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Research paper

Urbanicity and depression: A global meta-analysis

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ABSTRACT

Background: Previous meta-analyses have revealed that in adult and older adult populations of developed countries, depression is more prevalent in urban than rural areas. No meta-analyses have identified the effects of urbanicity on the general age demographic for developing countries. We conducted a meta-analysis of urban-rural differences in depression across all age demographics for developed and developing countries.
Methods: PubMed and PsycINFO databases were searched for studies published between 1980 and 2020. Studies were included if they reported prevalences of urban and rural depression, or odds ratios comparing urban-rural depression prevalence. Studies were excluded for: nonrepresentative samples, non-standard measures of depression, and reporting continuous outcomes only. Meta-analytic models of urban-rural differences in the odds of depression were conducted across country development levels and age demographics.
Results: From 1597 records screened and 302 full texts assessed for eligibility, 80 studies ($N = 539{,}557$) were included for meta-analysis. Urban residence was significantly associated with a higher prevalence of depression in developed countries (OR = 1.30, 95 % CI [1.17, 1.46], $z = 4.75$, $p < .001$), which was primarily driven by urban-rural differences in the general population age demographic (OR = 1.37, 95 % CI [1.22, 1.54], $z = 5.38$, $p < .001$).
Limitations: Studies reporting urban-rural differences in depression in terms of continuous symptom severity scores were not included.
Conclusions: Urbanicity appears to uniquely be associated with a higher prevalence of depression in developed countries, but not in developing countries.

1. Introduction

The United Nations (2018) predicts that by 2050, two-thirds of the global population will reside in urban areas. This global trend of increased urban living has raised concerns about the impacts of urbanization on mental health. Several recent reviews (Hoare et al., 2019; Sampson et al., 2020; Ventriglio et al., 2021) have identified multiple features of urban living – such as social disparities, economic insecurity, pollution, and lack of greenspace – as potential mental health risk factors that may disproportionately contribute to greater mental health risks for individuals living in urban areas compared to rural areas.

Major depression is one of the most common mental health disorders in the world, and considered a leading cause of disability worldwide (Friedrich, 2017; World Health Organization, 2021). A recent ecological analysis of 191 countries by van der Wal et al. (2021) revealed a between-countries correlation in the degree of country urbanization and the prevalence of common mental disorders like depression. Nevertheless, a limitation of van der Wal's study is their examination of the effects of urbanicity at the between-countries level: specifically, given that depression is experienced at the individual level, previously identified risk factors of urbanicity such as pollution, lack of greenspace, and social disparities (Hoare et al., 2019; Sampson et al., 2020; Ventriglio et al., 2021) should affect urban-rural differences in depression prevalence at the within-country level, and not just at the between-countries level of analysis (i.e., the ecological fallacy) (Piantadosi et al., 1988; Robinson, 1950; Schwartz, 1994). Consequently, a thorough meta-analysis of the quantitative evidence of within-country differences between urban and rural living and the prevalence of depression across the globe is warranted.

We identified two previous meta-analyses on the effects of urban vs rural living on the prevalence of depression. Peen et al. (2010) examined the general adult population of only developed countries, finding that the prevalence of multiple psychiatric disorders, including mood disorders, was higher in urban areas than rural areas. Purtle et al. (2019)

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examined older adult populations across both developed and developing countries, finding that major depression was more common in urban areas than rural areas in developed countries, but not in developing countries.

Consolidating the meta-analytic evidence from Peen et al. (2010) and Purtle et al. (2019) reveals a gap in the literature. Specifically, the impact of urbanicity on the prevalence of depression for the general adult demographic of developing countries is unknown. Additionally, there are no systematic meta-analyses on the effects of urbanicity on the prevalence of child or adolescent depression, either in developed or developing countries. Finally, the findings by Peen et al. (2010) are, at the time of this writing, over a decade old, thus, warranting an update to the literature on the effects of urbanicity on depression in developed countries. Related to this, and perhaps more important, is the need for an examination of possible changes in the relationship between urbanicity and depression over time.

