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Loneliness and neighbourhood characteristics:

A multi-informant, nationally-representative study of young adults

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Abstract

Objective: To investigate associations between the characteristics of the neighbourhoods young adults live in and their feelings of loneliness, using data from different sources.

Method: Data were drawn from the Environmental Risk Longitudinal Twin Study. Loneliness was measured via self-reports at ages 12 and 18, and also by interviewer ratings at age 18.

Neighbourhood characteristics were assessed between ages 12 and 18 via government data, systematic social observations, a resident survey, and participants' self-reports.

Results: Greater loneliness was associated with perceptions of lower collective efficacy and greater neighbourhood disorder, but not with more objective measures of neighbourhood characteristics. Lonelier individuals perceived the collective efficacy of their neighbourhoods to be lower than did their less lonely siblings who lived at the same address.

Conclusion: These findings suggest that feelings of loneliness are associated with negatively-biased perceptions of neighbourhood characteristics, which may have implications for lonely individuals' likelihood of escaping loneliness.

Keywords: loneliness, social isolation, neighbourhood, collective efficacy, social cohesion

Loneliness and neighbourhood characteristics: A multi-informant, nationally-representative study of young adults

Loneliness is defined as a form of ‘social pain’ that arises when individuals perceive the quality or quantity of their social connections to be wanting (Cacioppo & Hawkley, 2009). This applies to shortcomings not only in dyadic social relationships, but also in the relationships between individuals and larger social entities, such as local communities (Hawkley, Browne & Cacioppo, 2005). These relationships are embedded within, and are shaped by, a wider social structural context which includes features of the neighbourhood environment, such as urbanicity, crime, inequality and social cohesion (Berkman, Glass, Brissette & Seeman, 2000). For instance, high levels of crime in an area could undermine trust between neighbours and lead them to feel alienated from each other, while high social cohesion could foster stronger feelings of trust and belongingness. To the extent that the characteristics of a neighbourhood influence, for better or worse, the social ties that form between its residents, this may have implications for the extent to which they feel lonely (Kearns, Whitley, Tannahill & Ellaway, 2015). Increasingly, initiatives to reduce loneliness have placed an emphasis on intervention at the community level, including some neighbourhood-based approaches (Collins & Wrigley, 2014; Jopling, 2015). Understanding how the structural and social characteristics of the neighbourhoods in which communities operate are related to feelings of loneliness can have important implications for policy and interventions.

Recent discussions have focused on the trend of migration towards urban areas (United Nations, 2014), and the implications of city living for mental health (Peen, Schoevers, Beekman & Dekker, 2010). Despite the fact that people are increasingly living closer together, the issue of loneliness continues to grow as a public health concern (Holt-Lunstad, 2018). The notion of the

'lonely city' has been the focus of much popular writing in recent years (e.g. Laing, 2016). In the scientific literature, meanwhile, research on loneliness has traditionally placed an emphasis on older adults living in rural settings (De Koning, Stathi & Richards, 2017; Dugan & Kivett, 1994; Savikko, Routasalo, Tilvis, Strandberg & Pitkälä, 2005). However, new findings indicate that loneliness is most common among younger adults (Mental Health Foundation, 2010; Office for National Statistics, 2018). As individuals transition from the school environment to adult life, spaces in the neighbourhood such as parks, shopping malls, sports facilities and community centres could play an increasing role as settings for social contact. Together, these findings suggest that efforts to reduce loneliness in modern society can be strengthened by extending the focus of research to include the young and those living in urban settings. Some features of the neighbourhood, meanwhile, may increase loneliness irrespective of rurality versus urbanicity. For instance, feelings of loneliness among individuals living in deprived urban areas have been associated with higher reported rates of antisocial behaviour in the neighbourhood, lower perceived collective efficacy (a combination of social cohesion and the willingness of residents to intervene in the behaviour of others for the common good), lower safety, and poorer subjective neighbourhood quality (Scharf & de Jong Gierveld, 2008; Kearns et al, 2015).

To determine whether neighbourhood features *per se* influence loneliness, or instead are simply correlated features, it is important to rule out potential sources of bias that could yield spurious associations. First, potential reporting biases associated with mental health problems such as depression, and personality traits such as neuroticism – both of which are associated with loneliness in young people (Vanhalst, Klimstra, Luyckx, Scholte, Engels & Goossens, 2012) – signify a need to control for these confounders. Second, although the objective characteristics of the neighbourhood may exert an effect on individuals' feelings of loneliness, it is also possible

that loneliness itself may dispose individuals to perceive their neighbourhood in a more negative light. Loneliness is associated with biases in cognition including negative appraisals of social interactions and exaggerated vigilance for threat (Cacioppo & Hawkey, 2009). It is possible, therefore, that individuals who feel alienated from those around them may evaluate the closeness or safety of their neighbourhood in a negatively-biased manner. If this is the case, relying solely on self-reported data on loneliness and neighbourhood characteristics could be misleading, and interventions targeted at the neighbourhood level may not be effective at reducing loneliness.

