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Associations of neighbourhood sociodemographic characteristics with depressive and anxiety symptoms in older age: Results from a 5-wave study over 15 years

I. Motoc[a,*], E.J. Timmermans[a], D. Deeg[a], B.W.J.H. Penninx[b], M. Huisman[a,c]

[a] Amsterdam UMC, Vrije Universiteit Amsterdam, Department of Epidemiology and Biostatistics, Amsterdam Public Health Research Institute, De Boelelaan 1117, Amsterdam, the Netherlands
[b] Amsterdam UMC, Vrije Universiteit Amsterdam, Department of Psychiatry, Amsterdam Public Health Research Institute, De Boelelaan 1117, Amsterdam, the Netherlands
[c] Vrije Universiteit Amsterdam, Department of Sociology, De Boelelaan 1117, Amsterdam, the Netherlands

ABSTRACT

We examined the long-term association between objective neighbourhood sociodemographic characteristics (index of socioeconomic position (SEP), average income, percent low-income earners, average house price, percent immigrants and urban density) with depressive and anxiety symptoms, covering five 3-year waves of the Longitudinal Aging Study Amsterdam (n = 3,772). Multi-level regression models assessed each neighbourhood-level characteristic separately, adjusting for individual-level covariates. A higher percentage of immigrants and higher urban density, but not other neighbourhood characteristics, were significantly associated with depressive and anxiety symptoms over time in models adjusted for individual SEP. Results of time interaction models indicated that the associations were stable over the 15-year period.

1. Introduction

Evidence indicates that community and neighbourhood characteristics contribute to health (Diez Roux and Mair, 2010), yet the impact on mental health in older populations is less known. In European and associated countries, in adults older than 65 years of age, the 1-year prevalence of a major depressive episode is 6% and of any anxiety disorder is 11.4% (Andreas et al., 2017). The community context may be particularly salient in the lives of older adults. Most older adults spend relatively much of their time past retirement in their neighbourhood (Robert and Li, 2001; Wahl et al., 2009). This leads to longer exposure to their residential environment. According to Glass and Balfour (2003), older adults are more vulnerable to their environment due to physical and mobility decline, cognitive impairment, decreasing social ties and support, and increased fragility (Aneshensel et al., 2007). Additionally, older adults already facing psychosocial stressors are more psychologically vulnerable to suboptimal environmental conditions (Evans, 2003; Iwarsson, 2005).

The majority of studies examining neighbourhood effects are cross-sectional (Mair et al., 2008). However, neighbourhoods and their sociodemographic characteristics are not static. Therefore, these studies might not capture the effects of changing environments on mental health. Longitudinal studies have allowed more complex assessments of the temporal contextual effects of neighbourhoods on mental health (Diez Roux and Mair, 2010). Nevertheless, a neighbourhood characteristic is often assessed only at baseline as opposed to treating it as a time-varying exposure. The association between changes in the neighbourhood environment and health has been less studied, in part due to limited availability of data (Mair et al., 2015). It could be that long-term associations are not stable over time due to fluctuations in the social or physical environment of the neighbourhood, or due to changes in the population of the neighbourhood. The stability of the long-term associations of sociodemographic characteristics and mental health outcomes has not been investigated in old age. This research is essential for informing policy makers and urban planners to develop communities which promote healthy aging (Beenackers et al., 2018). Furthermore, knowledge about associations of sociodemographic characteristics and mental health may contribute to understanding etiological pathways of mental health.

Neighbourhood effects on mental health outcomes can be evaluated in terms of compositional effects (i.e. more older adults with risk factors for mental health outcomes cluster within certain neighbourhoods) and contextual effects (i.e. the neighbourhood has an effect on mental health outcomes) (Cummins et al., 2007). It has been established that beyond personal socioeconomic position (SEP), indicated by an individual's education, income and/or occupation, there is evidence of a modest independent contextual effect of place on health (Pickett and Pearl, 2001). Neighbourhood sociodemographic characteristics,

* Corresponding author. PO Box 7057, 1007 MB, Amsterdam, the Netherlands.
E-mail address: i.motoc@amsterdamumc.nl (I. Motoc).

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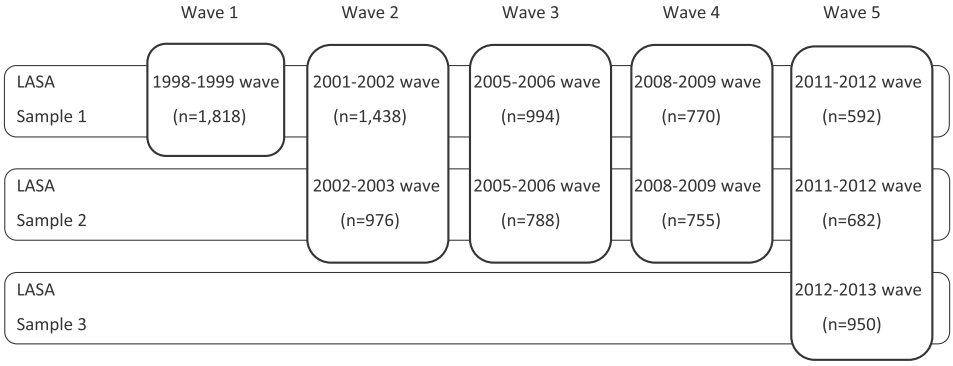

Sample sizes presented are for the starting sample (n=3,772). It is comprised of LASA participants which have data available for at least one outcome and at least one neighborhood characteristic.