1.1. *The present study*

The present study is attempts to consolidate the quantitative evidence comparing urban vs rural living and the prevalence of depression, and to help address the questions left open by recent review articles (Hoare et al., 2019; Sampson et al., 2020; Ventriglio et al., 2021) and not answered by the previous meta-analyses of Peen et al. (2010) and Purtle et al. (2019) We had three primary questions:

(1) Globally, is there an effect of urbanicity on the prevalence of depression, and, if so, how has this trend changed over time?
(2) Does the relationship between urbanicity and depression differ between developed and developing countries?
(3) Does the relationship between urbanicity and depression differ between age demographics, such as between the demographics of the general adult population, children/adolescents, and older adults?

2. Methods

This paper adheres to the PRISMA 2020 reporting guidelines (Page et al., 2021). A flow diagram of the study search and selection process is provided in Fig. 1.

2.1. *Information sources and search strategy*

To identify relevant peer-reviewed studies, we searched the PubMed and PsycINFO databases from 1980 (to correspond with the publication of the DSM-III (American Psychiatric Association, 1980)) to January 2020. Thus, studies conducted after the COVID-19 pandemic were excluded. Our search omitted non-peer reviewed and non-English publications. We searched for articles that contained the following terms in their title, abstract, or keywords, using the following operator: (*depression* OR *depressive*) AND (*urban* OR *city* OR *cities* OR *metropolitan* OR *urbanization*) AND (*rural* OR *countryside* OR *urbanicity*). Our search strategy and selection criteria were informed by previous meta-analyses conducted in this area (Peen et al., 2010; Purtle et al., 2019). The search procedure yielded 2376 articles to be screened for selection.

Exact search syntax as used for each database is presented in Appendix A. Note that this literature search was conducted before PubMed

