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# Does conurbation affect the risk of poor mental health? A population based record linkage study

**Short Title: Does conurbation affect the risk of poor mental health?**

## Introduction

There is growing concern over the negative implications for health associated with living in urban areas (Vlahov & Galea 2003; WHO 2014a). Urban residence is associated with increased all-cause mortality and morbidity including coronary heart disease, respiratory disease and lung cancer (Ahmad and Bhopal, 2005; O'Reilly et al., 2007). A recent report by the World Health Organisation found that about half of the world's urban population is exposed to dangerous levels of air pollution putting those people at an additional risk of serious, long-term health problems (Beatty & Shimshack 2014; Beverland et al. 2014; WHO 2014b). The observed relationship between urban residence and poor mental health dates back even further. Urban residence has been consistently associated with increased rates of the more severe manifestations of mental illness such as schizophrenia and psychoses (Faris and Dunham, 1939; Kelly et al., 2010; McGrath and Scott, 2006), leading some to propose the notion of an "urban psychiatric ghetto". A recent systematic review found that in most studies, urbanicity was associated with an approximate two-fold increase in risk of psychosis (March et al., 2008).

However, literature on the relationship between urban dwelling and non-psychotic disorders such as anxiety and depression is less clear. These common mood disorders are much more prevalent in society than the more severe psychoses, affecting approximately 20% of the population compared to the 1% affected by schizophrenia (Dominguez et al., 2011; Kessler et al., 2008). In the Northern Ireland Study of Health and Stress, lifetime prevalence of anxiety disorders in the adult population was estimated at 22.6% and major depression 16.3% (Bunting et al., 2012). In Europe, anxiety and mood disorders resulted in an annual cost of almost €188 billion in 2010, including direct medical costs, direct non-medical costs such as living allowances and indirect costs such as loss of earnings and loss of taxes to the national economy (Gustavsson et al., 2011). The burden of depression and anxiety is great and so an understanding of the predictors of these disorders is of paramount importance. A cross-national survey of major depression in ten countries found no significant difference in the likelihood of a major depressive episode in urban versus rural respondents in nine out of the ten countries (Andrade et al., 2003). In contrast, a recent systematic review found that pooled risk of depression and anxiety disorders were higher in urban areas compared to rural, with the risk for anxiety disorder bordering on significance (Peen et al., 2010). Studies to date have had a number of limitations including small sample sizes, reliance on self-reported measures of mental health; inconsistent sample selection methods (a mix of representative and probability sampling) and interviewer defined urban/rural classifications rather than an empirical measure.

Three hypotheses have been proposed to explain why people living in urban areas should have higher levels of poor mental health: psychosocial stressors; concentrated disadvantage and; selective migration (Berry, 2007). According to the psychosocial stressors theory, residents in more urbanised areas have poorer mental health because they are exposed to a greater level of individual stress including material disadvantage, unemployment and marital breakdown; all of which are known to be associated with poor mental health (Backhans and Hemmingsson, 2012; Boyle et al., 2008; Breslau et al., 2011). The concentrated disadvantage theory posits that the density of urban populations concentrates insults such as area disadvantage, social fragmentation and crime and disorder, intensifying their effects and inflating pressures on mental health (Berry, 2007).

Finally, the selective migration hypothesis proposes that the patterns of higher levels of poor mental health in more urbanised areas is not primarily caused by urban residence but is an artefact due to

the selective migration of people between areas. For example, an increased drift towards disadvantaged urban environments of people who have suffered a decline in mental health and perhaps an associated slide in social standing (Lapouse et al., 1956), or an outmigration of the more wealthy and healthy from larger conurbations to suburban areas (O'Reilly et al., 2001). No study to date has analysed all three hypotheses concurrently and, of late, studies have begun suggesting other factors which may be affecting health in urban areas including pollution, air traffic noise, social networks and the quality of the built environment (Galea et al., 2005; Kim, 2008).

This aim of this paper is to determine if (i) urban residence is associated with an increased risk of suffering from common mood disorders such as anxiety and depression (as measured by uptake of anxiolytic and antidepressant medication), and (ii) to determine if this association is independent of psychosocial stressors, area disadvantage and selective migration. This study is the largest in the UK to date of conurbation and common mood disorders utilising robust record linkage methods.