Fig. 1. Study design.

neighbourhood SEP (NSEP), percent immigrants in the neighbourhood and urban density of the neighbourhood, might be important determinants of mental health in old age (Julien et al., 2012). NSEP has been the most common neighbourhood characteristic investigated in mental health (Mair et al., 2008). Low SEP neighbourhoods, as compared to high SEP neighbourhoods, are characterized by fewer resources (Ruijsbroek et al., 2016), limited access to basic services and amenities, lower quality housing options, which can be reflected by house prices, and little opportunity for upward economic social mobility. Associations of NSEP with depression have been investigated in several cross-sectional studies (Aneshensel et al., 2007; Kubzansky et al., 2005; Walters et al., 2004; L. E. Wee et al., 2012) and longitudinal studies (Beard et al., 2009; Glymour et al., 2010; Wight et al., 2009). However, the results of these studies are contradicting. In the study by Walters et al. (2004), anxiety was also assessed, and no association was found with NSEP. Neighbourhood SEP has been operationalized in various ways in order to examine contextual effects on individual mental well-being (Schule and Bolte, 2015). It has been operationally defined as a single socioeconomic indicator such as median household income (Galea et al., 2007), percent individuals in the neighbourhood living below the poverty line (Gary-Webb et al., 2011) and average house price (Drukker et al., 2004). More rarely, it has been developed into an aggregate comprised of socioeconomic factors at the neighbourhood level (Aneshensel et al., 2007). So far, findings have generally been more consistent for studies focusing on specific neighbourhood attributes than those focusing on aggregate measures of socioeconomic position or deprivation (Mair et al., 2008). This suggests that studies should investigate both broader NSEP indices in addition to individual characteristics of SEP, such as average income, percent low-income earners and average house price, to evaluate the impact of NSEP on depression and anxiety in old age.

Neighbourhoods with a higher percentage of immigrants may be characterized as neighbourhoods with a relatively large ethnic heterogeneity. Ethnic homogeneity has been reported to be protective of depression when study participants are of the same ethnicity as their community (Ostir et al., 2003). In addition, ethnic heterogeneity has been shown to be associated with a risk of depression (Tweed et al., 1990). Research on the impact of ethnic composition on depression is difficult to summarize since ethnic composition might be a proxy for various positive and negative aspects of neighborhoods (Mair et al., 2008). Moreover, in two aging cohorts, ethnic composition of the neighbourhood was no longer associated with depression after controlling for individual-level characteristics (Aneshensel et al., 2007; Wight et al., 2009). However, besides these studies, results in old age cohorts are lacking.

Highly urbanised areas may contain more pollution and crime, be more segregated or have a larger concentration of low SEP neighbourhoods (Gruebner et al., 2017). Higher urban density has been shown to be associated with negative mental health outcomes (Peen et al., 2010). In a large scale Dutch study, urban-rural differences in mental health indicated that there is a higher prevalence of major depressive disorder and generalized anxiety disorder in urban and semi-urban areas (Zijlema et al., 2015). In a cross-sectional analysis of an aging cohort, population density was associated with depression and with anxiety, after adjusting for individual-level characteristics (Walters et al., 2004).

The aim of the study is to investigate the association of time-varying neighbourhood sociodemographic characteristics (index of NSEP, average income, percent low-income earners, average house price, percent immigrants, urban density) with depressive symptoms and with anxiety symptoms, using longitudinal data assessed over a 15-year study period, in older Dutch adults. Secondly, we will examine if the 15-year association is stable over time.

2. Methods

The Longitudinal Aging Study of Amsterdam (LASA) is an ongoing population-based sample study among Dutch older persons launched in 1992 (Hoogendijk et al., 2016). Participants were selected from 11 municipalities, across three geographic regions in The Netherlands, and comprised of three culturally distinct regions, the protestant north, the catholic south and secular parts. Participants from both urbanized and rural areas within each of these regions were recruited to obtain a nationally representative sample of Dutch adults (Huisman et al., 2011). Starting with the first sample in 1992 (n = 3,107), participants aged 55–85 years at baseline were recruited from municipality registries within three geographic regions and followed up every 3 years. Using the same sampling procedure, face-to-face interviews and self-administered questionnaires, a second LASA sample of respondents, aged 55–64 years old, was launched in 2002 (n = 1,002). A third LASA sample of respondents, aged 55–64 years old, was launched in 2012 (n = 1,023). Our study used data from seven waves collected from 1998 to 2013 which were combined in five waves for this study (Fig. 1). The sample was restricted to participants with at least one outcome measurement and at least one neighbourhood characteristic available (n = 3,772). Anxiety was not collected during the baseline measurement of the second sample evaluated in 2002–2003, hence the anxiety sample is smaller. All respondents received written information on study design and provided written informed consent. The average number of waves per participant analysed was 2.5 examinations for depression analyses and 2.3 examinations for anxiety analyses. Fourteen per cent of participants in the current study had five waves available for analysis, 22% had four waves available, 10% had three waves available, 14% had two waves available and 39% had only one wave available.