The aim of the present study was to investigate how aspects of the neighbourhoods young adults live in relate to their feelings of social disconnection, using a contemporary, nationally-representative cohort of United Kingdom residents. By integrating multiple sources of data on neighbourhood characteristics, we scrutinised the robustness and specificity of associations between loneliness and different characteristics of the neighbourhood. These data allow for novel and valuable insights into the purported epidemic of loneliness, and suggest targets for policy initiatives to tackle loneliness in society.

Method

Participants

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin Study, which tracks the development of a birth cohort of 2,232 British children. The sample was drawn from a larger birth register of twins born in England and Wales in 1994-1995 (Trouton, Spinath & Plomin, 2002). Full details about the sample are reported elsewhere (Moffitt and E-Risk Study Team, 2002). Briefly, the E-Risk sample was constructed in 1999-2000, when 1,116 families (93% of those eligible) with same-sex 5-year-old twins participated in home-visit assessments.

This sample comprised 56% monozygotic (MZ) and 44% dizygotic (DZ) twin pairs; sex was evenly distributed within zygoty (49% male). 90% of participants were of white ethnicity.

Families were recruited to represent the UK population with newborns in the 1990s, to ensure adequate numbers of children in disadvantaged homes and to avoid an excess of twins born to well-educated women using assisted reproduction. The study sample represents the full range of socioeconomic conditions in Great Britain, as reflected in the families' distribution on a neighbourhood-level socioeconomic index (ACORN [A Classification of Residential Neighbourhoods], developed by CACI Inc. for commercial use) (Odgers, Caspi, Bates, Sampson & Moffitt, 2012; Odgers, Caspi, Russell, Sampson, Arseneault & Moffitt, 2012). Specifically, E-Risk families' ACORN distribution matches that of households nation-wide: 25.6% of E-Risk families live in "wealthy achiever" neighbourhoods compared to 25.3% nationwide; 5.3% vs. 11.6% live in "urban prosperity" neighbourhoods; 29.6% vs. 26.9% live in "comfortably off" neighbourhoods; 13.4% vs. 13.9% live in "moderate means" neighbourhoods, and 26.1% vs. 20.7% live in "hard-pressed" neighbourhoods. E-Risk underrepresents "urban prosperity" neighbourhoods because such houses are likely to be childless.

Follow-up home visits were conducted when the children were aged 7 (98% participation), 10 (96%), 12 (96%), and at 18 years (93%). There were 2,066 children who participated in the E-Risk assessments at age 18, and the proportions of MZ (55%) and male same-sex (47%) twins were almost identical to those found in the original sample at age 5. The average age of the twins at the time of the assessment was 18.4 years ($SD = 0.36$); all interviews were conducted after their 18th birthday. There were no differences between those who did and did not take part at age 18 in terms of socioeconomic status (SES) assessed when the cohort was initially defined ($\chi^2 = 0.86, p = 0.65$), age-5 IQ scores ($t = 0.98, p = 0.33$), or age-5 emotional or

behavioural problems ($t = 0.40, p = 0.69$ and $t = 0.41, p = 0.68$, respectively). 49% of participants at age 18 were educated to A-Level (the school leaving qualification in the United Kingdom) while 29% had GCSEs at grade A*-C as their highest qualification (obtained at approximately 14-16 years). 71% of participants were currently studying and 57% were in work. 12% were neither in education or work at the time of the assessment.

Home visits at ages 5, 7, 10, and 12 years included assessments with participants as well as their mother (or primary caretaker). The home visit at age 18 included interviews only with the participants. The Joint South London and Maudsley and the Institute of Psychiatry Research Ethics Committee approved each phase of the study. Parents gave informed consent and twins gave assent between 5-12 years and then informed consent at age 18.

Measures

Self-reported loneliness in young adulthood

Loneliness was assessed when participants were 18 using four items from the UCLA Loneliness Scale, Version 3 (Russell, 1996): “How often do you feel that you lack companionship?”, “How often do you feel left out?”, “How often do you feel isolated from others?” and “How often do you feel alone?” A very similar short form of the UCLA scale has previously been developed for use in large-scale surveys, and correlates strongly with the full 20-item version (Hughes, Waite, Hawkey & Cacioppo, 2004). The scale was administered as part of a computer-based self-complete questionnaire. Interviewers were blind to participants’ responses. The items were rated “hardly ever” (0), “some of the time” (1) or “often” (2). Items were summed to produce a total loneliness score from 0-8 ($\alpha = 0.83$).

