommate was depressed.

Besides the social impact of the people living close by, shared characteristics of the neighborhood and its population (i.e., the socioeconomic composition of the neighbors and geographical features of and access to health care services in the neighborhood) can also affect individuals' mental health.

The type of social contact may differ depending of the socio-economic position in the neighborhood. Social contact may, for example, facilitate information on job openings, and this information depends on the share of the population in employment. The impact of the socioeconomic composition in the neighborhood on mental health could, however, be mediated by the negative consequences of being out of the labor market (Frank and Manning, 1992). In Galster

⁴ In a descriptive study on the relationship between prescription of psychiatric medication and neighborhood deprivation using Swedish data, Crump et al. (2011) find a monotonically increasing relationship.

⁵ The reflection problem refers to the problem of ascertaining whether group behavior affects individual behavior or whether group behavior simply is an aggregation of individual behaviors.

et al. (2008), the socio-economic composition in a neighborhood seems to affect men who are not fully employed in particular, with negative impacts on the income of high shares of low-income earners and positive impacts on the income of middle-income earners.

The socio-economic composition in a neighborhood can be a measure of a number of health risks, such as stress related to crime, violence, and over-crowding and access to an illegal drug market in the neighborhood (Morenof et al., 2004). These health risks may again affect the mental health and probability of using psychiatric medication among people moving into these neighborhoods.

The physical and geographical features of the neighborhood may also affect the individual's mental health status. For instance, neglected buildings and the local environment, including architecture and city planning, might affect social interaction among area residents. Thus, while social interaction with neighbors with certain characteristics (cf. above) might have a negative impact on a person's mental health, social isolation has also been found to be a risk factor for unhealthy behaviors and mortality (Morenof et al., 2004).

Deprived neighborhoods may lack access to mental health care, or the quality of the health care services might be lower compared to that of the care supplied in non-deprived neighborhoods (Bissonette et al., 2012). Also, differences in the general practitioner's (GP) tendency to prescribe psychiatric medication could depend on the characteristics of the GP's group of patients. In these cases, a significant impact of neighborhood characteristics on the probability of purchasing psychiatric medication will be measuring something other than variations in mental health. While we cannot identify the GP's tendency to prescribe psychiatric medication, descriptive analyses show that there is no difference in the tendency to change GPs depending on neighborhood

characteristics.⁶ While differences in access to health care services is a relevant issue when studying the effect of neighborhood characteristics on mental health problems, it is less relevant in Denmark, where a universal health care system exists and medication is highly subsidized. Furthermore, it is even less relevant in our context, as we examine the effect of neighborhood characteristics on a sample living in Copenhagen only. Given the relatively small size of Copenhagen (1.2 million inhabitants living in an area of 88 km²) and the proximity of deprived and non-deprived neighborhoods (see Figure A1), we expect the distance to GPs and hospitals to be short and more or less the same for residents living in deprived and non-deprived neighborhoods. In this study, we therefore consider differences in access to services or differences in service provider behavior to be less relevant for the treatment and development of mental health problems.

In an attempt to separate individual effects from neighborhood effects, previous US studies have examined a housing program called the Moving to Opportunity (MTO) experiment (Sanbonmatsu et al., 2011).⁷ In the MTO experiment, participants were randomly assigned to move to either a neighborhood that had a low poverty rate or any other self-chosen neighborhood. As in the PSH allocation program, the MTO experiment was aimed at low-income families, and as compared to the national population of individuals of the same age, race, gender and education, the sample had a much higher prevalence of depressive symptoms (Katz et al., 2001). However, in the MTO experiment, the treated groups are given a voucher to move and compared to a control group that is not given this voucher. In the PSH allocation program, both treated and control groups move,

⁶ For example, among those who did not take any psychiatric medication up till five years before allocation 31 percent among those allocated to non-deprived and 33 percent among those allocated to a deprived changed GP after the allocation. These percentages do not differ statistically.

⁷ Several papers have utilized natural experiments of random assignments into neighborhoods, to evaluate the neighborhood effects on, for instance, labor market and education outcomes, and crime and poverty rates (Åslund et al., 2011; Beaman, 2012; Chetty et al., 2016; Damm, 2014; Damm and Dustmann, 2013; Edin et al., 2003; Jacob, 2004; Kling et al., 2007; Ludwig et al., 2013, 2001; Popkin et al., 1995).

and those offered PSH are often in no position to reject the housing offer. Consequently, the compliance rate from the PSH program is high: 88% as compared to 47% for the treatment group in the MTO experiment (Sanbonmatsu et al., 2011). The short-term results on mental health from the MTO experiment—evaluated two years after the allocation—show that the moving group experienced a reduction in depressive periods, although these point estimates were not statistically significant at conventional levels (Katz et al., 2001). Longer-term results for children and adolescents exposed to the MTO experiment, evaluated both five and 10 to 15 years after the allocation, reveal an improvement in mental health (Kling et al., 2007; Ludwig et al., 2013). However, a study on the effect of the deployment of soldiers found a long-term negative impact on mental health using psychiatric medication as a mental health outcome among adult men (Lyk-Jensen et al., 2016).

While it seems intuitively clear that peers or relatives influence each other when it comes to their mental health, it is difficult—even in the presence of a natural experiment—to distinguish between the process whereby one person actually causes the depression of others and some common contemporaneous exposures, such as access to health care or the composition of residents with low economic status. In the MTO experiment, for example, the positive effects of moving to a better neighborhood for those who were very young when they were exposed could have arisen because these children subsequently went to better pre-schools and/or elementary schools or because they had access to better public services such as doctors and hospitals. These changes would not necessarily have had any causal relationship with the composition of residents in a neighborhood (Cheshire et al., 2014). We have the possibility of doing additional analysis where we examine which of the characteristics of the residents in the neighborhood has an impact on mental health among the newcomers.

3. Deprived neighborhoods and social housing allocation

3.1 Definition of neighborhoods

Previous literature on neighborhoods does not leave a clear definition of what a neighborhood is or what the geographical boundaries for a neighborhood should be. Often, definitions of neighborhoods are based on census data or spatial units, limited by data availability. In this paper, we define a neighborhood as physically contiguous public housing blocks that are legally founded and economically dependent.⁸ All of these housing blocks belong to a larger non-profit housing association. In Copenhagen, there exist 25 housing associations.⁹ In our sample, we have 291 physically contiguous public housing blocks that fit our definition of a neighborhood, and on average, 333 residents live in each of these blocks.¹⁰

We class a neighborhood as deprived if the share of 18-to-64-year-old residents without employment is in the highest quartile of the non-employment distribution (i.e., 45% of its residents are non-employed) and if the average gross income is in the lowest quartile of the income distribution (i.e., income level is below DKK 188,359/\$30,778, measured in 2014 prices) among residents living in the public housing block in 2013. While studies from other countries find that the socioeconomic position of neighborhoods develops significantly over time (Rosenthal and Ross,

⁸ The housing blocks are typically contiguous buildings delimited by the four intersections that constitute the corners of the block. The buildings are usually of the same type of material, and they are constructed in the same year. The construction of the housing blocks is initiated by a housing association requesting approval and support for the construction from the municipality. The housing block consists of a given number of rentals. Selected tenants form a board and manage issues related to the housing block, such as hiring a janitor (see BEK no. 718 of 13/06/2016).

⁹ See the list at <http://www.kk.dk/sites/default/files/almene-boligselskaber-kbh.pdf>

¹⁰ In a recent Danish study by (Hjorth and Dinesen, 2016) respondents are asked to draw their self-perceived neighborhood on maps. Combining these data with administrative registry data, the authors find that, the median size neighborhood consist of 479 residents.

2015), previous studies from Denmark have found that the characteristics of neighborhoods are relatively fixed over a time period of 30 years (Weatherall et al., 2016). Thus, the neighborhoods are classified as either deprived or non-deprived throughout the relevant period.

According to our definition of a deprived neighborhood, 13% of the neighborhoods are defined as such (37 neighborhoods), and 9% of the households allocated by the Copenhagen Municipality PSH program are offered an apartment in a deprived neighborhood. On average, 10 people are allocated to each deprived neighborhood per year.

Besides having a higher share of non-employed and low-income residents, deprived neighborhoods also have a larger percentage of residents from non-Western countries, a higher percentage of people purchasing psychiatric medication, and a higher percentage of people without a formal education when compared to non-deprived neighborhoods, while there is not much difference in crime rates (see figure A2). In Table A3, we present additional robustness analyses to assess the sensitivity of our definition of neighborhood.

3.2 Public social housing allocation

Since 1950, the Municipality of Copenhagen has, through the Public Social Housing (PSH) system, provided affordable housing for people with social problems and urgent housing needs. However, the municipality had to sell their properties due to financial bankruptcy in the mid-1990s. This led to a significant decrease in providing households with social problems and housing needs with affordable housing, and at the same time, there existed a disproportionate supply of available apartments in the public housing sector in the municipality. Consequently, in 1998, the city council of Copenhagen made an agreement with all public housing associations in the municipality—which account for 20 percent of the housing stock in the Municipality of Copenhagen—that each

association should provide every fourth vacant apartment for the PSH program. Since 2000, the housing associations have had to provide the municipality with every third vacant apartment.