2.1. Measures

Depressive symptoms were measured with the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977). The psychometric properties of the Dutch translation were tested in three groups of older persons prior to use of CES-D in LASA. Results were favorable and have been described in detail elsewhere (Beekman et al., 1997). This self-report scale consists of 20 items, measuring the depressive symptoms that the participant experienced in the past week. Each item rated on a four-point scale, ranging from 0: 'rarely or never', to 3: 'mostly or always'. The final score ranges from 0 to 60. Anxiety symptoms were measured with the Anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A) (Zigmond and Snaith, 1983). This subscale consists of seven self-rated items that indicate to what extent the participant felt tense, frightened, worried, relaxed, frightened in the stomach, restless, or had feelings of panic in the past four weeks. Items were scored on a Likert scale ranging from 0: 'rarely or never' to 3: 'mostly or always'. Scores of the item 'feeling relaxed' were reversed. The total anxiety score, the sum of the seven items, ranges from 0 to 21. Higher scores indicate the presence of more anxiety symptoms. Anxiety was not assessed in LASA in the 2002–2003 wave.

Objective neighbourhood sociodemographic characteristics data were obtained from the Geoscience and Health Cohort Consortium (GECCO) project (Timmermans et al., 2018). We investigated a range of neighbourhood characteristics as independent variables: an index of NSEP, average income, percent low-income earners, average house price, percent immigrants and urban density. The index of NSEP has been developed by the Netherlands Institute of Social Research and is based on several individual-level characteristics of the people who live in four-digit postal code areas (Knol, 1998). The average size of a four-digit postal code is 8.3 km^2, including approximately 1,870 households (Timmermans et al., 2018). The index was composed using factor analysis based on the inhabitants' educational level, income, and labor market position. The index is available for the years 1998, 2002, 2006, 2010 and 2014 (The Netherlands Institute of Social Research, 2018). Data for the three years in between these dates (e.g. 1999, 2000, 2001) were interpolated using the formula y = y1 + ((x - x1)/(x2 - x1)) * (y2 - y1). In this formula, y is the unknown index of NSEP and x is the year for which the index of NSEP is to be calculated. The values of y1 and y2 are the values of the index of NSEP for the year before (x1) and after (x2) the year for which the index of NSEP is to be interpolated. A lower index of NSEP indicates a lower neighbourhood SEP status (Knol, 1998).

The data for average income, percent low-income earners, average house price, percent immigrants and urban density in the neighbourhood were obtained from Statistics Netherlands (CBS Statline, 1998, 1999, 2001, 2002, 2003, 2005, 2006, 2008, 2009, 2011, 2012, 2013). These neighbourhood characteristics are aggregates of individual-level characteristics of the people who live in the area of the neighbourhood. The average size of a neighbourhood is 3.1 km^2, encompassing approximately 630 households (Timmermans et al., 2018). The average income in the neighbourhood is operationalized as the average disposable income per capita for the previous year. Starting from 2008, the income concept has been changed from disposable income of persons to personal income at the household level. Percent low-income earners in the neighbourhood was devised as the percent of income recipients earning less than 13,000 euros (the 40 percent point of the national income distribution), per a 52 week income period. The average house price in the neighbourhood measure is an average of the value of dwellings serving as main residence, homes with practice space and recreational homes, per neighbourhood. The average house price from 1997 to 2000 is based on the 1995 value. For the years 2001–2004, the mean house value is the average from the year 1999. Mean prices for 2005 and 2006 are based on the 2003 value of the home and 2007 values are based on the 2005 value. For the years past 2007, average house price is based on the value in the previous year. Percent immigrants in the neighbourhood is the number of non-Western immigrants, from Turkey, Africa, Latin America or Asia, with the exception of Japan and Indonesia, expressed in whole percentages of the population. It is used as an indicator of ethnic heterogeneity of the neighbourhood. Immigrant status in the Netherlands is based on the resident's country of birth and their parents' country of birth (Stronks et al., 2009). A resident is categorized as an immigrant if they were born outside of the Netherlands and at least one parent was born abroad outside of the Netherlands, or if they were born in the Netherlands and at least one parents was born outside of the Netherlands (e.g. CBS Statline, 1998). Urban density of the neighbourhood is measured as the average number of addresses per km^2 within a circle, with a radius of 1 km, around each address in the neighbourhood, averaged over the area of the neighbourhood (Den Dulk, Van De Stadt and Vliegen, 1992). There are five levels for this variable: 1) not urbanized (< 500 addresses/km^2), 2) hardly urbanized (500-1000 addresses/km^2), 3) moderately urbanized (1000-1500 addresses/km^2), 4) strongly urbanized (1500-2500 addresses/km^2), and 5) extremely urbanized (≥ 2500 addresses/km^2).