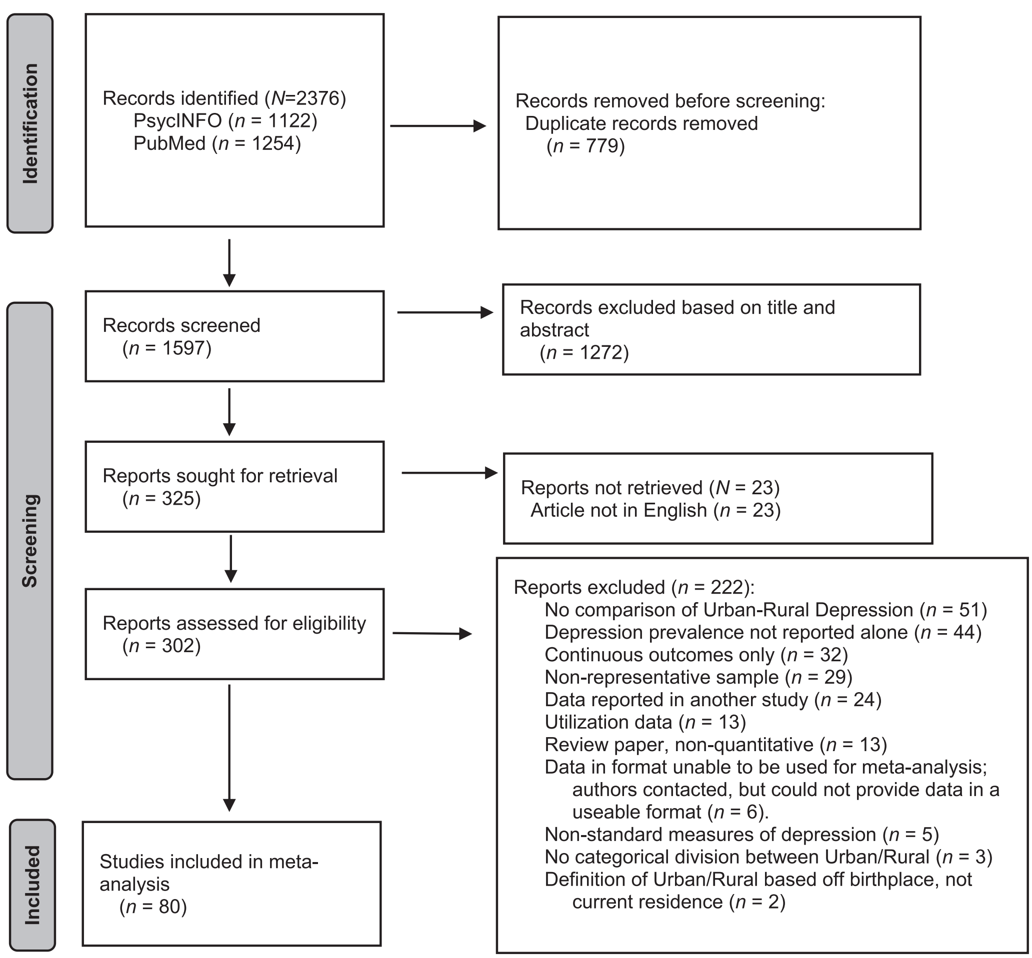

Fig. 1. PRISMA 2020 compliant flow diagram study selection diagram to identify studies comparing urban-rural difference in depression.

updated their search engine algorithm in July 2021 (Kang et al., 2021); thus, re-entering these terms into the current version of PubMed now returns a different pool of articles.

2.2. Eligibility criteria and study selection process

After duplicates were removed, 1597 articles were screened for inclusion. Articles were included if they assessed urban-rural differences in major depressive disorder. Studies that focused on urban or rural populations exclusively, without comparing urban-rural differences were excluded. This was done to ensure within-study consistency of the diagnostic procedures for assessing the prevalence of depression (Erkinjuntti et al., 1997). Other exclusion criteria included: non-empirical studies, such as review articles or case studies; studies focused on non-representative populations (e.g., institutionalized populations, samples drawn from internet volunteers); studies limited to clinical interventions (e.g., treatment trials); or studies that examined depression solely in the context of another condition (e.g., maternal depression, depression in cancer survivors). Studies focused on specific age demographics, such as adolescents and older adults, as well specific races/ethnicities or genders were not excluded as non-representative populations at this step.

Three reviewers (CX, LM, DT) divided the 1597 articles for title and abstract screening, with each author separately reviewing 1065 studies; thus, each article was screened by at least two reviewers. Articles were moved on to full text screening if at least one reviewer decided an article was relevant for full text screening.

Of the 1597 articles screened, 325 were moved on to full text screening. The full texts of 302 of these articles were obtained, and reviewed for suitability of data extraction with further inclusion criteria. Full texts with title/abstracts were assessed for eligibility by consensus of all three reviewers (CX, LM, DT). To be considered eligible for data extraction, further inclusion criteria, in addition to the above-described exclusion criteria, had to be met.

First, studies must have reported the prevalence of depression alone. Studies were excluded if they reported rates of depression only in aggregate with other psychiatric disorders (e.g., reporting rates of depression in conjunction with anxiety disorders or bipolar mood disorders; or studies reporting depression as a general component of "psychiatric distress"). Studies reporting only depressive disorders as an aggregate (i.e., both depression and dysthymia), but excluding bipolar mood disorders, were included.

Second, studies that used non-standard measures of depression, such as non-standardized survey questions asking about subjective feelings of depression were excluded. Standardized screener questionnaires (e.g., the CES-D (Lewinsohn et al., 1997)) and diagnostic interviews (e.g., the WHO CIDI (Robins et al., 1988)) were allowed.