The selection of applicants to the PSH program follows the following procedure: The municipality assigns a local caseworker to each applicant. The caseworker collects information on the applicant's urgent housing need, social problems, and financial means. Furthermore, the caseworker looks at whether the applicant has exploited all possible options to find an apartment. The caseworker evaluates the detailed information of the applicant (including that of family members) and predetermines if the applicant meets the requirements for a housing offer. Based on information on household income and household size, the caseworker prepares a budget for the applicant and determines the maximum of affordable rent, because the applicant should have ample financial means to be able to stay in the apartment offered by the PSH. If the caseworker decides that the applicant meets the criteria, the application will be sent to the PSH office in the Municipality of Copenhagen.

The PSH allocation office has final approval competence. Thus, the PSH office caseworker approves and offers the housing opportunity if the application and supporting documents show that the applicant has an urgent housing need that he or she is unable to solve on his or her own¹¹ and that he or she has other social problems, i.e., physical, psychological, or other socio-economic issues. There is no official guideline for determining the severity of the socio-economic problems and, subsequently, eligibility for PSH. However, the urgent housing problem must have arisen while the person was residing in Copenhagen and must not be due to relocation to Copenhagen.¹²

¹¹ The applicant must have explored all other options to find an apartment.

¹² The procedure by which the caseworkers select eligible applicants is described in Christensen and Stax (2002).

People with mental health problems make up a large proportion of the applicants and are usually eligible, unless they are not able to live alone.

Once an application has been approved, the caseworker at the PSH office matches household characteristics with the list of available apartments. The PSH office has no influence on apartment availability, as the availability depends on the number of people moving out of any apartment in the public housing sector at any given time. The applicants and apartments are matched based on the following characteristics only: the number of family members (and thereby rooms needed) and the financial means of the applicant.¹³ Applicants can request specific apartments regarding accessibility for disabled people, pet-friendliness, and preferred locations in Copenhagen. Approximately 4% of all apartments assigned by the Copenhagen social housing office allow pets. Anecdotal evidence from the PSH office proves that it is highly unlikely that a caseworker at the PSH office will take individual preferences into account when making a housing offer unless the applicant has been exposed to violence in the neighborhood to which he or she has been allocated.

Approved applicants have the right to refuse the first offer. However, the applicant is then required to provide a detailed explanation of the refusal before the application procedure can be started again, and the average waiting time between 2000 and 2007 was approximately 7 to 10 months. We find that only 12% decline the first offer. From 2000 to 2007, the applicant could apply a maximum of twice, where today they can only apply once.

From the described PSH allocation procedure, the allocation of housing offers seems very mechanical. Consequently, a PSH offer of an apartment is quasi-randomly distributed in different neighborhoods for applicants with the same family size and financial means. The quasi-random allocation of applicants in the Copenhagen Municipality PSH system creates a perfect setup for

¹³ On a data set including applicants that accept the housing offer, only, we find no significant relationship between the applicants' self-reported financial means and the probability of being allocated to a deprived neighborhood.

analyzing the impact of moving into a deprived neighborhood as opposed to moving into a non-deprived neighborhood.

4. Empirical strategy

As the PSH program includes a quasi-random allocation of disadvantaged applicants in deprived and non-deprived neighborhoods, we can estimate the causal effect of exposure to a deprived neighborhood on mental health. First, we estimate an intention-to-treat (ITT) effect. The ITT approach enables us to avoid the difficulty of addressing an applicant's decision on whether or not to accept a PSH offer, and, as far as some of the individuals are affected by the neighborhood characteristics, our analysis produces a lower (or conservative) bound for the true effect of neighborhood characteristics on mental health. Second, as we can observe who accepts (i.e., moves into the allocated area) and who does not accept a PSH offer, we extend our analyses and estimate a treatment on the treated (TOT) effect, using a two-stage least squares (TSLS) approach. Third, we examine the mechanism through which neighborhoods impact residents' mental health by using the quasi-random allocation of applications combined with the different characteristics of the neighborhood.

To estimate the ITT effect on mental health of being allocated to a deprived neighborhood using only post-treatment observations as the outcome, we run the following regression:

$$MH_{it} = \alpha + \beta_t + \delta alloc_deprived_t + \tau X_{it} + \varepsilon_{it} \quad (1)$$

In equation (1), MH is the mental health outcome (i.e., purchase of psychiatric medications for individual i at time t), β is a dummy for the year of allocation t , and X_{it} is a vector of control variables that potentially can affect mental health status: age, immigrant status, 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, the number of family members, the gross household income, and an

indicator for whether the individual has been purchasing psychiatric medication up to five years before the allocation. Furthermore, we include an indicator for whether the individual has previously lived in a deprived neighborhood. ε_{it} is the idiosyncratic error term. All control variables are measured in the pre-allocation period to avoid the “bad control” problem (Angrist and Pischke, 2008). The treatment dummy $alloc_deprived_t$ equals 1 when the individual is allocated to a deprived neighborhood and 0 when the individual is allocated to a non-deprived neighborhood.

The parameter of interest is δ , which shows the average effect for individuals in households allocated to a deprived neighborhood. As there are significant gender differences in health care utilization, we estimate separate models by gender to investigate heterogeneity effects. In the full sample, we cluster on household to allow for intra-group correlations. We estimate (1) with a linear probability model (LPM) using ordinary least squares, assuming linearity for the mental health variable, and include robust standard errors.

We examine the impact of certain neighborhood characteristics on mental health in the ITT set up. Thus, instead of the treatment dummy $alloc_deprived_t$ in (1), we include a list of variables measuring the share of neighbors in a neighborhood the year before allocation. These variables measure the average non-employment rate, household income, crime rate, share of people on psychiatric medication, and rate of immigrants.

To estimate the TOT effect, we use the PSH offer in a deprived or non-deprived neighborhood as an instrument for actual residence. The two-equation system is shown in (2) and (3).

$$MH_{it} = \alpha + \beta_t + \delta act_deprived_t + \tau X_{it} + \varepsilon_{it} \quad (2)$$

$$act_deprived_{it} = \mu + \gamma alloc_deprived_t + \lambda X_{it} + v_{it} \quad (3)$$

In (3), γ is the coefficient for the instrumental variable that captures the effect of the characteristics of receiving a PSH offer. In (2), δ is the parameter of interest, the impact of exposure to the actual

neighborhood the individual lives in. The parameter δ is identified under the assumption that the characteristics of first-offered neighborhoods are independent of the unobservable characteristics of the residents who ultimately move into deprived neighborhoods. This assumption is fulfilled when the housing allocation is quasi-random. In Section 6, we show various tests that confirm that the allocation of apartments through the PSH office is quasi-random. Furthermore, the neighborhood effect of the PSH offer is assumed to only influence the applicant if he or she accepts the PSH offer, and exposure to the neighborhood has to be monotonic, increasing with the PSH offer. We expect these last two assumptions to be fulfilled, given that the population offered an apartment through the PSH office is often in no position to reject the offer or to wait to move in when they are offered an apartment.

Equations (1) and (2) are estimated for mental health outcomes up to five years after the PSH offer. As we have yearly observations available for every year, we use the panel data. However, as one could expect an individual's purchase of psychiatric medications one year to correlate with that individual's purchase the following year, we apply a random-effects estimator, where the random variables are independent and identically distributed (IID) over the panels.¹⁴

We test the results and assumptions of the above models in Sections 6.1 and 6.3 using different model specifications, such as a difference-in-differences model, a matching model, a panel probit model with random effects, and a cross-section linear probability model.

5. Data

We derive our data from two primary sources: administrative registry panel data from the Copenhagen municipal PSH system from 2000 through 2007 and administrative registry data from Statistics Denmark for the entire Danish population from 1996 through 2013. The data from the

¹⁴ The random term is estimated by the method of Balestra and Varadharajan-Krishnakumar (1987).

PSH system include records on each applicant's date of allocation, acceptance or rejection of a PSH 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 were able to merge a long list of Danish administrative registries with the PSH records and identify the family members and relatives in the household both before and after they were offered an apartment through the PSH office. The administrative registries provide information on both health care use (i.e., admissions to psychiatric hospitals and prescribed and purchased psychiatric medications) and individual demographic and socio-economic characteristics such as age, current residence, moving patterns, country of origin, income, job status, and level of education.

We observe that 12% of the allocated households either never moved into the allocated apartments or had lived at the address for less than one year. Of the persons moving into the allocated apartments, 55% still lived in these apartments five years after the allocation.

Our final sample is a panel dataset including applicants and their family members assigned to an apartment through the PSH in Copenhagen from 2000 through 2007. We restrict our sample to this time period because rejections of housing offers were not registered prior to 2000, and in 2007, the town council prohibited allocation of non-employed people into deprived housing areas. We make only a few restrictions on the sample. First, households allocated to more than one address in the same year are only included once. For this group, we include only the latest observation, assuming that any allocation in a given year is quasi-random. Second, we wanted to look at adults that could potentially be active in the labor market, i.e., 18-to-60-year-olds. However, as the prescription data is reliable only for those aged 18 and older, we restrict the data set to individuals above the age of 23 in our analysis because we control for mental health problems up to five years before the allocation. Because we want to follow the residents up to five years after allocation, we restrict the allocated residents to be a maximum of 55 years old in the allocation year. Thus, we end

up with the total number of household members aged 23 to 55 allocated through the Copenhagen PSH office in the period from 2000 through 2007: 9,341, 47% of whom are women. In our final estimation sample, we excluded emigrants and deaths, as we lack information on their mental health for the years after the allocation.¹⁵

The mental health outcome that we examine is an indicator for purchasing psychiatric medication (i.e., anti-depressants, anti-psychotics, anti-anxiety drugs, psychostimulant medications, analgesics, and drugs used in addictive disorders) in a given year.¹⁶ We have tested a different category of psychiatric medication, including only psychotics, anti-anxiety drugs, and psychostimulant medication. Furthermore, we examine an indicator for hospitalizations with an affective or non-affective functional psychotic disorder.¹⁷

Compared to the general population living in Copenhagen, the households that are offered an apartment through the PSH office are predominantly immigrants, single people without children, non-employed individuals, and individuals in the lower income and shorter education groups. For example, while 85% of average residents living in Copenhagen are in employment, the same only applies to only 36% of residents living in an apartment provided by the PSH. Furthermore, compared to the average resident in Copenhagen, the group of people receiving PSH offers has a higher average crime rate and poorer overall mental health as measured by the purchase of psychiatric medication.¹⁸

¹⁵ In a sample including deaths, we found a positive but insignificant impact of a deprived neighborhood on mortality, see Table A2.