Potential confounders were age, sex, and individual SEP indicators, education level and income, collected at the individual level. We did not include ethnicity as a covariate since approximately 99% of the sample self-identified as Dutch at baseline. Educational level was entered as number of years which indicate the level of education categorized as: less than elementary, elementary, lower vocational education, general intermediate, intermediate vocational, general secondary education, higher vocational, college, and university. Net monthly household income of participant was collected in 12 categories, ranging from less than €454 to €2270 or more, for the 1998, 2001, 2002 and 2005 waves. For the 2008, 2011 and 2012 waves, net monthly household income of participant was collected in 24 categories, ranging from less than €454 to €5446 or more. In order to make individual income comparable among all respondents, we took the median value of each income category and multiplied this by 0.7 for respondents who indicated that their partner contributed to their monthly income (Kok et al., 2016). For missing income data, the income from the first subsequent measurement that was available, or the first preceding measurement that was available, was substituted. Income values for waves two through five of the study were adjusted for inflation, which was on average 2.7% per year for the 1998–2012 period (CBS The Netherlands Bureau of Statistics, 2012). The median values for each income category (corrected for inflation and presence of partner income) was calculated and expressed per thousand euros.

2.2. Analysis

Depression scores and anxiety scores were natural log transformed (+1) to address skewness. Descriptive statistics were used to examine the distribution of variables in the sample per wave. Pearson correlations were calculated to show the correlations between the neighbourhood characteristics and each characteristic's autocorrelation (with its previous wave). To take into account the correlation of repeated measurements within an individual and the clustering of respondents within the same neighbourhood, random intercept three-level models were assessed by multi-level regression analysis. Level-one units, individual repeated measures, are structured into level-two units, respondents, which are structured into level-three units, neighbourhoods. To consider variation across individuals and neighbourhoods, we included an individual-level random intercept and a neighbourhood-level random intercept in the multi-level model. The regression coefficient calculated by the model has both a between-person and within-person interpretation of the average association between the neighbourhood characteristics and outcome, over the 15-year period analysed. The within-person effect is a result of longitudinal data (i.e. respondents with more than one wave). The between-person effect depends on the number of participants analysed per wave. Therefore 39.2% of

Table 1
Correlations of neighbourhood sociodemographic characteristics over a period of 15 years (1998–2013) based on 8,734 observations with an average 2.4 waves per participant, for the starting sample (n = 3,772).

	Index of NSEP	Average Income	% Low-income	Average House Price	% Immigrants	Urban Density
Index of NSEP	0.86					
Average Income	0.44	0.70				
% Low-income	−0.52	−0.27	0.80			
Average House Price	0.55	0.75	−0.30	0.87		
% Immigrants	−0.66	−0.13	0.32	−0.26	0.96	
Urban Density	−0.36	0.05	0.09	−0.19	0.64	0.95

Diagonal values are the autocorrelation of the neighbourhood characteristic against the lag version of itself.

respondents of the study, who only had one data wave available for analysis, could only contribute to the between-person interpretation of the estimates. The results presented are the back-transformed regression coefficients and their 95% confidence intervals (CIs). Therefore the model coefficient was interpreted as the difference in outcome expected from the 1-unit change in the corresponding sociodemographic characteristic. Level-three units, were denoted by the respondent's neighbourhood. For NSEP analyses, the respondent's four-digit postal code was used to indicate neighbourhood cluster. Each neighbourhood sociodemographic characteristic was analysed separately because of high correlations between the characteristics (Table 1). The association between the neighbourhood characteristic and mental health outcome was adjusted for sex and age in Model 1, and additionally for individual SEP (education and income) in Model 2. Sex and education were added as time-invariant variables to the models. In order to test whether the average 15-year association assessed in Model 2 is stable over the five waves analysed, an interaction term between the neighbourhood characteristic and wave (as continuous time) was added in Model 3. A final model was constructed which included all the neighbourhood characteristics which were significantly associated with the outcome. Finally, the long-term association between neighbourhood characteristics and mental health outcomes among those who have recently moved to the neighbourhood might differ from those living already in the neighbourhood. Therefore we conducted a sensitivity analysis excluding those who recently moved to their current neighbourhood, i.e. moved the same year that they were examined. All analyses were performed in STATA 14. Associations were considered to be statistically significant at $p < 0.05$.

3. Results

Table 1 presents the correlations between neighbourhood sociodemographic characteristics over a period of 15 years. The diagonal line presents the autocorrelation of these characteristics. The autocorrelation values indicate that these neighbourhood characteristics are not static. Percent immigrants and urban density have the highest autocorrelation values (r = 0.95 and r = 0.96) which indicates that these measures fluctuate the least over time. The lowest autocorrelation was found for average income (r = 0.70), indicating that it was the most dynamic neighbourhood characteristic. Index of NSEP was moderately correlated with individual measures of NSEP (r = 0.44 to 0.55) and strongly correlated with percent immigrants (r = 0.66). NSEP was not strongly correlated with urban density (r = 0.05 to 0.36). Average neighbourhood income and average house price were strongly correlated (r = 0.75).

Baseline characteristics of the study sample are shown in Table 2 for each of the five waves analysed. The age across the sample ranges from 54 to 102 years of age. Average individual SEP, education and income, generally increase over time. Mean CES-D scores and HADS-A scores are comparable across waves. Neighbourhood characteristics are dynamic over the five wave period. It reflects both the natural fluctuation in changes in the neighbourhood and also captures neighbourhood differences in characteristics due to participants which have moved from one neighbourhood to another during the time period assessed. Sixty-eight per cent of the neighbourhoods analysed across all waves had between 0 and 10 percent immigrants (results not shown). The proportion of neighbourhoods characterized by urban density level is not static across waves. Over time, some participants moved away to other neighbourhoods in the Netherlands: 854 moves between waves were reported from 570 participants over the study period. Depressive symptoms and anxiety symptoms were highly correlated (r = 0.73) (results not shown).