Interviewer ratings of loneliness in young adulthood

After the age-18 home visits, interviewers completed a set of questions about their impressions of the participants, based on observations made during the interview. Three items from these questionnaires related to feelings of loneliness (“seems lonely”, “feels that no one cares for them” and “has trouble making friends”), and were used to derive interviewer ratings of loneliness. Items were coded “No” (0), “A little/somewhat” (1) and “Yes” (2), and summed to create a scale ($\alpha = 0.70$). Interviewers were blind to participants’ responses to the self-complete loneliness measure.

Self-reported loneliness in childhood

A measure of loneliness in childhood was derived using three items from the Children’s Depression Inventory (CDI; Kovacs, 1992), completed when participants were aged 12. Each item was presented as a set of three statements, and participants were instructed to select the statement that described them best: (1) “I do not feel alone”, “I feel alone many times” or “I feel alone all the time”; (2) “I have plenty of friends,” “I have some friends but I wish I had more” or “I do not have any friends”; and (3) “Nobody really loves me”, “I am not sure if anybody loves me”, “I am sure that somebody loves me”. Items were coded 0 to 3 and summed to produce a scale from 0-6 ($\alpha = 0.48$). Loneliness showed moderate stability from age 12 to age 18 ($r = 0.25$).

As the items used in this measure originated from an instrument designed to assess depression, the remaining items of the CDI were summed to produce a depressive symptom scale ($\alpha = 0.75$). This scale was entered as a covariate in analyses using the childhood loneliness measure, in order to account for the shared variance between them.

Neighbourhood characteristics

Extremely high-resolution data on neighbourhood characteristics were collected when participants were between the ages of 12 and 18 (Newbury, Arseneault, Caspi, Moffitt, Odgers, Baldwin, Zavos & Fisher, 2017). All neighbourhood measures were linked to the postcodes of participants' current home addresses, meaning that participants were truly embedded in the neighbourhood milieu represented by the measures. Neighbourhoods were coded as 'urban', 'intermediate' or 'rural' based on the Office for National Statistics' (ONS) Rural-Urban Definition for Small Area Geographies (RUC2011) classifications. At age 18, 32% of participants lived in urban areas, 48% in intermediate areas, and 20% in rural areas.

Measures of neighbourhood characteristics were grouped in four categories based on the source of the data:

Government data included neighbourhood socioeconomic status (based on ACORN category), population density (number of people in a 0.5 mile radius from the address, according to ONS figures), and violent crime rates within a 1-mile radius from the home address (obtained via an online data sharing resource operated by the UK Police; <https://data.police.uk>).

Systematic social observations were carried out by trained raters using Google's Street View tool to conduct a virtual 'walk' around participants' neighbourhoods when participants were aged 15-16 (Odgers, Caspi, Bates et al, 2012). Using systematic social observation measures adapted for the virtual context, raters coded the neighbourhood for physical decay, physical disorder and street safety, each on a 5-point scale. Ratings showed good inter-rater agreement (ICC's = 0.48 – 0.84), and good correspondence with ACORN ratings of deprivation (r 's = 0.30 - 0.47).

A *resident survey* was carried out when participants were aged 13-14, among households with the same postcode area as the participants' homes. Surveys were distributed via post to all households in the postcode area that were registered on the electoral roll (with the exception of participants' households). On average, 5 completed surveys were returned per neighbourhood. At least 3 surveys were returned for 80% of neighbourhoods, and at least 2 were returned for 95% of neighbourhoods. Survey measures included residents' ratings of neighbourhood safety, neighbourhood disorder, and collective efficacy. Scores were averaged across respondents within each neighbourhood to create summary scores for each participant.

Self-reports of neighbourhood characteristics were collected via face-to-face interviews with participants at age 18. Collective efficacy was measured via a 10 item measure of social control and social cohesion (Sampson, Raudenbush & Earls, 1997). These included questions about the likelihood that neighbours would intervene if, for example, "children were spray-painting graffiti on a local building", and level of agreement with statements such as "mine is a close-knit" neighbourhood (coded 1-5). Neighbourhood problems were measured by asking participants if certain types of disorder were a problem in their area, such as "litter, broken glass, rubbish in public places" and "groups of young people hanging out and causing trouble" (coded 0-2). Items were summed to produce scales of perceived collective efficacy and neighbourhood problems.