¹⁶ The Anatomical Therapeutic Chemical (ATC) codes for the psychiatric medication are: N05A, N05B, N05C, N06A (except N06AX12), N06B, N02 and N07B.

¹⁷ International Disease Classification (IDC-10) codes: F20, F24, F25, F28, F319, F323 and F333.

¹⁸ Descriptive statistics on the full population and the sub-group of the population who are offered an apartment are available from the authors upon request. Compared to, for example, the group of people living in the most deprived

Table 1 presents differences in health care utilization and demographic and socio-economic characteristics among individuals who were offered a PSH apartment in deprived or non-deprived neighborhoods the year before they were offered the apartment (i.e., before treatment). In the full sample, the groups allocated to a deprived or a non-deprived neighborhood do not differ significantly from each other except in the number of family members, which is one of the characteristics that the PSH office considers when matching apartments with applicants.

Among the applicants, approximately 50% are non-Western immigrants, 70% have less than 10 years of education, and 50% purchase psychiatric medication. When we split the sample by gender, there are significant differences in allocated neighborhood with respect to age, the number of family members (among men), and immigrant status (among women). The differences in baseline measurements of age and immigrant status may be explained by differences in the number of family members. In Section 6, we examine the quasi-randomization into deprived and non-deprived neighborhoods conditional on the characteristics by which apartments and applicants are matched.

The group of people offered an apartment differs significantly by gender, where men have fewer family members (they are more often single without children), are more often convicted of a crime, and are more often treated with psychiatric medication and admitted to psychiatric hospitals as compared to women. Thus, initially the sample of women seems to be more heterogeneous than the sample of men, and in particular, the female applicants seem to be less disadvantaged than the male applicants.

Table 1 also shows that different neighborhood characteristics—like shares of non-employed, convicted individuals, use of psychiatric medicine, non-Western immigrant status, and

neighborhood in the Whitehall II Study from England, the group of people living in the deprived neighborhoods in Copenhagen are more likely to be unemployed (Weatherall et al, 2014)

average household income—that could potentially be channels through which neighborhoods could impact a resident’s mental health are all significantly different between deprived and non-deprived neighborhoods. Exactly those neighborhood characteristics will be evaluated with respect to the mechanism by which a deprived neighborhood impacts mental health.

6. Results

6.1 Exogeneity of neighborhood allocation

Due to the process of the PSH offers described in Section 3, the allocation into a deprived or non-deprived neighborhood is based on a few observable factors only. Thus, any differences in neighborhood characteristics, conditioning on financial means and the number of family members, should be uncorrelated with unobserved factors related to the mental health outcome. While this key assumption cannot be tested directly, we can obtain suggestive evidence by examining correlations between PSH allocation into deprived areas and a list of variables, including previous mental health.

To test our key assumption, we estimate the probability of being offered an apartment in a deprived neighborhood compared to being offered an apartment in a non-deprived neighborhood, conditioning on individual characteristics of the applicant observed prior to the application and year fixed effects. We repeat the basic model and ran several different models including lagged mental health characteristics of the applicant to ensure that there is no allocation into neighborhoods conditioned on indicators of mental health.

In Table 2, we show the probability model, including two variables measuring mental health, i.e., whether the applicant has purchased psychiatric medication or been admitted to a psychiatric hospital up to five years before allocation.¹⁹ In Table 2, the first column shows that, in

¹⁹ When we include lagged variables for antidepressants, as well as lagged variables for the use of psychiatric medication and for hospitalizations for severe mental illness among family members the results are virtually the same.

the full sample, none of the characteristics are significantly related to the probability of being allocated into a deprived neighborhood through the PSH office.²⁰ Although the PSH office can account for affordable rent based on information on financial means and size of the household, these two variables do not significantly affect the overall allocation to a deprived or non-deprived neighborhood. The insignificant association between household income and the probability of being allocated could be explained by a lack of significant rent difference between the apartments the PSH office offers in deprived and non-deprived neighborhoods. The F statistics for including all variables except the number of family members, household income, and year fixed effects show that these variables explain an insignificant amount of the variation. The results of this test suggest that the PSH allocation to a deprived neighborhood seems quasi-random.

In the third and second columns of Table 2, we examine the probability of being allocated to a deprived neighborhood by gender. Among men, age is statistically significant at the 10% level, but the parameter estimate is relatively small, indicating that an increase in age of one year is associated with a 0.1 percentage point increase in the probability of being allocated to a deprived neighborhood. Thus we control for age in the final estimations. The number of family members is statistically significant, which was expected. Among both men and women, the F test on joint insignificance is not rejected, indicating that the allocation into a deprived neighborhood is quasi-random in the samples. The results are virtually the same when standard errors are clustered on neighborhoods (results are available upon request).

Additional tests of the randomness of the allocation into neighborhoods are the balancing tests in Table A1. Here, we test the correlations between a list of individual characteristics of the applicant on the following average characteristics of the neighborhood the year before the

²⁰ In all regressions, year fixed effects are significant, capturing yearly observed correlations, such as tendencies to allocate applicants to certain areas.

allocation: share of residents 1) purchasing psychiatric medication, 2) being non-employed, 3) having less than 10 years of education, 4) having non-Western immigration status, or 5) having a crime conviction. Finally, we examine this relationship on average gross household income in the neighborhood. In these six regressions, only one variable, being a non-Western immigrant, is significant, but it is relatively small and negative (-0.003) when we estimate based on the share of non-Western immigrants in the neighborhood. In all regressions, except the regression on the share of non-Western immigrants, the F test on joint insignificance of the included variables, except household size and income and year-fixed effects, is not rejected.²¹

Based on the results from Tables 2 and A1 and the way the policy was implemented (see Section 3), we believe that the allocation of households through the PSH office in the Municipality of Copenhagen is quasi-random with respect to deprived neighborhoods.

6.2 The impact of neighborhood characteristics on mental health

Table 3 reports our estimated ITT effects, i.e., the impact of initial allocation to a deprived neighborhood on the probability of purchasing psychiatric medication. Panels A and B present the estimated average effects five years after the housing offer, and panel C presents the effects for each year following the allocation. In all regressions, we condition on the number of family members and gross household income, and in columns 2, 4 and 6, we further include the full set of control variables that could potentially influence mental health status. The standard errors take into account the clustering of the family members (in the full sample) in panel A and C and, following Damm and Dustmann (2013), the clustering of observations by neighborhood of assignment in panel B.

²¹ In Table A1, the results are virtually the same when the standard errors are clustered on neighborhood.

As argued in the empirical section, it makes sense to analyze the impact of living in a deprived neighborhood separately for men and women. However, we estimate all our models separately by gender and for the full sample. In the full sample in Table 3, the parameter estimate on allocation to a deprived neighborhood is positive and significant in panel A when we cluster on family members, but it becomes insignificant when we cluster on the neighborhood of assignment. The parameter estimates in columns 1 and 2 when we include the full list of controls are almost the same, indicating that factors besides those that could potentially have an effect on the allocation, such as financial means and family size, have little impact on the relationship between allocation and outcome.²²

Columns 3-6 reveal significant differences by gender. While the impact of allocation to a deprived neighborhood increases the probability of using psychiatric medication by five percentage points per year among men (when including the full list of controls), no significant impact is found among women (see panel A and B). In the sample of men, 32% purchased psychiatric medication the year before they were allocated through the PSH, and thus the translated effect size among men is approximately 15%.

If the use of psychiatric medication increases, one could expect that other mental health measures are influenced as well. We test other mental health variables: mortality, psychiatric hospitalization, and purchase of antidepressants, psychostimulants, and psycholeptics (see Table A2). The results for psychiatric hospitalizations and the group of psychiatric medication that only includes antidepressants, psychostimulants, and psycholeptics are in line with the results presented in Table 3, panel A. Among men, being allocated to a deprived neighborhood increases the probability of a psychiatric hospitalization by three percentage points. There is a positive but

²² The results are also virtually the same, if we exclude household income in the regressions (the parameter estimates becomes marginally smaller when we exclude household income). These results are available upon request.

insignificant impact of being allocated to a deprived neighborhood on mortality among both men and women.

Table 3, panel C presents the result of the impact of being allocated to a deprived neighborhood on the purchase of psychiatric medication for each year, up to five years after the allocation. Among men, the effect is positive in all years but only significant four (six percentage points) and five (12 percentage points) years after allocation. Among women, the impact of being allocated to a deprived neighborhood is negative (five percentage points) and significant the year after allocation but positive (four percentage points) five years after. Thus, there seems to be a lagged effect of exposure. Descriptive statistics show that the average rate of non-employment, education level and the use of psychiatric medication are not significantly different depending on the time living in a deprived neighborhood (these results are available upon request), indicating that the long-term effects are not driven by a selection of people staying who have more mental health problems.