Third, studies that reported urban-rural differences as a continuous outcome only were excluded. That is, studies were only included if they reported rates of depression as a binary outcome or the difference between urban-rural depression as an odds ratio, for the following reasons. Firstly, binary outcomes such as raw prevalences can be readily converted into odds ratios, given only the prevalence rates and sample sizes. Secondly, because a wide variety of measures could be selected to assess depression, comparing equivalence across measures – when the distributional properties of these measures may vary significantly – is difficult. Further compounding this difficulty is the challenge of managing potential cross-cultural variability in means and distributions of these measures (Byrne and Campbell, 1999; Byrne and van de Vijver, 2010). Thus, we opted to exclude measures reporting depression in the form of continuous outcomes such as means of symptom scores. Instead, we included only studies that reported depression in terms of binary outcomes (such as raw prevalence rates, prevalence percentages, or odds ratios), as any potential cultural effects on measuring rates of depression would remain constant for a given measure across both the urban and rural groups within a country. Studies using continuous measures, but also used cutoff scores to determine the prevalence of depression, were included, though only information on the binary outcomes as derived from the cutoff scores were extracted for analysis.

Fourth, non-representative samples were excluded. We excluded utilization data (e.g., hospital records, insurance records) as non-representative, because rates of treatment seeking behavior does not necessarily reflect rates of the presence of a disorder (e.g., differences in stigma between urban and rural areas can affect rates of active treatment seeking (Hoyt et al., 1997; Rost et al., 1993)). Studies conducted at single treatment centers were excluded for non-representativeness. Studies conducted within college or university populations exclusively were excluded, as students in post-secondary education are not representative of the general population (Henrich et al., 2010). However, studies sampling public elementary, middle, or high schools were allowed, because sampling from public schools is a common convenience sample for obtaining a representative sample of children and adolescents in a country (Polanczyk et al., 2015). Other exclusions for non-representativeness were if there were specific features to an urban or rural sample that would make it non-representative of urban or rural areas in general (e.g., urban slums; rural workers all employed at a single farm).

Fifth, studies that did not have a clear urban-rural categorical divide were excluded. Studies that reported urbanization data in the form of a gradient, such as those using geographic information system (GIS) data, were excluded if they did not provide clear categories of urban and rural depression prevalence.

Sixth, studies that examined transitions between urban and rural living, such as urban-rural migrants or vice versa, were excluded. Studies that categorized urbanicity based on respondents' birthplace, instead of residence at the time of assessment, were also excluded.

Seventh, studies that reported data that were otherwise reported in other papers were excluded. For example, multiple studies reported findings on urban-rural depression prevalence from major surveys such as the National Comorbidity Survey (Blazer et al., 1994), the 10/66 Dementia Research Group study (Honyashiki et al., 2011), or the European Outcome of Depression International Network (ODIN) study (Ayuso-Mateos et al., 2001). For these studies, we chose the individual papers that reported the clearest data on urban-rural differences in depression prevalence. Thus, for these major surveys, no duplicated results were included.

There were several studies that met all other inclusion criteria, but reported results in a format that did not permit the extraction of information required for the meta-analysis. For example, a study was excluded if it reported a p-value for the effect of urbanicity on depression, but did not report accompanying odds ratios, sample sizes, or prevalences. When possible, we requested from the authors of these studies the information needed for the meta-analysis. The authors of two studies (Leggett et al., 2012; Pillai et al., 2008) were able to provide data in a format that was able to be incorporated into our meta-analysis.

2.3. Data extraction

Studies that met inclusion criteria ($n = 80$) were moved on to data extraction. Data extraction was conducted as a consensus process by three reviewers. Final extracted values from the 80 studies were independently double-checked for errors by two reviewers.