Table 3 presents associations of neighbourhood sociodemographic characteristics and depression. Index of NSEP and average income in the neighbourhood were not significantly associated with depression in the sample. Percent low-income earners in the neighbourhood and average house price were significantly associated with depression in Model 1. However these associations were no longer significant after adjusting for individual SEP (Model 2). Percent immigrants in the neighbourhood and urban density were significantly associated with depressive symptoms over the 15-year period and remained significant in Model 2. For every 10% difference in immigrants in the neighbourhood, there was a 1.041 [1.030, 1.062] average difference in depressive symptoms over the 15-year period. The coefficient for the time interaction term in Model 3 was not significant (0.999 [0.996, 1.001]). This indicates that the 15-year association found in Model 2 is stable over the 5 waves analysed. Urban density level was associated with depression beyond individual SEP. For every 1-level difference in urban density in the neighbourhood, there was a 1.064 [1.044, 1.085] average difference in depressive symptoms over the 15-year period. In Model 3, the coefficient for the time interaction term was not significant (0.998 [0.996, 1.001]). Therefore the association found in Model 2 is stable over the study period.

Table 4 presents associations of neighbourhood sociodemographic characteristics and anxiety. Index of NSEP, average income, percent low earners and average house price were not associated with anxiety. Percent immigrants in the neighbourhood and urban density were significantly associated with anxiety scores over the 15-year period and remained significant after adjusting for individual SEP. For every 10% difference in immigrants in the neighbourhood, there was a 1.025 [1.008, 1.042] average difference in anxiety symptoms over the 15-year time period. The time interaction term in Model 3 was not significant (0.998 [0.996, 1.001], therefore this association was stable over time. For every difference in urban density level, there was a 1.042 [1.025, 1.060] average difference in anxiety symptoms over the 15-year time period. The time interaction term was not significant (0.998 [0.996, 1.001]), therefore this association was stable over the study period.

In a model adjusting for both percent immigrants and urban density, percent immigrants was no longer significantly associated with mental health outcomes (results not shown). There was a slight attenuation in the coefficients for urban density. For every difference in urban density level in the neighbourhood, there was a 1.051 [1.027, 1.077] average difference in depressive symptoms over 15 years. Similarly, for every difference in urban density level in the neighbourhood there was a 1.032 [1.011, 1.055] average difference in anxiety symptoms over the study period. Therefore a sensitivity analysis explored whether

Table 2
Descriptives of the study participants and the sociodemographic characteristics of the neighbourhoods, by wave, for the starting sample (n = 3,772).

	T_1	T_2	T_3	T_4	T_5
	1998–1999	2001–2003	2005–2006	2008–2009	2011–2013
Individual-Level Characteristics					
Total Sample, n	1,803	2,397	1,775	1,519	2,217
Age, mean (range)	74.1 (60.8–91.6)	69.2 (54.8–94.3)	71.2 (57.7–97.5)	73.0 (60.9–99.0)	68.7 (55.0–102.0)
Sex, % women	55.0	53.9	54.1	54.3	53.4
Education, nr. Years	9.1	9.7	9.9	10.1	10.8
Income, 1000€/month	1,080.1	1,366.1	1,632.1	2,141.7	2,660.7
Ethnicity, % Dutch	99.0	98.6	99.0	99.0	99.0
Depression Sample, n	1,796	2,391	1,771	1,515	2,214
CESD Score, mean (SD)	8.6 (7.5)	8.6 (7.6)	8.3 (7.3)	7.7 (7.2)	7.8 (7.2)
Anxiety Sample, n	1,803	1,420	1,775	1,518	2,215
HADS-A Score, means (SD)	2.8 (3.3)	3.1 (3.2)	3.0 (3.2)	2.8 (3.1)	2.9 (3.2)
Neighbourhood-Level Characteristics					
Index of NSEP	(n = 1,790)	(n = 2,376)	(n = 1,761)	(n = 1,508)	(n = 2,199)
Mean (SD)	−0.4 (0.8)	−0.3 (0.8)	−0.005 (0.9)	0.04 (0.9)	0.2 (0.9)
Average Income	(n = 1,526)	(n = 2,307)	(n = 1,701)	(n = 1,474)	(n = 2,178)
Mean per €1,000, (SD)	10.3 (1.5)	11.9 (2.1)	12.3 (2.0)	21.2 (4.2)	22.1 (4.3)
% Low-income Earners	(n = 1,523)	(n = 2,170)	(n = 1,701)	(n = 1,481)	(n = 2,162)
Mean, (SD)	39.4 (7.0)	39.1 (6.3)	39.5 (5.7)	39.7 (6.4)	40.3 (6.3)
Average House Price	(n = 1,498)	(n = 2,356)	(n = 1,753)	(n = 1,483)	(n = 2,158)
Mean per €10,000, (SD)	8.1 (2.8)	13.6 (4.5)	21.3 (7.1)	25.2 (8.4)	24.0 (8.1)
% Immigrants	(n = 1,354)	(n = 2,262)	(n = 1,753)	(n = 1,511)	(n = 2,195)
Mean (SD)	13.0 (14.5)	11.5 (15.0)	11.8 (15.7)	12.0 (15.6)	12.7 (16.0)
Urban Density	(n = 1,802)	(n = 2,397)	(n = 1,775)	(n = 1,519)	(n = 2,215)
L1: <500 addresses/km^2, %	22.7	16.2	16.1	16.6	12.0
L2: 500 to <1000 addresses/km^2, %	17.5	25.4	25.2	25.5	29.2
L3: 1000 to <1500 addresses/km^2, %	20.1	15.8	18.3	16.7	8.7
L4: 1500 to <2500 addresses/km^2,%	20.4	22.4	22.8	22.5	28.6
L5: >2500 addresses/km^2, %	19.3	20.2	17.7	18.8	21.5