When testing the interaction of treatment with the duration of a individual living in a deprived neighborhood (from one to five years), the first-year interaction is positive and significant in the full sample and among men but insignificant among women. The second-to-fifth-year interaction is negative for all, men, and women but only significantly different from zero for all and women in the second year. While these results are descriptive, they indicate that even a single year of exposure to a deprived neighborhood has a negative impact on mental health. The results are available upon request.

The results in Table 3 are ITT effects, and these results are based on all individuals who received an offer from the PSH office. To the extent that some of the individuals do not move into the apartments offered, these estimates would be a lower bound for the effect of being exposed to a deprived neighborhood. Table 4 presents the TOT effect for those actually moving into the

allocated neighborhood. The first stage results show a strong and positive relationship between being allocated to a deprived neighborhood and actually living in this neighborhood up to five years later.

The 2SLS estimates in Table 4 show that, among men, exposure to a deprived neighborhood increases the probability of purchasing psychiatric medication by seven percentage points per year over a five-year period. Among women, the yearly impact over five years after allocation is small and not significantly different from zero.

In the two samples including either all persons or men only, the TOT estimates are larger than the ITT estimates but similar with respect to the sign and significance of the parameter estimate. The parameter estimates presented in Tables 3 and 4 are not directly comparable with previous results from the literature, as exposure, samples, and outcomes all differ. However, our results are in line with the results of a positive relationship between neighborhood deprivation and mental health problems, as found in Katz et al. (2001), Kling et al. (2007), and Ludwig et al. (2013).

To examine which of the neighborhood characteristics have the greatest impact on the mental health of the applicants, we include the continuous variables of different neighborhood characteristics from Table 1 in the estimations. The average characteristics of the neighborhood are measured the year before allocation. As our definition of a deprived neighborhood is based on both a high non-employment rate and a low share of income, we include an interaction between these two variables. The results in Table 5 show that the socio-economic composition of the neighbors seems to mainly affect men. Neither income nor non-employment is statistically significant among women. However, the rate of convicted crimes has a negative impact on the purchase of psychiatric medication among women: the parameter estimate is statistically significant at a 10 percent level.

In the two samples including either all persons or men only, the average share of the population purchasing psychiatric medication has a large and significant impact on the probability

of purchasing psychiatric medication. This neighborhood characteristic is not statistically significant among women when we include the full list of control variables.

The average share of non-Western immigrants in the neighborhood seems to have the opposite impact on men and women. In the model where we include the full list of control variables, an increase in the share of non-Western immigrants has a positive impact on men but a negative (but not statistically significant) impact on women.

To sum up the results in Table 5, we see significant gender differences in the results. Among men, the socio-economic composition of the neighbors, the share of neighbors purchasing psychiatric medication, and the share of immigrants seem to be characteristics of the neighborhood that are important for mental health. Among women, the results are less consistent and less significant.

The impact of the socio-economic composition of neighbors on mental health among men is in line with the results in Table A2, panel D, which presents the results of the impact of allocation to a deprived neighborhood on being non-employed. Among men, being allocated to a deprived neighborhood increases the probability of being non-employed by three percentage points. The results are not statistically significant among women. The negative impact of a deprived neighborhood on employment among men again indicates the channels by which the neighborhood can influence its residents.

6.3 Sensitivity test

Although the procedure for allocating PSH seems to yield a quasi-random experimental design of allocation to different neighborhoods, we cannot exclude the possibility that there are fixed unobserved characteristics that correlate with both the PSH allocation and mental health, e.g., if the caseworker subconsciously considers emotional robustness when allocating apartments. We

therefore test the results using a difference-in-differences (DID) approach that controls for unobserved, time-fixed omitted variables.

In the DID model, the impact of being allocated to a deprived neighborhood on purchases of psychiatric medication is positive but insignificant among all, positive and significant among men, and negative and insignificant among women (see Table A3, panel A). Thus, the results from the DID model are in line with the main results shown in Table 3.

Although Table 1 showed only minor differences on observable characteristics in the means, one might surmise that the control and treatment groups would be more similar when matching on a list of unique control variables. In Table A3, panel B, we further test the model specification with a propensity-score matching model, where we match on observables before allocation.²³ The results from this model show a positive and significant impact from being allocated to a deprived neighborhood in the full sample and among men and a negative and insignificant impact among women. Again, these results confirm the results found in Table 3.

One could argue that a fairly long time series can cause serial correlation and result in inconsistent standard errors. To account for this problem, we collapse our data and estimate a simple cross-section linear probability model where the outcome is the sum of years purchasing psychiatric medication over five years after allocation. The results in Table A3, panel C again confirm a positive relationship between living in a deprived neighborhood and taking psychiatric medicine. Our dependent variable is bivariate; therefore, we also test a panel probit model with

²³ To estimate the propensity-score matching model including covariate balance testing, we use Leuven and Sianesi's Stata module `psmatch2` (210, version 4.0.4, <http://ideas.repec.org/c/boc/bocode/s432001.html>). In the results presented in Table A3, panel B, we use nearest-neighbor matching (without replacement) and include the full list of control variables.

random effects. The results in Table A3, panel D again confirm the positive impact on men found in Table 3.

To test if the results are sensitive to the geographical boundaries that we use as a proxy for the neighborhood, we present the results from a model where we use a larger spatial unit than the neighborhoods described in Section 3. These large-scale neighborhoods are natural geographical neighborhoods with at least 1,000 residents living in physically contiguous residential areas dominated by the public housing sector.²⁴ The results in Table A3, panel XX show a positive and significant parameter estimate on allocation to a deprived neighborhood among men, which confirms the overall results found in Table 3.

7. Discussion and conclusion

In this paper, we use a unique quasi-experiment of the allocation of applicants into different neighborhoods through the public social housing office, merged with administrative registry panel data, to estimate both short- and long-term effects on mental health of being exposed to a deprived neighborhood.

Our evidence suggests that being exposed to a deprived area increases the probability of purchasing psychiatric medication. For men, the estimated ITT effect size is approximately 15% on a yearly basis (over five years), and the estimated yearly effect is significant among men in year four and five after allocation, indicating a lagged effect of exposure. For women, we find no significant five-year average effect, which can partly be explained by the existence of greater heterogeneity among the women applying for an apartment through the Copenhagen social housing

²⁴ Based on the definition by the Ministry of Housing, Urban and Rural Affairs

<http://uim.dk/filer/bolig/ghettolisten/liste-over-saerligt-udsatte-boligomraader-dec-2014.pdf>

office. We find that the socio-economic composition of new neighbors and the share of neighbors purchasing psychiatric medication are both important characteristics of the neighborhood that affect mental health among men.

We estimate both intention-to-treat (ITT) and treatment of the treated (TOT) using the initial allocation of apartments as an instrument for the actual neighborhood in a 2SLS model. We find similar effects when we test different model specifications and various outcomes, i.e., being hospitalized with a severe mental health disease (e.g., schizophrenia or affective disorders) and purchasing another group of psychiatric medication. The impact on mortality of being allocated to a deprived neighborhood is not significant. Although mortality is considered a good measure of health status, this non-result can be explained by the fact that few people in our sample age range, ages 23 to 55, die. Furthermore, mortality may not be a good measure of mental health status alone.

The results differ significantly by gender. While the effect of being allocated to a deprived area increases the probability of purchasing psychiatric medication by five percentage points on average among men (an effect size of approximately 15%), this effect is not significant among women. The TOT effects are larger than the ITT effects in all models, which is expected, as the ITT effects include the 12% of the sample that never moves into the allocated neighborhood. Among men, the estimate of the TOT effect is 6.6 percentage points. The larger TOT effect compared to the ITT effect indicates that those refusing the housing offer make a wise choice.

By exploiting the panel of administrative registry data, we were able to examine the yearly impact of exposure to a deprived neighborhood. We find that among men, allocation to a deprived neighborhood increases the probability of purchasing psychiatric medication in years four and five after the allocation by six and 12 percentage points respectively. Thus, while the parameter estimates among men were positive one to three years after allocation, these effects were relatively low and insignificant, indicating that the negative impact of being exposed to a deprived

neighborhood has long-term consequences. Among women, being allocated to a deprived neighborhood *reduces* the probability of purchasing psychiatric medication by five percentage points one year after allocation but increases this probability by five percentage points five years after allocation. In descriptive analyses, we do not see any signs of significant correlations between the duration in a deprived neighborhood and, for example, being unemployed, having less than 10 years of education, or purchasing psychiatric medication. These results indicate that the lagged effect of exposure is not driven by a selection of those who stay having more severe mental health problems. However, a delayed effect on mental health, when measured by use of psychiatric medication, is not surprising, and a study of the impact of deployment among male soldiers also finds a delayed effect on psychiatric medicine years after exposure (Lyk-Jensen et al., 2016).