Summary statistics of the loneliness and neighbourhood measures are shown in Table 1.

Covariates

Participants were assessed for symptoms of depression at age 18 via a structured interview, based on the criteria in the Diagnostic and Statistical Manual of Mental Disorders, 5th

edition (American Psychiatric Association, 2013). Neuroticism was measured via a child version of the Big Five Inventory, completed by interviewers following the home visit (John & Srivastava, 1999). As the sample consisted of twin pairs, participants were also asked if they were currently living with their co-twin at the time of the interview. This information was used firstly to control for the potential effect of being separated in adulthood on loneliness (which could be stronger in twins than in conventional sibling pairs), and also to derive a subgroup of cohabiting twins for the sibling control analyses.

Data analysis

Associations between loneliness and neighbourhood characteristics

To test associations between loneliness and neighbourhood characteristics, we conducted regression analyses in Stata Version 15 (StataCorp, 2017), using the `vce(cluster)` option to adjust for the non-independence of observations in twin data (Williams, 2000). In the first step, we regressed loneliness on each neighbourhood characteristic individually, while controlling for gender and SES. In the second model, we controlled additionally for depression and neuroticism, and whether the participant lived with their co-twin. The neighbourhood measures were collected at various different time points between the ages of 12 and 18, during which time 591 (29%) of participants interviewed at age 18 had moved home at least once. This high rate of mobility may be partially explained by some participants having already moved away to university at age 18. Consequently, for these participants, some of the measures collected between ages 12 and 18 referred to different neighbourhoods. Therefore, in the third model we controlled for whether the participants had moved between ages 12 and 18. Finally, in the fourth model, we restricted the analyses to a sub-set of participants who had lived at the same address throughout this period (N = 1,475). Residential mobility was correlated with low SES, female sex, childhood externalising

problems, and young adult loneliness, and therefore the excluded participants differed from this subset in terms of several important risk factors. Therefore, inverse probability weighting was used in model 4 to correct for bias introduced by excluding these participants.

Co-twin control analyses

To test for a potential response bias in the self-report neighbourhood measures, a sibling control method was used to compare the reports of twins who lived together in the same home, thus holding the effects of the neighbourhood constant by design. This involves computing a within-twin pair difference score, by subtracting one twin's loneliness score from that of their co-twin, and doing the same for their ratings of collective efficacy and neighbourhood disorder. These difference scores represent variance explained by genetic differences and unique environmental exposures, but not by environmental effects that are shared between siblings (such as the neighbourhood). Thus, if within-twin pair differences in loneliness correlate with within-pair differences in their ratings of these neighbourhood characteristics, this association cannot be explained by the neighbourhood itself, but by other factors that influence individuals' perceptions of the neighbourhood.

Sensitivity analyses

Differential reporting of neighbourhood characteristics by lonely versus non-lonely siblings living in the same home would be consistent with a bias being present in self-report data. However, this would not in itself convey whether loneliness itself is the source of bias or whether other, methodological sources of bias are responsible. For instance, the association between self-reports of loneliness and neighbourhood perception could be inflated by shared-method variance. This can be partially addressed by assessing loneliness via sources other than

self-reports. Independent observers have been shown to rate other people's loneliness with reasonable accuracy (Luhmann, Bohn, Holtmann, Koch & Eid, 2016), indicating that there is potential value in taking a multi-informant approach to measuring loneliness. Therefore, to test whether associations between the self-reported neighbourhood characteristics and loneliness are inflated by shared reporter method variance, the regression analyses of these associations were repeated using interviewer reports of participants' loneliness.

A further source of bias could be the time lag between measures. Loneliness and self-rated neighbourhood perceptions were collected concurrently, whereas other measures of the neighbourhood were collected up to 6 year earlier. This could lead to unfair comparisons being made, with stronger effects emerging for the cross-sectional associations, and more temporally-distal associations being underestimated. One way to address this is by using data on loneliness collected on different occasions, to test whether the cross-sectional associations are replicated when using measures administered at different times. Therefore, as a further sensitivity analysis, the associations between loneliness and neighbourhood characteristics were tested again with early adolescence loneliness (age 12) substituted for the age-18 measure.