## Method

### Data Sources

This was a record linkage study involving multiple administrative datasets linked to the Northern Ireland Longitudinal Study (NILS). The NILS is a representative 28% of the population (approximately 500,000 people), selected by birth on one of 104 birthdays, drawn from the universal health-card registration dataset and linked to the 2001 Census returns, with regular updating of vital events such as deaths, migrations and address changes. A full cohort description is available elsewhere (O'Reilly et al., 2012). The NILS also includes individual Health and Care Number (a unique identifier for use within the health system) which facilitates linkage of this dataset to administrative healthcare data including the Enhanced Prescribing Database (EPD), a centralised collation of all medications dispensed in primary care in Northern Ireland, creating a NILS-EPD dataset.

### Cohort Description

The study cohort consisted of all non-institutionalised individuals aged between 22 years and 70 years at the time of the 2001 Census (236,939 individuals with full Census information). Data on prescribed medication is available from 2008 to 2010 so this age restriction allowed for the youngest possible age group at the time of prescribing whilst maintaining the most accurate socio-economic data from the 2001 Census. Reported age in the remainder of this paper is at 2009 and categorised in five 10-year age bands from 30-39 years through to 70-79 years. Other cohort attributes known to be associated with poor mental health were identified from the Census returns including: gender; marital status (never married, married, separated/widowed/divorced), educational attainment (no formal qualifications, completed formal schooling with some qualifications, university degree or higher), employment status (employed, unemployed, permanently sick, homemaker, other – mostly students or retired) and physical health determined from the limiting long term illness question (do you have any long-term illness, health problem or disability which limits your daily activities/the work you can do) (Cohen et al., 1995). These factors were used as indictors of psychosocial stress.

### Area Characteristics

Areas are defined in a number of ways in the NILS-EPD dataset. The usual Census geography, the electoral ward, is not useful for comparisons as electoral ward populations range from over 1000 inhabitants to just over 10 000 inhabitants. Census Output Areas (COAs) were introduced after the 2001 Census built from clusters of adjacent postcodes. They have similar population sizes of around 125 households and 350 people. There were 5022 COAs in Northern Ireland relating to the 2001 Census. However, the most commonly used area-identifier in the reporting of Census geography is

the larger Super Output Area (SOA) made up of 5 or 6 adjacent COAs. In total, Northern Ireland is made up of 890 SOAs with an average population of 2000 people. SOA's are the optimal small area geography for reporting results such as levels of deprivation as they have been designed to be as similar as possible in population size whist being big enough to ensure robust estimates of area-level socioeconomic status. In this analysis, level of conurbation is derived from the COA geography whereas other area measures, including deprivation, fragmentation and level of crime, are based on SOA.

Urban-Rural: There is no universally agreed definition of what constitutes an 'urban' or 'rural' area. An approach appropriate to Northern Ireland based on population size, density and access to services has been used to produce an official classification of conurbation derived from the 5022 COAs (NISRA, 2005). For the purposes of this study the urban/rural distinction was classified into three categories: urban, intermediate and rural representing settlements of >75 000 people, 2250–75 000 people and <2250 people respectively. The urban group consists solely of Northern Ireland's two largest cities, the Belfast Metropolitan Area and the Derry Urban Area .

Other area characteristics - Three indicators relating to area of residence were derived from the 890 Census SOAs to act as measures of concentrated disadvantage. A measure of social fragmentation was constructed using four Census variables (Congdon, 1996): the percentage of people in privately rented accommodation; the percentage of adults unmarried; the percentage of the population aged 65 years or younger living alone and the percentage population turnover in the year preceding the Census. The social fragmentation measure gives an indication of neighbourhood level cohesion (low fragmentation) or isolation (high fragmentation). The Northern Ireland Multiple Deprivation Measure (NIMDM) consists of a range of deprivation related domains and is the official national measure of spatial deprivation. It is generated using Census and administrative data sources (NISRA, 2010). A measure of monetary disadvantage was extracted from the income deprivation domain which provides information on the proportion of the population in each area living in households in receipt of income related benefits and tax credits. A measure of crime was derived from the crime domain in the NIMDM which measures the number of reported crimes in each area. These range from antisocial behaviour and robbery through to drug related and violent crimes. This measure only ascertains frequency and not severity. Each domain was ranked separately and split into quintiles containing approximately equal proportions of the population.