While previous studies based on the MTO have found that moving to a better neighborhood mainly benefits (young) women (Kling et al., 2007; Leventhal and Brooks-Gunn, 2003; Ludwig et al., 2013), we mainly find a negative neighborhood effect among men. The results from Galster et al. (2008) suggest a negative socio-economic impact on not-fully-employed men living in neighborhoods with a high share of low-income neighbors. The gender differences in our results may partly be explained by the socio-economic characteristics of the men and women allocated through the PSH allocation system. Descriptive statistics showed that, compared to women, men allocated through the PSH system were more likely to be single without children and to have previously been hospitalized with severe mental diseases. Thus, the group of men seems to be a more vulnerable group than the group of women, which might make them more affected by the socio-economic composition of the neighbors. Furthermore, social comparison with the neighbors living in the deprived neighborhoods would likely be different by gender (Exline and Lobel, 1997). The insignificant results among women may then be due to the fact that the women allocated to deprived neighborhoods make downward social comparisons (because they are surrounded by

people who are in a worse situation than they themselves are and therefore feel relief) and are therefore less affected by the exposure. This result is in line with previous literature on peer effects and mental health. Using the random assignment of roommates among first-year college students, Eisenberg et al. (2013) found an increase in specific mental health measures for men with pre-existing depression if their roommate was depressed. No significant effect was found for women.

The five percentage point decrease in the probability of purchasing psychiatric medication one year after allocation indicates that moving to a deprived neighborhood can even have a positive impact on mental health among women. However, the effect reverses in the longer run, where the effect of the new comparison group is perhaps no longer relevant.

We extend the analysis and examine which of the neighborhood characteristics have the greatest impact on the mental health of the applicants. We found that the usual characteristics of a deprived neighborhood—i.e., high shares of people with no relation to the labor market and with low income—mainly affect the males. Furthermore, the share of people with mental health problems seems to be an important neighborhood characteristic that has a negative impact among men. There are several possible explanations for this result.

First, while we cannot dismiss that the high share of neighbors with mental health problems reflects a tendency among health care providers connected to these neighborhoods to (over)prescribe psychiatric medication, this may not be the only explanation. Given the relatively small size of Copenhagen (1.2 million inhabitants living in an area of 88 km²) and the fact that deprived and non-deprived neighborhoods are closely located to one another, we expect GP- fixed effects to be less likely. Furthermore, as mentioned earlier, we see in the descriptives no significant differences in purchasing psychiatric medicine and changing GPs.

Another explanation could be that, when moving to a neighborhood with a high share of residents on psychiatric medication, the norm for taking this kind of medication might be modified

as the result of a general higher acceptance of drug abuse or as the result of psychological imitation among the group of peers living nearby.

Finally, it seems obvious that being surrounded by vulnerable and fragile people with few resources (both financial and psychological) might not be the best solution for the type of people allocated through the PSH, as they—besides being in housing need—also have social problems. Unfortunately, without highly detailed information on an individuals' characteristics, choices, preferences, and environment, we are not able to draw firm conclusions as to whether neighbors' simultaneous behaviors are attributable to the fact that they are neighbors or to exposure to a common environmental factor unobserved by us researchers.

The overall result, viz. that exposure to a deprived neighborhood has long-term negative impacts on mental health, is in line with previous literature, which also shows a significant impact of neighborhood characteristics on mental health. However, the measures of mental health used in previous studies of the impact of neighborhood characteristics (Kling et al., 2007; Ludwig et al., 2013) differ from ours, and the parameter estimates are thus not directly comparable. Our measure of mental health is based on prescription records in the administrative registries. Utilizing administrative registry data is particularly useful in studies of fragile and disadvantaged groups, as measurement problems in the form of self-reporting and attrition biases are highly reduced.

One main finding in the previous literature on the causal impact of neighborhood characteristics is that it is the amount of exposure to better neighborhoods during childhood rather than total lifetime exposure that matters for long-term economic success (Chetty et al., 2016). However, our results suggest that exposure to a deprived neighborhood during adulthood also has long-term negative effects on mental health.

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TABLES

Table 1: Baseline characteristics of the population allocated by the Copenhagen PSH office in the years 2000-2007 (main applicant and family members) by deprived and non-deprived neighborhood. All, men, and women aged 23-55 at time of allocation. Mean and standard deviation (SD).

	All				Men				Women			
	non-deprived		deprived		non-deprived		deprived		non-deprived		deprived	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
<i>Personal characteristics</i>												
Age (years)	34.80	8.13	35.26	8.55	36.26*	8.07	37.12	8.45	33.17	7.88	33.30	8.23
Women	0.47	0.50	0.49	0.50								
Non-Western immigrant	0.46	0.50	0.49	0.50	0.44	0.50	0.43	0.50	0.49*	0.50	0.54	0.50
No. of fam. members	2.07*	1.41	2.15	1.37	1.75*	1.39	1.92	1.36	2.34	1.37	2.39	1.33
<10 years of education	0.71	0.46	0.69	0.46	0.70	0.46	0.69	0.46	0.71	0.45	0.68	0.47
Log of family gross income	6.01	1.71	6.03	1.69	6.36	1.86	6.38	1.81	5.62	1.42	5.67	1.46
Unemployed	0.70	0.46	0.71	0.45	0.71	0.45	0.72	0.45	0.69	0.46	0.70	0.46
Convicted for crime ¹	0.11	0.31	0.11	0.31	0.16	0.37	0.15	0.36	0.04	0.21	0.06	0.24
Psychiatric medication ²	0.48	0.50	0.48	0.50	0.50	0.50	0.53	0.50	0.46	0.50	0.42	0.49
Psychiatric hospitalization ³	0.07	0.26	0.06	0.25	0.09	0.28	0.09	0.29	0.05	0.22	0.04	0.19
Previously lived in a deprived neighborhood	0.08	0.27	0.09	0.29	0.07	0.26	0.10	0.30	0.08	0.28	0.09	0.29
<i>Average neighborhood characteristics</i>												
Non-employment	37.67***	8.00	55.23	15.62	37.714***	7.85	56.79	17.99	37.63***	8.17	53.64	12.63
Gross HH income	213939***	26373	174054	25613	213592***	25074	173962	27571	214326***	27750	174147	23506
Convicted for crime	2.36***	1.26	4.71	10.55	2.49***	1.26	6.29	13.57	2.21***	1.24	3.11	5.72
Psychiatric medication	1.30***	1.09	2.02	4.71	1.41***	1.11	2.67	6.05	1.17***	1.04	1.36	2.63
Non-Western immigrant	30.43***	17.77	49.67	27.62	28.84***	16.88	44.60	28.50	32.21***	18.55	54.80	25.74
Number of inhabitants	320***	132	378	239	331**	145	378	262	331***	141	404	266
Observations	8534		807		4515		415		4019		392	

Notes: * indicates significant differences between groups in deprived and non-deprived neighborhoods at a 5% significance level. 1) Convicted for violating the following types of crime: criminal law, laws on firearms, and laws on narcotics. 2) Psychiatric medication includes the following Anatomical Therapeutic Chemical

(ATC) codes: N05A, N05B, N05C, N06A (except N06AX12), N06B, N07B, and N02. 3) Psychiatric hospitalization includes hospitalization with the international classification of diseases (ICD) codes: F20, F24, F25, F28, F319, F323, and F333.

Table 2: The probability of being offered an apartment in a deprived vs. non-deprived neighborhood through the PSH office in the years 2000-2007. All, men, and women aged 23-55 at the time of allocation. Linear probability model. Robust standard errors in parentheses.

	All	Men	Women
Age (years)	0.0007	0.0010*	0.0002
	(0.0004)	(0.0005)	(0.0006)
Women	0.0055		
	(0.0057)		
Non-Western immigrant	0.0029	-0.0078	0.0138
	(0.0068)	(0.0085)	(0.0090)
Number of family members	0.0044	0.0079***	0.0004
	(0.0029)	(0.0030)	(0.0033)
Less than 10 years of education	-0.0047	0.0011	-0.0121
	(0.0070)	(0.0090)	(0.0102)
Log of family gross income	0.0008	0.0004	0.0018
	(0.0018)	(0.0021)	(0.0031)
Non-employed	0.0046	0.0032	0.0064
	(0.0065)	(0.0090)	(0.0095)
Psychiatric medication ²	-0.0023	0.0049	-0.0103
	(0.0060)	(0.0083)	(0.0088)
Psychiatric hospitalization	-0.0025	0.0059	-0.0206
	(0.0118)	(0.0145)	(0.0175)
Previously lived in deprived neighborhoods	0.0136	0.0263	0.0013
	(0.0126)	(0.0169)	(0.0157)
Convicted for crime ¹	0.0085	-0.0001	0.0355
	(0.0100)	(0.0108)	(0.0232)
Constant	0.0502**	0.0333	0.0745**
	(0.0231)	(0.0275)	(0.0319)
Year of allocation	X	X	X
Observations	9,341	4,930	4,411
R-squared	0.0034	0.0041	0.0067
F-statistics	F(9, 8172) = 0.64	F(8, 4912) = 1.04	F(8, 4393) = 1.25
Prob > F	0.7629	0.4010	0.2640

Notes: *** p<0.01, ** p<0.05, * p<0.1. 1) Convicted for violating the following types of crime: criminal law, laws on firearms, and laws on narcotics. 2) Purchased psychiatric medication includes the following ATC groups: N05A, N05B, N05C, N06A (except N06Ax12), N06B, N07B, and N02. 3) Psychiatric hospitalization includes hospitalization with one of the following diagnoses: ICD codes: F20, F24, F25, F28, F319, F323, and F333. In the sample including all, standard errors are clustered on household because of intra-household correlations.