Results

Associations between loneliness and neighbourhood characteristics

Mean scores of loneliness did not differ significantly between individuals living in urban, intermediate and rural neighbourhoods (1.53, 1.60 and 1.59, respectively; $p = 0.84$). Furthermore, measures of neighbourhood characteristics captured via independent sources such as government data, systematic social observations and resident surveys were not associated with loneliness in young adulthood (Table 2, Model 1). In contrast, self-reports of neighbourhood

social conditions were significantly associated with loneliness: higher self-reported collective efficacy was associated with lower loneliness ($\beta = -0.18, p < 0.001$), while higher self-reported neighbourhood disorder was associated with higher loneliness ($\beta = 0.10, p < 0.001$).

Loneliness was associated with greater depressive symptoms ($\beta = 0.41, p < 0.001$) and higher neuroticism ($\beta = 0.27; p < 0.001$). Furthermore, participants who lived with their co-twins were less lonely ($\beta = -0.08, p = 0.003$). When these covariates were controlled for, self-reported collective efficacy and neighbourhood disorder remained significantly associated with loneliness ($\beta = -0.14, p < 0.001$ and $\beta = 0.05, p < 0.001$; Table 2, Model 2). Supplementary Tables S1 and S2 show the attenuation of the associations when each individual covariate was added to the model.

Participants who had moved home between the ages of 12 and 18 were also lonelier on average ($\beta = 0.07, p = 0.01$). Controlling for this did not attenuate the associations between self-reports of neighbourhood characteristics and loneliness (Table 2, Model 3). When the sample was restricted to participants who had lived in the same neighbourhood between ages 12 and 18, the associations between self-reported collective efficacy and loneliness remained significant ($\beta = -0.04, p < 0.001$), as did the association between self-reported neighbourhood disorder and loneliness ($\beta = 0.04, p = 0.03$).

Co-twin control analyses

Among cohabiting twin pairs, within-pair differences in loneliness were significantly associated with differences in self-reported collective efficacy ($\beta = -0.11, p = 0.006$), indicating that lonelier individuals perceived lower collective efficacy in their neighbourhoods compared to their less lonely siblings who lived in the same neighbourhood (Figure 1). That is, loneliness was

associated with lower perceived levels of collective efficacy even after holding actual neighbourhood conditions constant by design. This association remained robust when controlling for twin differences in depression ($\beta = -0.12$, $p = 0.004$) and in neuroticism ($\beta = -0.11$, $p = 0.006$). However, twin differences in loneliness were not associated with differences in self-reported neighbourhood disorder ($\beta = 0.06$, $p = 0.12$). That is, lonely and non-lonely siblings perceived comparable levels of disorder in the same neighbourhood, suggesting that the correlation between these variables is partly explained by environmental exposures shared by siblings in a family (including the neighbourhood).

Sensitivity analyses

The interviewer ratings of participants' loneliness were not associated with the independently measured neighbourhood characteristics (Table 3). They were, however, associated with participants' self-reports of collective efficacy ($\beta = -0.19$, $p < 0.001$) and neighbourhood disorder ($\beta = 0.12$, $p < 0.001$). This indicates that the association between self-reported loneliness and perceived collective efficacy was not due to shared method variance arising from the use of a single informant in the analyses above. These associations remained when controlling for covariates (collective efficacy: $\beta = -0.13$, $p < 0.001$; neighbourhood disorder: $\beta = 0.05$, $p = 0.02$). Similarly, loneliness at age 12 was not associated with any of the neighbourhood characteristics measured via government data, systematic social observations or resident surveys (Table 3). However, it was associated with lower self-reported collective efficacy at age 18 ($\beta = -0.13$, $p < 0.001$). This indicates that the pattern of significant and non-significant associations found for loneliness at age 18 was not due to self-reported neighbourhood characteristics being measured at the same age, while the other measures were more temporally distal from the loneliness measure. The association between childhood

loneliness and perceived collective efficacy was robust to covariates ($\beta = -0.11$, $p < 0.001$), and to the childhood depression scale containing the remaining items of the CDI ($\beta = -0.05$, $p = 0.01$). An association was also found between childhood loneliness and perceived neighbourhood disorder in young adulthood ($\beta = 0.10$, $p < 0.001$). This association was robust to the age-18 covariates ($\beta = 0.07$, $p = 0.01$); however, it became non-significant when controlling for the childhood depression scale ($\beta = 0.02$, $p = 0.30$).