Within-country Migration

The NILS includes information on place of residence on Census day and this was used to allocate cohort members to either the rural, intermediate or urban settlement at baseline. The regular updating of address changes from the health card registration system allowed place of residence in 2009 to be identified. A comparison of residence at baseline on Census day in March 2001 and in March 2009 enabled the direction and amount of within-country migration between urban and rural areas to be measured to quantify the effect of selective migration.

Mental Health Outcomes

Receipt of anxiolytic or antidepressant medication (British National Formulary (BNF) categories 4.2.1 and 4.3 respectively) was taken as a proxy measure of anxiety disorder or depression. Previous studies have affirmed that the most common indications for antidepressant or anxiolytic prescribing are depression and anxiety (Gardarsdottir et al., 2009; Henriksson et al., 2003). Prescription information, including BNF category, was retrieved from the Enhanced Prescribing Database (EPD), an electronic record of all prescriptions provided by a General Practitioner and dispensed in community pharmacies in Northern Ireland from 2008 onwards (Maguire et al., 2013). Northern Ireland has a free at the point of service healthcare system available to the entire population. Whilst prescription medications are currently also free of charge (since April 2010), during the study period a small fee would have applied which may have affected medication utilisation. Individuals were

identified as anxiolytic or antidepressant medication users if they received at least three prescriptions for each drug over the twenty-four month study period October 2008 to September 2010. This ruled out one-off prescriptions for transitory episodes. Sensitivity analyses were carried out using a cut-off of at least six prescriptions and categorising ever versus never use yielding similar results. Previous studies have relied on self-report measures of mental health which are subject to a variety of biases, most importantly responder bias, as individuals with poor mental health are less likely to respond to questionnaires (Vercambre and Gilbert, 2012). Utilising administrative data overcomes this, and although it is subject to potential misclassification bias, this will affect such a small proportion of individuals in the large population wide prescribing dataset it is likely to have little effect on the results.

## Data Linkage

The prescribing data were linked to the NILS via one to one linkage of unique health and care number. Linkages were undertaken by the respective data custodians and the resultant research dataset containing only fully anonymised data was held in a data secure environment by the Northern Ireland Statistics and Research Agency (NISRA) and made available to the research team for this study. The study was approved by the Office for Research Ethics Committees Northern Ireland (ORECNI#:10/NIR02/21).

## Analytic Approach

In the first part of the analysis, the prevalence of medication use in individuals who were resident in urban areas was compared with that of the rest of the population. The second stage of analysis involved the construction of multilevel logistic regression models to quantify the association between city dwelling and prescription drug uptake, adjusting for the natural clustering of individuals within SOAs. Models were built to adjust for factors known to be associated with poor mental health in an attempt to explain the variation in medication uptake. The percentage change in effect between models was calculated to quantify the variation explained by the independent variables in the model compared to the unadjusted value. Interactions between independent variables were tested for moderation effects based on strong suggestions from the descriptive analysis. The third part of the analysis examined the effect of selective migration by measuring medication dispensing to those who moved between urban, intermediate and rural areas between 2001 and 2009. This resulted in nine migration categories. The absolute number of moves was recorded and t-tests applied to determine any significant differences in the characteristics of those who moved and those who did not. These categories were entered as dummy variables in logistic regression models to determine the likelihood of receiving medication given origin-destination status while adjusting for possible confounders.

## Results

The study cohort consisted of 236 939 individuals aged between 30 and 79 years in 2009 (52.4% female). The greatest proportion of the cohort lived in urban (city) areas (39.5%). There were no substantial differences in the age and sex distribution between urban, intermediate and rural areas (Table 1), though urban areas contained a higher proportion of separated, widowed or divorced individuals than rural areas (15.0% versus 8.1%). The socioeconomic differences between urban and rural areas were modest with a slightly higher prevalence of employment associated with increasing rurality, though the proportion with no academic achievement also increased in this direction. There were however marked differences in the characteristics of the SOAs that made up these larger geographic categories of urbanicty. Rural areas tended to be more affluent than deprived, with only 2.5% of rural areas falling into the most deprived quintile. Urban areas were more polarised with over 50% described as either most affluent or most deprived. Intermediate areas tended to be more affluent than deprived. Over two-thirds (66.5%) of the most deprived SOAs are in the urban