Table 3: The impact of being allocated to a deprived neighborhood on mental health (psychiatric medication). Intention to treatment effects. Linear probability panel model with random effects. Robust standard errors in parentheses.

	All		Men		Women	
	(1)	(2)	(3)	(4)	(5)	(6)
	Basic list of controls	Full list of controls	Basic list of controls	Full list of controls	Basic list of controls	Full list of controls
<i>Panel A¹:</i>						
Deprived neighborhood	0.024*	0.024**	0.059***	0.049***	-0.014	-0.001
	(0.014)	(0.012)	(0.021)	(0.017)	(0.020)	(0.017)
<i>Panel B: Cluster on neighborhood</i>						
Deprived neighborhood	0.024	0.024	0.059*	0.049**	-0.014	-0.001
	(0.027)	(0.019)	(0.031)	(0.021)	(0.030)	(0.020)
<i>Panel C: Cluster on family</i>						
Deprived neighborhood *t+1	-0.016	-0.015	0.027	0.018	-0.062***	-0.049**
	(0.018)	(0.015)	(0.026)	(0.022)	(0.024)	(0.020)
Deprived neighborhood *t+2	0.004	0.005	0.025	0.015	-0.019	-0.006
	(0.019)	(0.016)	(0.026)	(0.023)	(0.025)	(0.022)
Deprived neighborhood *t+3	0.018	0.019	0.036	0.026	-0.002	0.012
	(0.018)	(0.016)	(0.026)	(0.023)	(0.025)	(0.023)
Deprived neighborhood *t+4	0.025	0.026	0.066**	0.057**	-0.019	-0.006
	(0.018)	(0.016)	(0.027)	(0.024)	(0.025)	(0.023)
Deprived neighborhood *t+5	0.080***	0.081***	0.127***	0.117***	0.030	0.043*
	(0.019)	(0.017)	(0.027)	(0.025)	(0.026)	(0.023)
No. of obs.	41,498		21,768		19,730	
Sample outcome mean	0.298		0.319		0.274	

Notes: Sample includes all men and women aged 23-55 at time of being offered an apartment through the Copenhagen PSH. The basic list of controls includes the number of family members and (log of) gross household income. The full set of control variables further includes age, immigrant status, an indicator of less than 10 years of education, an indicator for being employed, an indicator for whether the individual has been convicted of a crime, an indicator for whether the individual has been purchasing psychiatric medication up to five years before the allocation, and an indicator for having previously lived in a deprived neighborhood.

¹ In the full sample, standard errors are clustered on family. Level of significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Exposure to a deprived neighborhood on mental health. Two-stage least square (2SLS) linear probability panel model with random effects. Robust standard errors in parentheses.

	All		Men		Women	
	Basic list of controls	Full list of controls	Basic list of controls	Full list of controls	Basic list of controls	Full list of controls
Deprived neighborhood	0.032	0.032**	0.080***	0.066***	-0.019	-0.001
	(0.019)	(0.016)	(0.028)	(0.023)	(0.027)	(0.022)
First stage results: Effect of allocation on moving into a deprived neighborhood	0.741*** (0.004)	0.740*** (0.004)	0.735*** (0.006)	0.733*** (0.005)	0.748*** (0.006)	0.748*** (0.005)
Observations	41,498	41,498	21,768	21,768	19,730	19,730
Sample outcome mean	0.298	0.298	0.319	0.319	0.274	0.274

Notes: Sample includes all men and women aged 23-55 at the time of being offered an apartment through the Copenhagen PSH. The basic list of controls includes the number of family members and (log of) gross household income. The full set of control variables further includes age, immigrant status, an indicator for more than 12 years of education, an indicator for being employed, an indicator for whether the individual has been convicted of a crime, an indicator for whether the individual has been purchasing psychiatric medication up to five years before the allocation, and an indicator for having previously lived in a deprived neighborhood. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Cluster on household in full sample.

Table 5: The impact of continuous neighborhood characteristics: average non-employment rate, gross income, crime rate, education (more than 12 years of education) rate, and share of immigrants on purchases of psychiatric medication. All, men, and women. Robust standard errors in parentheses.

	All		Men		Women	
	(1)	(2)	(3)	(4)	(5)	(6)
Average neighborhood characteristics						
Non-employment	1.591+	1.359*	2.144+	2.085*	1.436	0.800
	(1.019)	(0.812)	(1.404)	(1.156)	(1.349)	(1.083)
Log of gross HH income	0.034	-0.033	0.072	-0.080	-0.011	0.025
	(0.087)	(0.072)	(0.118)	(0.097)	(0.121)	(0.103)
Non-employment* Log of gross HH income	0.315+	0.271*	0.453*	0.430*	0.246	0.138
	(0.194)	(0.155)	(0.267)	(0.222)	(0.257)	(0.206)
Convicted for crime	-0.107	-0.089	-0.017	0.006	-0.185	-0.368*
	(0.156)	(0.119)	(0.204)	(0.156)	(0.246)	(0.204)
Psychiatric medication	0.365***	0.200**	0.387***	0.221**	0.312**	0.155
	(0.096)	(0.082)	(0.129)	(0.107)	(0.142)	(0.128)
Immigrants	-0.116***	0.013	-0.032	0.085**	-0.210***	-0.069
	(0.036)	(0.031)	(0.051)	(0.042)	(0.052)	(0.046)
Number of inhabitants	-0.014**	-0.010**	-0.007	-0.007	-0.020***	-0.013**
	(0.005)	(0.004)	(0.008)	(0.007)	(0.007)	(0.006)
Observations	41,498	41,498	21,768	21,768	19,730	19,730
Sample outcome mean	0.298	0.298	0.319	0.319	0.274	0.274

Notes: Sample includes all men and women aged 23-55 at the time of being offered an apartment through the Copenhagen PSH. The basic list of controls includes the number of family members and (log of) gross household income. The full set of control variables further includes age, immigrant status, 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, an indicator for whether the individual has been purchasing psychiatric medication up to five years before the allocation, and an indicator for having previously lived in a deprived neighborhood. The mean baseline descriptive statistic for average neighborhood characteristics are Non-employment: 0.389. Log of gross HH income: 2.32; crime rate: 0.024; psychiatric medication: 0.21; immigrants: 0.310. *** p<0.01, ** p<0.05, * p<0.1.

Appendices

Table A.1: Balancing test: Average characteristics in the neighborhood the year before allocation in terms of share of residents purchasing psychiatric medication, share of residents non-employed, share of residents with less than 10 years of education, yearly gross household income among residents, share of residents with non-Western immigrant status, and share of residents convicted for crime.

	Psychiatric medication	Non-employed	Less than 10 years of education	Gross household income	Non-Western immigrant	Convicted for crime
Age	-0.0000	0.0000	0.0001*	-18.8576	-0.0000	-0.0000
	(0.0000)	(0.0001)	(0.0001)	(11.6239)	(0.0000)	(0.0000)
Woman	0.0000	0.0005	0.0010	-141.2670	0.0008	0.0003
	(0.0006)	(0.0008)	(0.0007)	(164.1383)	(0.0007)	(0.0003)
Non-Western immigrant	0.0002	-0.0012	-0.0006	103.8955	-0.0030***	0.0002
	(0.0006)	(0.0010)	(0.0010)	(220.6033)	(0.0008)	(0.0003)
No. of fam. members	0.0003	0.0008*	0.0006	-14.4045	0.0003	0.0001
	(0.0003)	(0.0004)	(0.0006)	(113.8305)	(0.0003)	(0.0001)
<10 years of education	0.0001	0.0000	-0.0002	-85.6166	-0.0007	-0.0000
	(0.0006)	(0.0010)	(0.0008)	(189.1373)	(0.0007)	(0.0003)
Log of family gross income	0.0001	0.0002	-0.0001	62.0135	0.0002	0.0001
	(0.0002)	(0.0003)	(0.0004)	(52.6688)	(0.0002)	(0.0001)
Not employed	-0.0007	0.0004	-0.0006	-118.6296	-0.0003	0.0003
	(0.0006)	(0.0007)	(0.0007)	(202.6733)	(0.0007)	(0.0002)
Previous lived in a deprived neighborhood	-0.0015	-0.0017	-0.0017	653.2703*	0.0010	-0.0009
	(0.0011)	(0.0017)	(0.0016)	(360.4940)	(0.0013)	(0.0006)
Convicted for crime	0.0001	-0.0007	0.0001	417.7498	-0.0013	-0.0004
	(0.0009)	(0.0013)	(0.0014)	(304.5561)	(0.0013)	(0.0004)
Psychiatric medication	0.0002	-0.0003	0.0005	-16.6572	0.0005	-0.0002
	(0.0006)	(0.0009)	(0.0009)	(199.3682)	(0.0009)	(0.0003)
Psychiatric hospitalization	0.0000	-0.0021	0.0010	153.3620	-0.0015	0.0004
	(0.0011)	(0.0015)	(0.0015)	(333.7942)	(0.0014)	(0.0004)
Year of PSH allocation.	X	X	X	X	X	X
Neighborhood FE	X	X	X	X	X	X
Constant	0.2032***	0.3863***	0.4186***	208,527***	0.2705***	0.0206***
	(0.0029)	(0.0060)	(0.0076)	(1,126.095)	(0.0058)	(0.0020)
Observations	9,241	9,241	9,239	9,241	9,241	9,241

R-squared	0.8200	0.8430	0.8314	0.9273	0.9731	0.6901
Test of joint insignificance ¹	F(9,284) = 0.55	F(9,284) = 0.71	F(9, 283) = 0.72	F(9,284) = 0.95	F(9,284) = 2.11	F(9, 284) = 1.16
Prob > F	0.833	0.700	0.686	0.479	0.029	0.320

Notes: Robust standard errors in parentheses. Clustered by family ID. *** p<0.01, ** p<0.05, * p<0.1. 1) Test of joint insignificance of all variables included except number of family members, gross household income, and year fixed effects.