Discussion

The findings of this study reveal that among young adults, loneliness occurs equally within many different types of neighbourhoods, irrespective of urbanicity, population density, deprivation or crime. This complements previous findings in this sample which indicated that loneliness among young people is an indiscriminate phenomenon that shows no gender difference and no socioeconomic gradient (Matthews, Danese, Odgers, Goldman-Mellor, Caspi, Moffitt & Arseneault, 2018). Despite the consistent pattern of null associations when looking at objective measures of the neighbourhood, lonelier individuals viewed their neighbourhoods as having lower collective efficacy (i.e. trust, cohesion and control) and greater neighbourhood disorder (i.e. physical and social signs of threat), even though surveys of other residents in the neighbourhood did not corroborate this perception. Prior studies have also found associations between loneliness and more negative self-reports of neighbourhood characteristics (Bromell & Cagney, 2014; Scharf & de Jong Gierveld, 2008; Kearns et al, 2015). This study extends these findings by using a multi-informant approach to address the potential for a bias effect when relying only on self-report data.

The disparity between self-reports and more independent or objective sources of data suggests that lonelier individuals have more negatively skewed perceptions of their

neighbourhoods. This would be consistent with previous research showing that loneliness is associated with cognitive biases that include more negative expectations and appraisals of social interactions, and heightened sensitivity to threatening social stimuli (Bangee, Harris, Bridges, Rotenberg & Qualter, 2014; Cacioppo & Hawkey, 2009; Spithoven, Bijttebier & Goossens, 2017). This hypothesis of a reporting bias is supported by the sibling control analyses which showed that even within sibling pairs who live in the same home, the lonelier siblings are more likely to perceive their neighbourhoods' collective efficacy to be lower. Further, the controls for covariates showed that these perceptions are not attributable to depression or neurotic personality traits, suggesting that there is something specific to loneliness that is associated with negatively-biased perceptions of collective efficacy.

On the other hand, the sibling control analyses also indicated that the association between loneliness and perceived neighbourhood disorder was partly explained by environmental effects shared by siblings within a family, which may include the neighbourhood. This does not, however, explain why lonelier individuals' higher average ratings of neighbourhood disorder, while corroborated by their non-lonely siblings, were not borne out by the ratings made by other residents, nor by the systematic social observations. This suggests that the shared environmental effects that drive the association between loneliness and perceived neighbourhood disorder do not arise from the neighbourhood itself, but from other factors that are shared by siblings, such as family or peer group influences. Alternatively, it may be the case that siblings living at the same address may jointly witness more of the same examples of disorder in their neighbourhood, making their reports more similar to each other, whereas the reports by other residents in the neighbourhood may be more heterogeneous. Furthermore, the measure of neighbourhood

disorder refers to more concrete details such as physical evidence and threatening events, whereas the measure of collective efficacy is more open to interpretation.

18 year-olds who still lived together with their siblings were less lonely than those who lived apart. Moving out of the family home, potentially to a different town or city, is a significant milestone in young adults' lives, and the upheaval caused to social networks could be an isolating experience for some. Furthermore, people who had moved home at any point during the 6-year period covered in this study were lonelier on average. Thus, although objective features of the neighbourhood were not associated with loneliness, there was evidence that the *stability* of the neighbourhood environment may still play a role. This too may reflect the pressures of moving away from friends or family and putting down roots in a new, unfamiliar location (Oishi & Talhem 2012).

Limitations

These findings should be interpreted in the context of some limitations. Whereas the self-report measures were collected when participants were aged 18, the other measures were collected between ages 12 and 18. In comparing their respective associations with loneliness, it is not taken into account that aspects of the neighbourhood could have changed over time between the different measurement points. Nonetheless, the sibling comparison analyses address this by cross-sectionally comparing the perceptions of individuals living in the same neighbourhood at the same time. Additionally, the analyses using the measure of childhood loneliness indicate that the differential pattern of associations for self- versus 'other'-reports of neighbourhood characteristics was not simply an artefact of loneliness and self-reported neighbourhood perceptions being measured cross-sectionally.

Second, loneliness at age 12 was measured using items from a depression scale, rather than a validated loneliness scale. These items were selected for their face validity, and are similar to items in the widely-used Children's Loneliness Scale (Maes, Van den Noortgate, Vanhalst, Beyers & Goossens, 2017), which captures feelings such as being alone, lacking friends and not being liked. Nonetheless, further work is required to validate this approach. Moreover, the fact that loneliness was assessed using different measures at 12 and 18 could have led to underestimation of the stability of loneliness between these ages. However, the UCLA Loneliness Scale is primarily used to assess loneliness in adults, and may not be age-appropriate for young children.

Third, the size of the study sample was not sufficient to examine the geographic distribution of loneliness in the United Kingdom. The UK charity Campaign to End Loneliness has called for 'loneliness maps' to be published, in order to help identify where the loneliness members of society are concentrated (Goodman, Adams & Swift, 2015). Although the E-Risk dataset is a rich source of postcode-linked information, there was insufficient density of observations to generate heat maps of loneliness in the UK, and therefore much larger sample sizes are required to identify loneliness 'hotspots'. However, the pattern of null associations in this study indicate that loneliness is evenly distributed across diverse types of neighbourhoods, and we therefore hypothesize that the geographical spread of loneliness will be similarly indiscriminate.