settlement category indicating that disadvantage is more concentrated in urban areas (results not shown here). These urban/rural differences also pertained for social fragmentation. The starkest differences were in levels of reported crime and disorder; over a quarter of urban areas were ranked in the highest quintile of reported crime, compared to 19% for intermediate areas and only 0.5% of rural areas. Pearson's correlation coefficient was calculated for each of the area characteristics with coefficient values of 0.53 between deprivation and reported crime and disorder, 0.61 between deprivation and social fragmentation and 0.66 between reported crime and disorder and social fragmentation. These correlation coefficients are modest, confirming that each of the area level measures is capturing a different construct. Anxiolytic medication use was 75% higher in urban compared to rural areas (7% compared to 4%) and antidepressant medication 30.1% higher in urban compared to rural areas (19% compared to 14.6%).

(Table 1 about here)

Given the observed disparity of deprivation, crime and fragmentation in rural versus urban areas possible interactions between conurbation and area characteristics were tested using likelihood ratios tests. There was a significant interaction between area level deprivation and conurbation for both likelihood of anxiolytic medication (LR $\chi2=105.5$, $p<0.001$) and likelihood of antidepressant medication (LR $\chi2=95.3$, $p<0.001$). The interaction was most evident in the most deprived quintile. This means that medication uptake of those living in an urban or rural residence differed according to whether the resident was in a deprived or affluent area. Consequently, the analysis of medication use across urban/rural categories was stratified according to deprivation score, using the highest quintile of deprivation to identify "deprived" areas, with the other categories grouped together and defined as "non-deprived". Interactions between crime and fragmentation and conurbation were significant also for both anxiolytic medication ((LR $\chi2=82.3$, $p<0.001$) and (LR $\chi2=32.9$, $p<0.001$) respectively) and for antidepressant medication ((LR $\chi2=65.4$, $p<0.001$) and (LR $\chi2=47.3$, $p<0.001$) respectively). However numbers were too small to stratify areas by those with the highest level of crime and those with the highest level of fragmentation. For this reason these variables were added to the models as confounders.

Multi-level logistic regression models were constructed to determine the likelihood of anxiolytic or antidepressant medication given area of residence in both deprived and non-deprived areas. Likelihood of anxiolytic medication is illustrated in Table 2.

(Table 2 about here)

In the unadjusted model, individuals living in deprived urban areas were 2.45 times more likely to receive anxiolytic medication compared to those living in deprived rural areas (OR=2.45, 95%CI 1.75, 3.40). After adjusting for age, sex, marital status, education, economic activity and health this association attenuated a little (OR=2.02, 95%CI 1.50, 2.83). Approximately 30% of the difference in anxiolytic medication uptake in deprived urban compared to deprived rural areas can be explained by compositional factors (Table 2, Model 4). After further adjustment for area level crime and fragmentations (Model 6), individuals living in deprived urban areas were still 74% more likely to received anxiolytic medication compared to those living in deprived rural areas (OR=1.74, 95%CI 1.11, 2.73). The same association between conurbation and mental health was observed in non-deprived areas but the effect size was reduced. In the unadjusted model, individuals living in non-deprived urban areas were 38% more likely to receive anxiolytic medication compared to those living in non-deprived rural areas (OR=1.38, 95%CI 1.26, 1.50). Adjusting for compositional factors

had no effect on the association between urban residence and likelihood of anxiolytic medication (Model 4). After full adjustment (Model 6), individuals living in non-deprived urban areas were still 25% more likely to receive anxiolytic medication compared to those living in non-deprived rural areas (OR=1.25, 95%CI 1.15, 1.36).