2.4. Primary outcome/dependent variable

Urban and rural sample sizes were extracted where reported, or calculated from the reported urban or rural percentages of the total sample size from each study. Information on the prevalences of urban and rural depression were also extracted. Where studies directly tested the difference between urban and rural depression prevalence, we aimed to use published odds ratios. If both adjusted (i.e., corrected for demographic covariates such gender or socioeconomic status) and unadjusted odds ratios were both reported, the adjusted odds ratio was given preference for our meta-analysis. Odds ratios and their accompanying 95 % confidence intervals were extracted. Where studies did not directly test the difference between urban and rural depression prevalence, or for studies where odds ratios were not present, we extracted reported sample sizes and their respective prevalence rates, and used that information to calculate odds ratios and 95 % confidence intervals of the difference between urban and rural depression prevalence.

In cases where both 12-month and lifetime prevalence were reported, we used 12-month prevalence, as this is a closer estimate to the point prevalence that is reported in many studies that used simple screener questionnaires. When studies reported prevalences using more than one diagnostic system (e.g. DSM vs. ICD), we used the classification method that the authors used for reporting the primary finding.

2.5. Primary independent variable

Our primary independent variable was urbanicity. As per our inclusion criteria, studies had to include a comparison of the prevalence of depression as categorically divided into urban and rural samples. Thus, our classification of urbanicity was based off of what a study's authors used to define urbanicity. Studies varied in definitions of urbanicity, ranging from specific named locations, definitions using total population or population density statistics, or categories as defined by a government entity (e.g., census bureau). Note that as long as clearly defined categories of urbanicity were provided, the definition of urbanicity was not an exclusion criteria. We accounted for definition of urbanicity as a factor in our study quality assessment ratings; see section below on Quality Assessment, as well as Appendix B.

When studies reported more than two categories of urbanization (e.g., metropolitan, urban, suburban, rural), only data from the two most extreme categories were selected (e.g., metropolitan vs rural). We followed this procedure to remain consistent with Peen et al. (Peen et al., 2010).

2.6. Studies reporting data from multiple countries

Several studies reported information from multiple countries. As we were interested in the individual country-level effects, we divided these studies into individual sub-studies for each country. These sub-study splits were treated as individual studies for meta-analytic purposes. Specifically, sample sizes, prevalence rates, and odds ratios for each study split were extracted and calculated separately, although information such as year of data collection or study quality assessment ratings remained common between the study splits for a single study. This separation into individual countries was possible for all studies that contained information from multiple countries. Out of 80 studies, we obtained 89 study splits.

For studies that reported separate prevalences for subgroups within a certain country (e.g., male vs female rates of depression), we aggregated the prevalence data into a single group, which was then used to calculate an odds ratio.

2.7. Age demographic categories

Studies were classified into three age demographics: children/adolescent, older adult, and the general adult population. Age demographic classifications were made in accordance to each study's target demographic as reported by the authors. Where information was available, data on the age ranges used for study inclusion criteria were recorded. Some studies did not report age range inclusion criteria, but instead reported mean or median ages; these studies were categorized into the three age categories as according to the study authors' reported target demographic.

2.8. Country development level

We defined country development level according to the UN's World Economic Situation and Prospects (WESP) 2022 report categories (United Nations, 2022). The UN defines countries as having developed economies, developing economies, or as economies in transition. Purtle et al. (Purtle et al., 2019) used the UN's WESP 2014 report for classifying countries as developed or developing. Incidentally, the countries included in our meta-analysis, as categorized by the UN's WESP 2022 report, remain unchanged from the categories of the UN's WESP 2014 report (United Nations, 2014).

Our meta-analysis only included one study (Glendinning and West, 2007) conducted in an economy in transition, Russia. The WESP report additionally classified countries by income level, and the 2014 WESP (United Nations, 2014) report lists Russia as a “High Income” country, along with other developed countries. Thus, for the purpose of our meta-analysis, we categorized Russia as a developed country.

2.9. Quality assessment

We assessed the methodologic quality of each study on eight domains using a quality assessment scale adapted from Purtle et al. (2019). Three reviewers (CX, LM, DT) reviewed the 82 included studies and made consensus ratings on study quality. Each domain was scored out of a possible two points. An aggregate quality score is then calculated by the sum of total domain scores. The quality assessment scale is reported in Appendix B.