Implications

If lonelier individuals perceive the collective efficacy in their neighbourhoods to be lower than is actually the case, the implications of these findings are threefold. First, from a research perspective, it is important to consider that relying on self-report data alone to judge features of

the environment may lead to over-reporting of negative experiences by lonely individuals. Using data from independent informants in conjunction with self-reports can address this potential source of bias. Second, in young adulthood, individuals begin to make decisions about where they want to live. If lonelier individuals are disposed to perceive neighbourhoods more negatively, this could lead to them making biased choices and avoid areas which are in fact more cohesive than they judge them to be. This in turn could limit their opportunities to join close-knit communities and escape loneliness. Third, although interventions targeted at the neighbourhood or community level may convey benefits, our findings do not support neighbourhoods as a cause of loneliness among young adults. Instead, these data suggest that addressing lonely individuals' perceptions could be an important additional target for intervention. This is consistent with a meta-analysis showing that addressing maladaptive cognitions is more effective at reducing loneliness compared to other strategies such as increasing social contact (Masi, Chen, Hawkley & Cacioppo, 2011).

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Author declarations

T. Matthews was involved in reviewing the literature, analysing the data and writing the draft manuscript. All other authors reviewed the manuscript. A. Caspi and T. E. Moffitt were involved in the conception, design and management of the study. L. Arseneault was involved in supporting data analysis and interpretation, and in the conception, design and management of the study. All authors approved the final manuscript for submission.

The authors declare no conflicts of interest

Table 1. Descriptive statistics of all variables

Variable	Participant's age at measurement	N	Mean (SD) or %	Range
<u>Loneliness</u>				
Self-report (age 18)	18	2,051	1.57 (1.94)	0 – 8
Interviewer report (age 18)	18	2,063	0.68 (1.19)	0 – 6
Self-report (age 12)	12	2,130	0.48 (0.86)	0 – 6
<u>Neighbourhood characteristics</u>				
<i>Government data</i>				
Low neighbourhood SES	12	2,138	26.10%	1 – 5
Population density	12	2,134	17.54 (24.50)	0.25 – 219.94
Violent crime	16 – 17	2,094	29.24 (36.48)	1 – 257.42
<i>Systematic social observations</i>				
Physical decay	15 – 16	2,026	1.18 (1.22)	0 – 4
Physical disorder	15 – 16	2,024	0.93 (1.00)	0 – 4
Unsafe neighbourhood	15 – 16	2,004	2.29 (1.10)	1 – 5
<i>Residents survey</i>				
Neighbourhood safety	13 – 14	2,148	– 0.03 (0.48)	–2.67 – 0.69
Neighbourhood disorder	13 – 14	2,152	0.49 (0.34)	0 – 1.93
Collective efficacy	13 – 14	2,152	2.35 (0.51)	0 – 3.7
<i>Self-report</i>				
Collective efficacy	18	2,062	35.81 (6.64)	10 – 50
Neighbourhood disorder	18	2,062	3.12 (2.96)	0 – 12
<u>Covariates</u>				
Depression	18	2,063	1.81 (2.97)	0 – 9
Neuroticism	18	2,065	1.73 (1.72)	0 – 10
Living with co-twin	18	2,044	80.3	0 – 1

M = mean. SD = standard deviation. SES = socioeconomic status.