Table 3
Long-term associations of neighbourhood sociodemographic characteristics and depressive symptoms.

	Model 1: Associations adjusted for sex, age and wave b [95% CI]		Model 2: Associations adjusted for sex, age, individual SEP and wave b [95% CI]		Model 3: Associations adjusted for sex, age, individual SEP, wave and wave*neighbourhood characteristic b [95% CI]	
Index of NSEP[a] (n/=/3,736)						
Index of NSEP	0.978	[0.952, 1.006]	0.989	[0.962, 1.016]	0.977	[0.939, 1.017]
index of NSEP*wave					1.001	[0.997, 1.004]
Average Income[b] (n/=/3,657)						
Average Income[g]	0.998	[0.991, 1.005]	1.001	[0.994, 1.009]	0.996	[0.985, 1.006]
average income*wave					0.999	[0.998, 1.001]
% Low-income Earners[c] (n/=/3,619)						
% Low-income Earners[h]	1.004	[1.001, 1.008]	1.003	[0.999, 1.007]	1.004	[0.999, 1.009]
% low-income*wave					0.999	[0.999, 1.001]
Average House Price[d] (n/=/3,670)						
Average House Price[i]	0.999	[0.999, 0.999]	0.999	[0.999, 1.001]	1.001	[0.999, 1.001]
average house price*wave					0.999	[0.999, 0.999]
% Immigrants[e] (n/=/3,623)						
%Immigrants[j]	1.042	[1.023, 1.061]	1.041	[1.030, 1.062]	1.053	[1.026, 1.080]
% immigrants*wave					0.999	[0.996, 1.001]
Urban Density[f] (n/=/3,718)						
Urban density	1.060	[1.040, 1.081]	1.064	[1.044, 1.085]	1.077	[1.051, 1.103]
urban density*wave					0.998	[0.996, 1.001]

[a]Number of observations = 9,610; Average observations per respondent = 2.6; Number of neighbourhoods = 268; Average respondents per neighbourhood = 35.9.
[b]Number of observations = 9,163; Average observations per respondent = 2.5; Number of neighbourhoods = 237; Average respondents per neighbourhood = 38.7.
[c]Number of observations = 9,015; Average observations per respondent = 2.5; Number of neighbourhoods = 236; Average respondents per neighbourhood = 38.2.
[d]Number of observations = 9,226; Average observations per respondent = 2.5; Number of neighbourhoods = 238; Average respondents per neighbourhood = 38.8.
[e]Number of observations = 9,055; Average observations per respondent = 2.5; Number of neighbourhoods = 235; Average respondents per neighbourhood = 38.5.
[f]Number of observations = 9,427; Average observations per respondent = 2.5; Number of neighbourhoods = 243; Average respondents per neighbourhood = 38.8.
[g]Per 10,000 euros.
[h]Per 10% of low-income earners in the neighbourhood.
[i]Per 100,000 euros.
[j]Per 10% immigrants in the neighbourhood.

Table 4
Long-term associations of neighbourhood sociodemographic characteristics and anxiety symptoms.

	Model 1: Associations adjusted for sex, age and wave b [95% CI]		Model 2: Associations adjusted for sex, age, individual SEP and wave b [95% CI]		Model 3: Associations adjusted for sex, age, individual SEP, wave and wave*neighbourhood characteristic b [95% CI]	
Index of NSEP[a] (n/=/3,622)						
Index of NSEP	0.989	[0.965, 1.015]	0.996	[0.970, 1.021]	0.968	[0.931, 1.005]
index of NSEP*wave					1.003	[0.999, 1.007]
Average Income[b] (n/=/3,546)						
Average income[g]	1.001	[0.995, 1.008]	1.004	[0.997, 1.010]	0.994	[0.985, 1.004]
average income*wave					0.999	[0.999, 1.001]
% Low-income Earners[c] (n/=/3,530)						
% Low-income earners[h]	1.001	[0.998, 1.005]	1.001	[0.998, 1.004]	1.003	[0.999, 1.008]
% low-income*wave					1.000	[0.999, 1.001]
Average House Price[d] (n/=/3,556)						
Average house price[i]	0.999	[0.999, 1.001]	0.999	[0.999, 1.001]	1.001	[0.999, 1.001]
average house price*wave					0.999	[0.999, 0.999]
% Immigrants[e] (n/=/3,508)						
%Immigrants[j]	1.026	[1.010, 1.042]	1.025	[1.008, 1.042]	1.041	[1.016, 1.066]
% immigrants*wave					0.998	[0.996, 1.001]
Urban Density[f] (n/=/3,603)						
Urban density	1.040	[1.023, 1.058]	1.042	[1.025, 1.060]	1.055	[1.032, 1.080]
urban density*wave					0.998	[0.996, 1.001]