Table A.2: The impact of allocation to a deprived neighborhood on mortality, psychiatric hospitalization, a group of psychiatric medication only including antidepressants, psychostimulants, and psycholeptics, and the probability of being non-employed. ITT. Linear probability panel model with random effects. Robust standard errors in parentheses.

	All	Men	Women
<i>Panel A: outcome: mortality</i>			
Deprived neighborhood	0.005 (0.007)	0.004 (0.011)	0.004 (0.009)
<i>No. of obs.</i>	8,654	4,592	4,062
<i>Panel B: outcome: psychiatric hospitalization</i>			
Deprived neighborhood	0.018 (0.011)	0.029* (0.016)	0.009 (0.016)
Observations	41,498	21,768	19,730
<i>Panel C: outcome: antidepressants, psychostimulants, and psycholeptics</i>			
Deprived neighborhood	0.013	0.030*	-0.006
Observations	41,498	21,768	19,730
<i>Panel D: outcome: Non-employed</i>			
Deprived neighborhood	0.024 (0.011)	0.029* (0.015)	0.020 (0.016)
Observations	41,498	21,768	19,730

Note: Sample includes all men and women aged 23-55 at the time of being offered an apartment through the Copenhagen social housing office. Panel B excludes all deaths. The basic list of controls includes the number of family members and gross household income. The full set of control variables further includes age, immigrant status, 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, an indicator for whether the individual has been purchasing antidepressants up to five years before the allocation (panel B), and an indicator for having previously lived in a deprived neighborhood. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: The impact of being allocated to a deprived neighborhood on mental health (psychiatric medication). Test of model and a large-scale neighborhood.¹ Difference-in-differences, matching, cross-section linear probability, and panel probit model with random effects. Parameter estimates for all, men, and women. Robust standard errors in parentheses.

	All	Men	Women
<i>Panel A: Difference-in-differences model</i>			
Deprived neighborhood	0.010	0.018*	0.001
	(0.007)	(0.010)	(0.010)
After	0.092***	0.089***	0.095***
	(0.003)	(0.004)	(0.004)
Deprived neighborhood* after	0.014	0.029**	-0.002
	(0.010)	(0.014)	(0.014)
No. of obs.	85,709	45,247	40,462
<i>Panel B: Matching</i>			
Deprived neighborhood	0.006	0.042*	-0.035
	(0.016)	(0.024)	(0.022)
No. of obs.	7,121	3,637	3,484
<i>Panel C: Cross-section LPM</i>			
Deprived neighborhood	0.119**	0.239***	-0.003
	(0.06)	(0.085)	(0.084)
No. of obs.	8,323	4,366	3,957
<i>Panel D: Probit panel model with random effects (marginal effects)</i>			
Deprived neighborhood	0.104*	0.052***	-0.008
	(0.014)	(0.020)	(0.092)
No. of obs.	41,498	21,768	19,730
<i>Panel E: Model with large scale neighborhoods</i>			
Deprived neighborhood	0.018	0.041**	-0.004
	(0.013)	(0.018)	(0.017)
No. of obs.	41,179	21,504	19,675

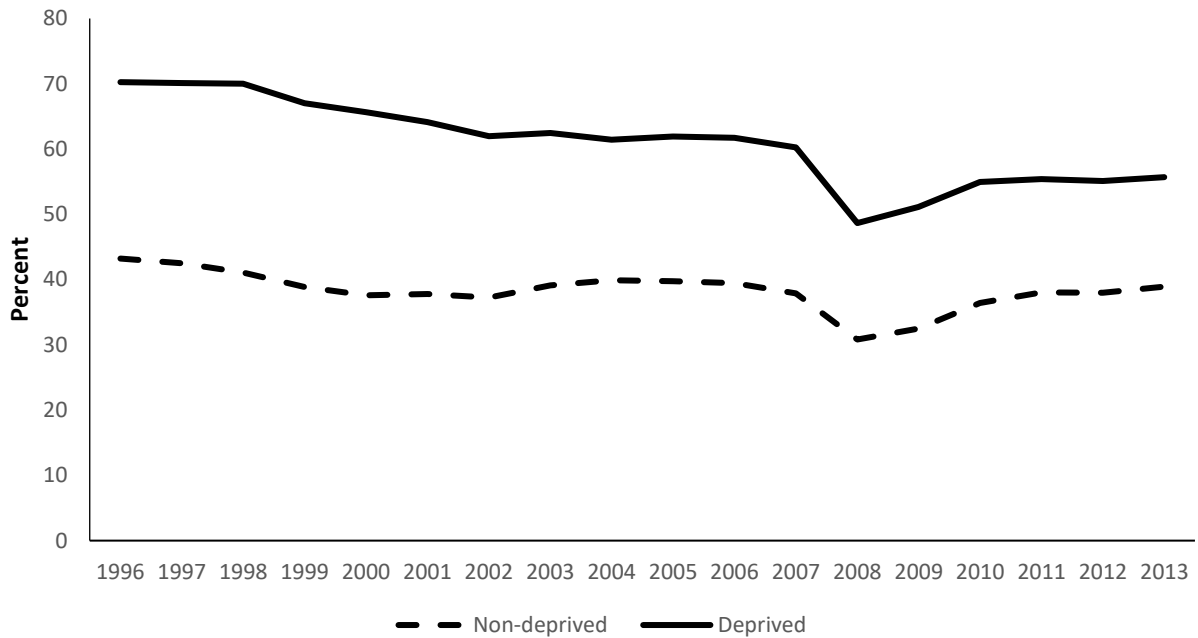
Note: Sample includes all men and women aged 23-55 at time of being offered an apartment through the Copenhagen social housing office. Only matched men and women are included in the sample in Panel B. Panel B presents the results from propensity score matching using nearest-neighbor matching without replacement. The list of controls includes the number of family members, family gross household income, age, immigrant status, 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, an indicator for whether the individual has been purchasing psychiatric medication up to five years before the allocation, and an indicator for having previously lived in a deprived neighborhood.¹ A large-scale neighborhood includes, on average, 1000 residents. These neighborhoods are natural, geographical neighborhoods with at least 1,000 residents in physically contiguous residential areas dominated by the public housing sector defined by the Ministry of Housing, Urban, and Rural Affairs. The number of observations is reduced in panel E, as not all apartments are located in a large-scale neighborhood.

Figure A1: Map of Copenhagen Municipality and possible allocated staircases by the PSH office from 2000-2007 and the number of deprived neighborhoods by postal code areas.

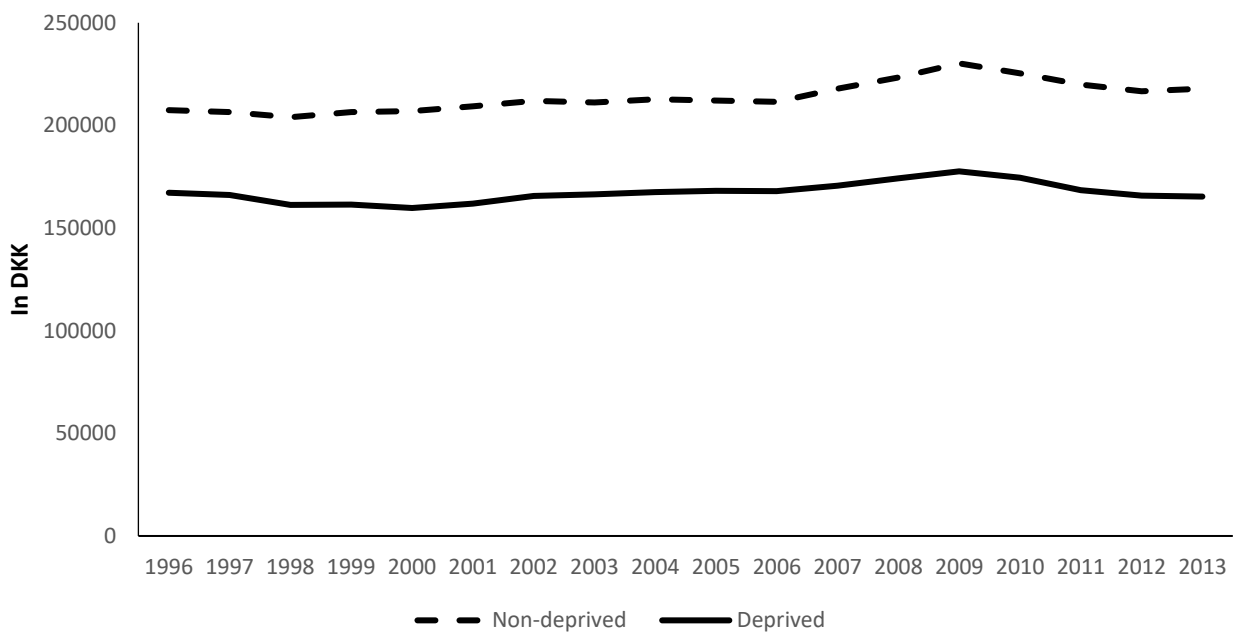


Figure A2: Fraction characteristics of population aged 18-64 living in deprived and non-deprived neighborhoods. 1996-2013, in percentages.