Table 2: Associations between neighbourhood characteristics and loneliness

Variable	Model 1			Model 2			Model 3			Model 4		
	B	β	p	B	β	p	B	β	p	B	β	p
<i>Government data</i>												
Low neighbourhood SES	-0.09	-0.02	0.56	-0.17	-0.04	0.22	-0.17	-0.04	0.22	-0.09	-0.03	0.24
Population density	-0.00	-0.03	0.19	-0.00	-0.02	0.41	-0.00	-0.02	0.41	-0.00	-0.01	0.71
Violent crime	0.00	0.01	0.72	0.00	0.02	0.59	0.00	0.02	0.60	0.00	0.02	0.49
<i>Systematic social observations</i>												
Physical decay	0.01	0.00	0.87	0.01	0.00	0.88	0.01	0.00	0.88	0.02	0.02	0.57
Physical disorder	0.02	0.01	0.70	0.01	0.01	0.77	0.01	0.01	0.77	0.01	0.01	0.82
Unsafe neighbourhood	0.04	0.02	0.40	0.02	0.01	0.66	0.02	0.01	0.66	0.03	0.01	0.66
<i>Residents survey</i>												
Neighbourhood safety	-0.05	-0.01	0.63	0.05	0.01	0.59	0.05	0.01	0.60	0.02	0.01	0.85
Neighbourhood disorder	0.10	0.02	0.55	-0.04	-0.01	0.81	-0.04	-0.01	0.80	0.02	0.00	0.92
Collective efficacy	0.03	0.01	0.80	0.03	0.01	0.74	0.03	0.01	0.74	-0.02	-0.00	0.87
<i>Self-reports</i>												
Collective efficacy	-0.05	-0.18	< 0.001	-0.04	-0.14	< 0.001	-0.04	-0.14	< 0.001	-0.04	-0.13	< 0.001
Neighbourhood disorder	0.10	0.16	< 0.001	0.05	0.08	< 0.001	0.05	0.08	< 0.001	0.04	0.06	0.03

B = unstandardised regression coefficient. β = standardised regression coefficient. SES = socioeconomic status.

Model 1: Controlling for gender and family socioeconomic status (N's range from 1,845 to 2,048).

Model 2: Controlling additionally for depression and neuroticism, and whether the participant lived with their co-twin (N's range from 1,823 to 2,025).

Model 3: Controlling additionally for change of address between ages 12 and 18 (N's range from 1,823 to 2,025).

Model 4: Restricted additionally to individuals who lived at the same address from ages 12 to 18 (N's range from 1,318 to 1,452). Analyses in Model 4 were weighted to account for bias due to factors related to residential mobility.

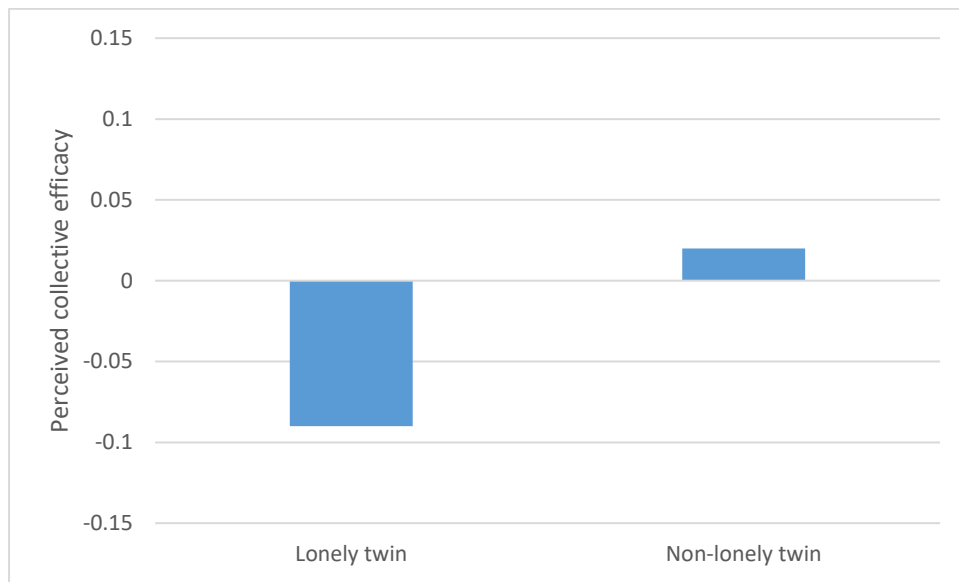
Table 3: Results of sensitivity analyses

Variable	Association (β) with:	
	Interviewer rated loneliness (age 18)	Self-reported loneliness (age 12)
<i>Government data</i>		
Low neighbourhood SES	0.04	0.00
Population density	0.01	-0.03
Violent crime	0.05	-0.01
<i>Systematic social observations</i>		
Physical decay	-0.02	0.00
Physical disorder	0.02	-0.01
Unsafe neighbourhood	-0.02	-0.02
<i>Residents survey</i>		
Neighbourhood safety	-0.02	-0.01
Neighbourhood problems	0.01	0.00
Neighbourhood disorder	0.00	0.00
Collective efficacy	0.01	0.02
<i>Self-report</i>		
Collective efficacy	-0.19 ***	-0.13 ***
Neighbourhood disorder	-0.12 ***	-0.10 ***

β = standardised regression coefficient. SES = socioeconomic status. All analyses adjusted for gender and family socioeconomic status.

*** $p < 0.001$

Figure 1: Mean (standardised) ratings of collective efficacy among 537 cohabiting twin pairs discordant for loneliness.



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