[a]Number of observations = 8,660; Average observations per respondent = 2.4; Number of neighbourhoods = 269; Average respondents per neighbourhood = 32.2.
[b]Number of observations = 8,250; Average observations per respondent = 2.3; Number of neighbourhoods = 238; Average respondents per neighbourhood = 34.7.
[c]Number of observations = 8,233; Average observations per respondent = 2.3; Number of neighbourhoods = 236; Average respondents per neighbourhood = 34.9.
[d]Number of observations = 8,275; Average observations per respondent = 2.3; Number of neighbourhoods = 238; Average respondents per neighbourhood = 34.8.
[e]Number of observations = 8,102; Average observations per respondent = 2.3; Number of neighbourhoods = 235; Average respondents per neighbourhood = 34.5.
[f]Number of observations = 8,470; Average observations per respondent = 2.4; Number of neighbourhoods = 244; Average respondents per neighbourhood = 34.7.
[g]Per 10,000 euros.
[h]Per 10% of low-income earners in the neighbourhood.
[i]Per 100,000 euros.
[j]Per 10% immigrants in the neighbourhood.

including participants who moved to the neighbourhood less than one year prior to their examination (n = 65), led to a biased sample since a recent move could be due to the outcomes investigated. Results were similar to those of the full sample (results not shown). This indicates that the associations presented in the main analysis were not affected by those that recently moved into the neighbourhood.

4. Discussion

We investigated the association between neighbourhood sociodemographic characteristics and mental health outcomes in a representative sample of Dutch older adults. Our results demonstrate that measures of NSEP are not associated with mental health outcomes over a 15-year period. Urban density and percent immigrants were significantly associated with depression and with anxiety over 15 years, in models adjusted for individual SEP. Neighbourhoods characterized by higher percentage of immigrants and higher urban density are associated with higher depression scores and with higher anxiety scores. Percent immigrants was no longer associated with mental health outcomes in a model including both neighbourhood characteristics. Nevertheless, the associations between urban density and mental health outcomes were only slightly attenuated.

Our results demonstrate that neither an index of NSEP nor single NSEP measures are associated with mental health outcomes over a long period of time in old age. These null findings are in contrast to previous research in which effects of area-level SEP on depression have been found. Several studies found that for older adults, living in a poor neighbourhood was associated with higher levels of depressive symptoms, above and beyond individual circumstances (Beard et al., 2009; Kubzansky et al., 2005; Liang En Wee et al., 2014). Corresponding with our findings, some studies have found that after controlling for individual SEP, depression and NSEP were no longer associated in old age (Aneshensel et al., 2007; Walters et al., 2004). Similar results were found when examining average change over time in depressive symptoms (Wight et al., 2009) and the incidence of depression (Glymour et al., 2010). Similar to our findings, NSEP was not associated with anxiety in an aging cohort in a previous study (Walters et al., 2004). NSEP measures are aggregates of SEP measures of the individuals living in a particular neighbourhood. In our study, the neighbourhood measures were objectively assessed, i.e. neighbourhood SEP is based on the aggregated SEP of its residents and not the SEP of the LASA respondents. Nonetheless the SEP of the individuals in a neighbourhood is highly correlated with the SEP of their neighbourhood (Pickett and Pearl, 2001). In an earlier study we showed that LASA respondents showed little discrepancy in terms of income, with their neighbourhood SEP (Deeg and Thomése, 2005). Therefore these measures are not independent. This could explain that for percent low-income earners and average house price, the significant association with depression found initially was nullified once we adjusted for individual SEP.

In our study, percent immigrants in the neighbourhood, used as an indicator for neighbourhood ethnic heterogeneity, was associated with depression and with anxiety over time. Percent immigrants in our study refers to percent non-Western immigrants, i.e. residents classified, according to their and their parents' country of birth. The Statistics Netherlands country of birth classification highly correlates with self-reported ethnicity (Stronks et al., 2009). Ethnic composition has ethnic-specific effects on mental health (Erdem et al., 2017). Studies investigating the ethnic/racial composition of neighbourhoods have focused on the impact it has on depression in specific ethnic/migrant groups, using the native population as the reference group. However, this work cannot inform our results since the study participants belong to the native population. Furthermore, the 'group conflict theory' states that ethnically heterogeneous neighbourhoods introduce a feeling of anxiety between minorities and majority groups due to resource competition (real or perceived), social identity and relative positions of power and status (Cea D'Ancona, 2018). If older people who live in

neighbourhoods with a high percentage of immigrants view themselves as the outgroup, they could experience anxiety through these pathways. Conversely the 'contact theory' explains that bringing groups in contact minimizes stereotypes (Sturgis et al., 2014). However, diversity does not necessarily imply contact between different groups. Neighbourhoods can be integrated (social contact and interaction between groups) or segregated (social contact between groups is minimized). The level of segregation has an impact on social processes such as social cohesion. These processes may be particularly important in old age. For example, less socially cohesive neighborhoods have been associated with increased depression in old age (Echeverria et al., 2008). Additionally, the 'ethnic density hypothesis' explains that for persons of a given ethnicity, rates of mental disorder decrease as the number of persons of similar ethnicity, living in their neighbourhood, increases (Becares et al., 2018; Henderson et al., 2005). This could be due to increased social cohesion, mutual social support and a stronger sense of community and belongingness (Becares, 2014). These potential explanations are based on reasoning from existing theories, but we did not have the data available to actually test these mechanisms.