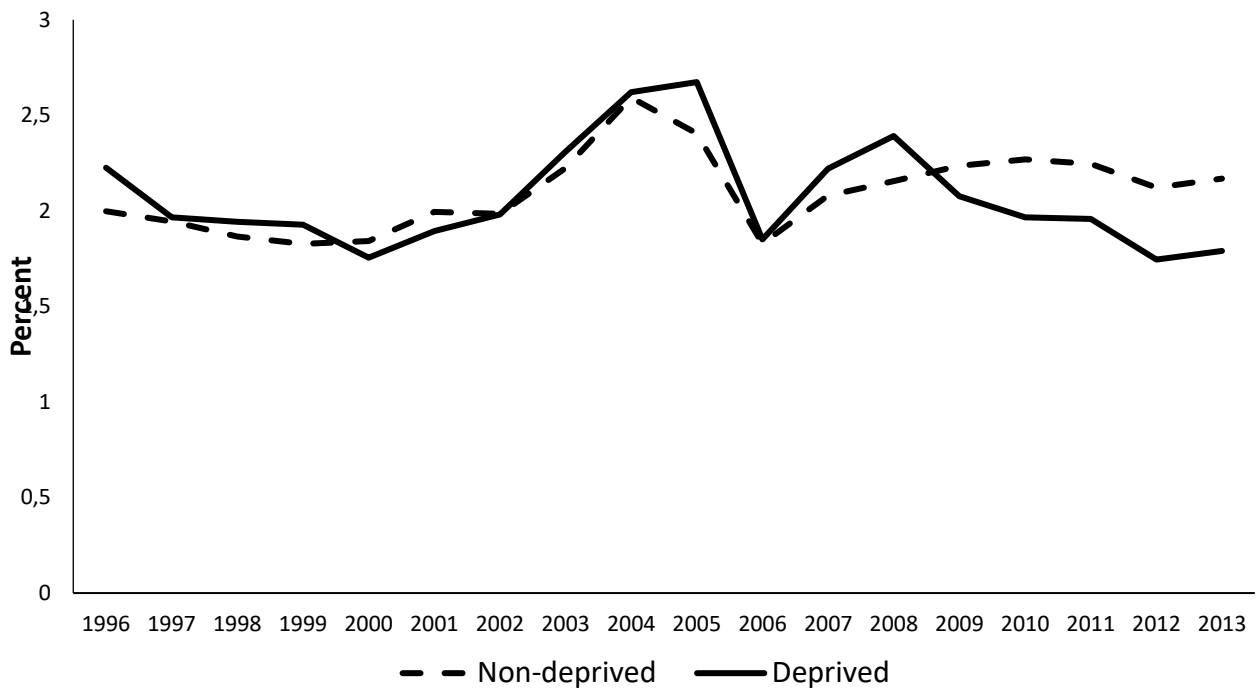
Average fraction of non-employed residents in neighborhoods 1996-2013



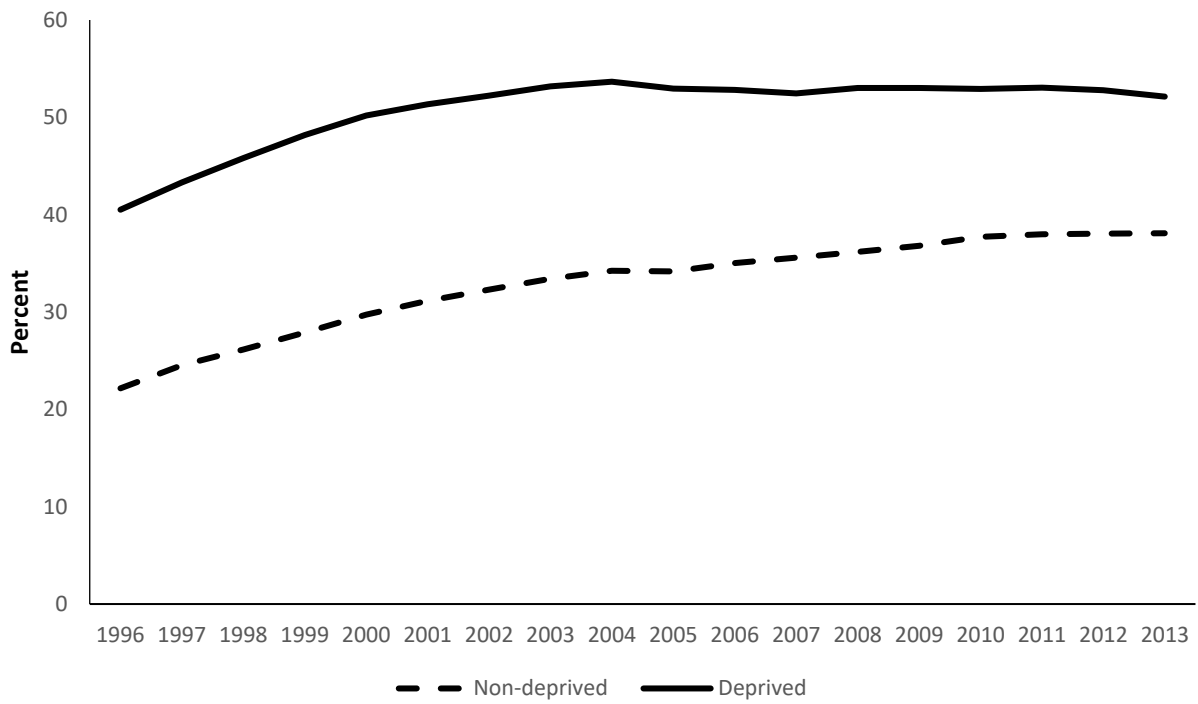
Average gross income among residents in neighborhoods 1996-2013



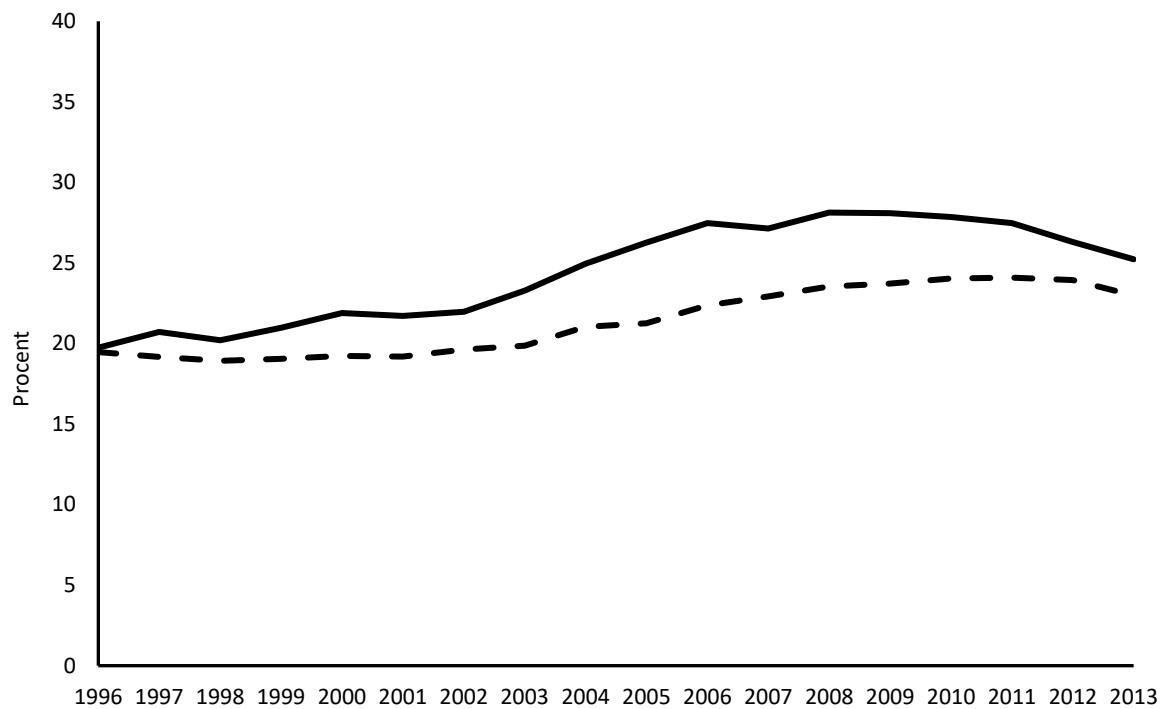
Average fraction of convicted² residents in neighborhoods 1996-2013



Average fraction of non-Western immigrants in neighborhoods 1996-2013



Average fraction of residents purchasing psychiatric medicine¹ in neighborhoods 1996-2013



Notes: The sample includes all residents in the public sector in Copenhagen in each year. A neighborhood is a unit that is both a psychically contiguous residential area and an administrative unit in both legal and economic terms. To be classified as a deprived unit, the average characteristics of the neighborhood in terms of unemployment and income must be in the higher and lower end respectively of the distribution of these characteristics for all units in the public housing sector. 1) Psychiatric medication includes the following Anatomical Therapeutic Chemical (ATC) codes: N05A, N05B, N05C, N06A (except N06AX12), and N06B. 2) Convicted for violating the following types of crime: criminal law, laws on firearms, and laws on narcotics.