Likelihood of antidepressant medication is illustrated in Table 3. The association was similar to that observed with anxiolytic medication. In the unadjusted model, individuals living in deprived urban areas were 99% more likely to receive antidepressant medication compared to those living in deprived rural areas (OR=1.99, 95%CI 1.59, 2.48). Those in non-deprived urban areas were 14% more likely to receive antidepressant medication compared to those living in non-deprived rural areas (OR=1.14, 95%CI 1.08, 1.20). Compositional effects accounted for approximately 25.3% of the difference in antidepressant medication uptake in deprived urban compared to deprived rural areas (Table 3, Model 4), with adjustment for age, sex, marital status, education, economic activity and health attenuating the likelihood to 74% (OR=1.74, 95%CI 1.43, 2.11), but had no effect on the likelihood of antidepressant medication in non-deprived areas. After full adjustment (Model 6), individuals living in deprived urban areas were 65% more likely to receive antidepressant medication compared to those living in deprived rural areas (OR=1.65, 95%CI 1.24, 2.19) and individuals living in non-deprived urban areas were 12% more likely to receive antidepressant medication compared to those living in non-deprived rural areas (OR=1.12, 95%CI 1.07, 2.17). The odds ratios did not change substantially in non-deprived areas.

(Table 3 about here)

Table 4 shows the proportions of the cohort who moved between urban and non-urban categories over the nine year study period and those who did not change category. It should be noted that the total number changing residence was much larger than this but only those resulting in a change of category are counted here. Overall 9% of the cohort changed category between 2001 and 2009 with rural areas experiencing the greatest increase in population while urban and intermediate areas lost 2.7% and 0.4% of their respective populations. The mean age of movers was slightly lower than that of the stable population (44 years versus 52 years) but there were no significant differences in the socio-demographic characteristics of those who moved and those who did not (results available on request). Most migrants moved to adjacent categories (such as rural to intermediate; or intermediate to urban) with much fewer moving between urban and rural categories. The marked urban/rural gradient in the use of both antidepressant and anxiolytic use is evident amongst those who did not change their category over the study period.

(Table 4 about here)

The highest uptake of anxiolytic medication was observed in those who remained in urban areas at both time points (7.1%) and the highest uptake of antidepressant medication was observed in those who moved from rural to intermediate areas (19.3%). The lowest uptake of anxiolytic medication was observed in individuals who moved from urban to rural areas (3.3%). Logistic regression models were constructed to calculate the likelihood of anxiolytic or antidepressant medication based on migration history between 2001 and 2009, with the stable population used as the referent group (Table 5).

There is evidence that moving from more rural to more urban areas is associated with an increased likelihood of being on either anxiolytic and antidepressant medication. In the fully adjusted models individuals who moved from rural to intermediate areas were 46% more likely to receive anxiolytic medication than those who lived in rural areas throughout (OR=1.46, 95%CI 1.22, 1.74), and those who moved from intermediate to urban areas were 21% (OR=1.21, 95%CI 1.01, 1.46) more likely to receive anxiolytic medication than those who lived in intermediate areas throughout (Table 5). Levels of anxiolytic use were not significantly associated with moves in the opposite direction.

(Table 5 about here)

The association of higher use of medication amongst those moving from more rural to more urban areas was also evident for antidepressants. Individuals who moved from rural to intermediate areas were 50% more likely to receive antidepressant medication than their peers who remained in rural areas (OR=1.50, 95%CI 1.36, 1.65), and those who moved from intermediate to urban areas were 13% more likely (OR=1.13, 95%CI 1.01, 1.26) to be receiving antidepressant medication than their peers who had remained in the intermediate areas. However, there was some evidence of worse mental health in those who moved away from urban areas as these migrants had a 22% (1.22, 95%CI 1.12, 1.34) higher likelihood of antidepressant medication use than those who lived in urban areas throughout.

The overall impact of migration on the patterns of mental health across the urban/rural categories can be approximated if we make the assumption that, on average, the mental health of individuals was unaffected by migration. The data above allows us to estimate what the patterns of mental health across the urban/rural categories might have been in 2001 and to compare them to those in 2009. Thus, over the study period urban areas lost 2.7% of their total population but a smaller proportion of those on antidepressants or anxiolytics (2.5% and 1.4% respectively). The net effect of this would have been to increase the proportion of people in urban areas with depression or anxiety. During the same time the population of rural areas increased by 5.6% but the numbers with depression only increased by 4.6% while the number being treated with anxiolytics increased by 1.0%. Collectively this selective migration would have increased the urban/rural gradient in mental health, though the magnitude of these effects was modest; for example, the prevalence of depression in respectively urban and rural areas would have been 18.9% and 14.6% in 2001, rather than 19.0% and 14.5% respectively in 2009.