Urban density has been shown to be associated with physical and social factors such as air pollution, noise pollution, neighbourhood disadvantage, and a higher concentration of immigrants (Gruebner et al., 2017; Stirbu et al., 2006). Lower neighbourhood safety, higher neighbourhood noise and more air pollution increase the risk of depression in old age (Barnett et al., 2018). Therefore high urban density neighborhoods characterized by these indicators could explain the long-term associations between urban density and mental health outcomes found. In the Netherlands, residents living in urban neighbourhoods, defined as those areas with more than 1,500 addresses per km^2, are exposed to higher levels of air pollution and traffic noise than those living in rural areas (Timmermans et al., 2018). In a sensitivity analysis, we investigated the association between mental health outcomes and urban density, adjusted individually for safety (The Netherlands Ministry of the Interior and Kingdom Relations), noise (The Netherlands Environmental Assessment Agency) and air pollution (Eeftens et al., 2012). We found that safety, noise and air pollution are strongly correlated with urban density (r = 0.5 to 0.8). In models adjusted for safety and air pollution, the coefficients for urban density were attenuated. The addition of noise to the model did not change the association between urban density and mental health outcome. However, because we did not have complete data available for the period of the study, we could not properly test these mechanisms. Regardless, the spatial variation in environmental stressors, such as pollution, could explain the spatial concentration of depression and anxiety ('breeder hypothesis') (Verheij, 1996), which should be investigated in further empirical research.

The mechanisms underlying the link between context and health operate at the neighbourhood level and individual level. At the individual level, stress, in various forms, can result in dysregulation in multiple biological systems and increasing the risk of anxiety and depression (Lynch et al., 2004; Magalhaes et al., 2010). At the neighbourhood level, the social and material environment gives way to triggers, stressors and/or protectors which can affect mental health, beyond individual factors (Diez Roux and Mair, 2010; Matheson et al., 2006). On the positive side, highly urbanised areas are places in which people can come into contact with one another often and this could have a positive impact on mental health.

In the model including simultaneously percent immigrants and urban density, only urban density remained significantly associated with depression and anxiety. In the Netherlands, the percentage of immigrants is higher in urban neighbourhoods compared to rural areas (Timmermans et al., 2018), i.e. these indicators are highly correlated. Urban density and percent immigrants may ultimately reflect similar underlying social environment factors which are associated with mental health. Furthermore, urban density may capture the effects of additional physical environmental factors, such as pollution. This indicates the need for greater understanding of the role of these environments, as well as into the social processes and physical environmental conditions, which are found in neighbourhoods characterized by high urban density.

One of the strengths of this study is the usage of 15-year longitudinal data. Repeated measures allowed assessing these long-term associations within-persons and between-persons concurrently. Furthermore, we were able to investigate the stability of long-term associations and demonstrate that these are stable over the five time points analysed. We accounted for the clustering of participants in neighbourhoods and the correlation of individual measurements by using multi-level models. The study sample was large and it is representative of older adults in the Netherlands. Using a composite NSEP variable in addition to individual measures of NSEP, facilitated a comprehensive analysis of the impact of NSEP on mental health outcomes. A sensitivity analysis performed excluded new-comers to the neighbourhood who might have moved recently due to mental health issues. The results of the sensitivity analysis were similar to the full sample therefore the results presented are not influenced by participants whose mental health status has dictated their place of residence. One of the limitations of the study is that not every participant had five waves available for analysis. Participants of the third LASA sample had only one wave available for analysis, however it was still valuable to add this sample to the analysis since it reflects between-persons effects. Additionally, the current study design does not account for lagging effects of exposure. Nonetheless the high autocorrelations of neighbourhood variables indicate that these exposures might not change greatly over time, indicating that the long-term associations found are a good indication of the overall contextual effect of urban density and percent immigrants.

5. Conclusion

The long-term associations of sociodemographic neighbourhood characteristics with mental health in old age are particularly important as individuals age in their neighbourhood. These characteristics could be proxies of social processes or physical environmental conditions which are relevant to depression and anxiety. Our results indicate that percentage immigrants and urban density, not NSEP, are associated with depression and with anxiety in older Dutch individuals over 15 years. These long-term associations were stable over the five waves analysed. More research is needed to investigate which underlying aspects of urban density and ethnic composition are driving the long-term associations with depression and anxiety in old age.

Declarations of interest

None.

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Availability of data and material

Access to data from the Longitudinal Aging Study Amsterdam can be requested by submitting a LASA analysis proposal form for evaluation. The LASA evaluation committee provides access to the data on the condition that the goals of the data request are in keeping with the overarching aims of LASA that its participants have provided consent for. The LASA analysis proposal template includes the option to request data for replication purposes. The template of the analysis proposal form can be obtained at www.lasa-vu.nl, or by sending a request to the LASA secretariat, f.kursun@amsterdamumc.nl. Analysis proposals can be submitted to the LASA secretariat.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2019.102172.

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