## Discussion

This study asked if living in urban areas was associated with an increased likelihood of suffering from poorer mental health, as assessed by the use of medications for the more common mood disorders such as anxiety or depression. The answer is 'yes', with the urban/rural gradient more pronounced in areas that were in the most deprived quintile. After full adjustment for factors known to be associated with poor mental health, residents in urban deprived areas were 74% (95% CI 1.11, 2.73) more likely to receive anxiolytic medication and 65% (95% CI 1.24, 2.19) more likely to receive antidepressant medication than their rural peers. Only a modest proportion (approximately 30%) of the higher use of medications in urban areas was due to differences in the socio-demographic or socioeconomic characteristics of the population across the urban/rural spectrum. Although urban areas are characterised by a higher prevalence of reported crime and higher levels of social fragmentation, adjustment for these factors resulted in little attenuation of the urban/rural gradients in mental health. In terms of migration, there was a clear association between moving to

increasingly urban areas and increased likelihood of both anxiolytic and antidepressant medication, consistent with the social drift of those with poorer mental health into urban areas and migration of "healthy" individuals out of urban areas. The highest use of anxiolytic medication was observed amongst the long-term residents of urban areas. This study shows that the higher rates of poor mental health in urban areas can in part be explained by the higher levels of psychosocial stressors and concentrated disadvantage in urban areas and by selective migration between urban and rural areas, however, much of the variation remains unexplained.

Comparison with other studies

The observed urban/rural gradient in the prevalence of anxiety or depressive disorder mirrors the findings of earlier studies which have shown an increased prevalence of any psychiatric disorder in urban areas (Sundquist et al., 2004), especially severe psychiatric disorders such as schizophrenia and psychoses, and dying by suicide (Congdon, 1996; Faris and Dunham, 1939; McGrath and Scott, 2006; Schelin et al., 2000). The current study provides evidence that the same associations exist for the more common mood disorders. This supports a recent UK study which found a modest, but statistically significant association between rural dwelling and better mental health as measured by the GHQ-12, independent of socio-economic status (Weich et al., 2006). Few studies have looked directly at psychiatric medication uptake in urban versus rural areas, but a Swedish study of deprivation and urban/rural residence found that residency in large cities increased the likelihood of any psychiatric medication by 16% (Crump et al., 2011); a much smaller effect than that observed in the current study. It has been noted that these differences may reflect variations in treatment levels rather than in levels of mental health per se and some studies have suggested that individuals in urban areas have greater access to resources and hence higher rates of treatment for mental ill health (Eberhardt and Pamuk, 2004). However, a recent study in the US found no difference between access to mental health resources in primary care and level of conurbation, which is precisely what is measured in prescription drug uptake (Petterson, 2003). In addition, the small geography of Northern Ireland means that every individual is within 45 minutes of a GP/Pharmacy and so access to resources may not play such an important role in this environment. Cross national comparisons are problematic given the differing definitions of urban and rural in different countries.

While the study does confirm that approximately 30% of the higher anxiolytic and antidepressant medication usage in urban areas is due to differences in population composition, it does provide strong support for an independent effect of area of residence (Diez Roux, 2001). The interaction with area deprivation suggests that the deleterious effects of urban dwelling are most evident amongst those who are also living in deprived areas, and this supports the theory that concentrated disadvantage is in part responsible for the poorer mental health observed in urban areas (Berry, 2007). Previous studies have shown deprivation to be associated with an increased risk of both mild and major depression and receipt of psychiatric medication (Crump et al., 2011; Lorant, 2003; Lorant et al., 2007). However, after adjustment for both individual and area level indicators of disadvantage, urban residence still produced an independent effect on the likelihood of receiving antidepressant or anxiolytic medication. The highest use of anxiolytic medication was observed amongst the long-term residents of urban areas. Other studies have pointed to the theory that city living impacts neural stress processing making city dwellers more sensitive to stress to explain this (Lederbogen et al., 2011). Moves into urban areas were associated with an increased risk of anxiolytic and antidepressant medication. This association between urban/rural migration and mental health was also observed in a cohort study of Finnish adults (Lankila et al., 2013). Though, in this study, as medication use was only measured after migration it is not possible to say whether poor mental health preceded migration or was a result of change of residence, which is known to be a stressful life event. Nevertheless, the migration effect appears to be counteracted by similar

proportions of moves out of urban areas resulting in a small net change in health due to selective migration.

This study suggests that the three predominant hypotheses; psychosocial stressors, concentrated disadvantage and selective migration, only partially explain the association between cities and poor mental health. Other possible explanations that have been gaining impetus recently include levels of air or noise pollution (Haines et al., 2001; WHO, 2014a), reduced access to green space (Lee and Maheswaran, 2011), or reduced levels of social support (DeSilva, 2005). A recent study found that living close to an urban park had the same mental health benefits as decreasing local unemployment rates by 2 percentage points, suggesting at least the potential of environmental interventions to improve population mental health (Sturm and Cohen, 2014). It has also been suggested that differing job roles in the city, and associated increased work stress, may contribute to the poorer mental health observed in cities (Godin et al., 2005). Another possible explanation is fear of crime, which encompasses both perceived risk of being a victim of crime and emotional response to crime (Lorenc et al., 2014). The measure of crime used in this study related only to reported crime and may therefore understate the true urban/rural differences as fear of crime has been shown to be a greater predictor of health than crime itself (Ruijsbroek et al., 2015). Fear of crime is widespread in western society, resulting in anxieties which can erode quality of life (Farrall and Gadd, 2004). Fear of crime has been found to be associated with poor living environment and levels of graffiti which are more pronounced in urban areas (Jackson, 2004), and has been empirically shown to have a negative effect on self-assessed mental health (Jackson and Stafford, 2009). Direction of cause though remains to be elucidated.

Strengths and Potential Limitations

This study has all the advantages and some of the disadvantages of a large record linkage study. It is based on a large and representative sample of the population with no responder bias or loss to follow up; it also includes a valid measure of medication history. However, although there was good information on prescribed medications there was no associated clinical information on indication for use and we have assumed that use was in accordance with the medication name. While these medications are occasionally prescribed for other indications, most studies have found that the most common indications for antidepressant or anxiolytic prescribing are depression and anxiety (Gardarsdottir et al., 2009; Henriksson et al., 2003). The dataset does not capture private prescriptions or those issued by psychiatrists which may result in an underestimation of the effect. However, prescriptions issued in these instances are likely to be for more severe expressions of mental ill health. In addition, individuals treated for common mood disorders via other therapies are not identified. This misclassification bias would only lead to a dilution of the actual effect.

We also recognise that the measures of crime and fragmentation used here may not accurately reflect the breadth or depth of these phenomena. As mentioned above, the crime measure related only to levels of reported crime and did not capture fear of crime, which may be more pertinent in a study of mental health. The measure of social fragmentation was Congdon's and derived from four Census variables, but other measures are available which may have greater validity (Ivory et al., 2011). It has been suggested that mood disorders such as anxiety and depression are more prone to influence from factors such as social cohesion and social capital than the more severe psychoses (Whitley and McKenzie, 2005), and a more accurate measure of these concepts may account for a larger proportion of the observed urban/rural variation in mental health. Absent from the psychosocial stressors proxy were indicators of individual level stressful life events such as marital breakdown or bereavements, which are known to be associated with risk of poor mental health (Kristensen et al., 2012). However, it is unlikely that the remainder of the observed effect of urban residence on mental health can be explained by these factors alone. In addition, the urban category

subsumed Northern Ireland's two largest cities, which may mean the observed association are more indicative of a "city-effect" per se, than a more general effect of conurbation. However, stepwise associations between levels of conurbation and levels of mental health are observed, reinforcing the supposition of an urban effect on mental health.

## Conclusions and Implications

Where you live seems to have a strong independent effect on your mental health, with residents in deprived urban areas faring worst. Conurbation can affect mental health through a variety of complex pathways; the increased prevalence of psychosocial stressors, more concentrated disadvantage and selective migration between areas contribute but do not fully explain the higher rates of anxiolytic and antidepressant uptake observed in urban areas. Other factors such as fear of crime, access to green space, pollution, job stress and social capital need to be assessed in conjunction with the known predictors of poor mental health to fully understand the mechanisms underlying this relationship.

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**Conflict of interest**

None

**Ethical standards**

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