2.10. Statistical procedure

2.10.1. Model specification

Meta-analytic models were constructed using the metagen() function of the meta package in R (Schwarzer, 2022). The odds ratio between urban and rural rates of depression was specified as the dependent variable. Because we expected heterogeneity between studies (e.g., due to between-country differences in the rates of depression), all meta-analytic models were run as random effects models (Borenstein et al., 2010; Hedges and Vevea, 1998).

As we were primarily interested in the effects of country development level on the relationship between urbanicity and depression, we ran primary two meta-analytic models, one each for developed countries and developing countries. For our secondary investigation on the effect of age demographic, we ran separate meta-analytic models for each of the subgroups of age demographics (general population, older adult, and child/adolescent) within both developed and developing countries. Thus, we ran a total of two primary meta-analytic models, and six secondary meta-analytic models. Because of the number of meta-analytic models tested, we imposed a Bonferroni corrected alpha level of $\alpha = 0.00625$ per test (0.05 / 8).

Heterogeneity of each meta-analytic model was assessed, and I^2 values were interpreted in line with the recommendations from the Cochrane manual (Deeks et al., 2022).

2.10.2. Meta-regression

We additionally ran meta-regression models for each of the above meta-analytic models to examine changes in the relationship between urbanicity and depression prevalence over time. Meta-regression models were run using the metareg() function of the meta package in R (Schwarzer, 2022; Schwarzer et al., 2015). Specifically, we coded median year of data collection as the independent variable for each meta-regression model. Studies that did not report a year of data collection were excluded from the meta-regression analysis. Because of the number of meta-regression models tested, we imposed a Bonferroni corrected alpha level of $\alpha = 0.00625$ per test (0.05 / 8).

To assess for the effects of study quality, we additionally ran meta-regression analyses using only the sum quality score as the independent variable.

2.10.3. Risk of bias assessment

To check for the risk of publication bias, we conducted funnel plot analyses (Sterne et al., 2011) for the significant meta-analytic models as described above. We also conducted trim-and-fill analyses (Schwarzer et al., 2015) for each meta-analytic model.

3. Results

Eighty studies were identified, with a total of 89 study splits. See Fig. 1. There were 51 study splits of developed countries, with 3 child/adolescent, 9 older adult, and 33 general population. There were 45 study splits of developing countries, with 8 child/adolescent, 25 older adult, and 11 general population.

Out of a total reported sample size of N = 1,207,178, the total reported urban sample size was 314,537 and the total reported rural sample size was 225,020, for a total minimum analysis sample size of 539,557 (four studies only reported odds-ratios of urban-rural differences and did not include separate urban and rural sample sizes). The difference of 667,621 is accounted for by studies that reported multiple categories of urbanization (e.g., rural, suburban, urban), as we only extracted prevalences from the two most extreme categories of urbanization provided.

3.1. Meta-analytic findings

All meta-analytic models showed substantial to considerable heterogeneity (see accompanying test statistics as described below), indicating that random effects models were appropriate.

For developed countries, there was a significant effect of urbanicity on depression (OR = 1.30, 95 % CI [1.17, 1.46], z = 4.75, $p < .001$; substantial heterogeneity, I^2 = 78 %, τ = 0.10, $p < .01$). See Fig. 2. For developing countries, there was no significant effect of urbanicity on depression (OR = 0.89, 95 % CI [0.71, 1.12], z = −0.99, p = .32; considerable heterogeneity, I^2 = 92 %, τ = 0.49, $p < .01$). See Fig. 3.

Within developed countries, the effect of urbanicity appears to be driven primarily by the general population demographic, where urban residence was significantly associated with a greater prevalence of depression than urban residence (OR = 1.37, 95 % CI [1.22, 1.54], z = 5.38, $p < .001$; substantial heterogeneity, I^2 = 76 %, τ = 0.08, $p < .01$). See Fig. 4. Within the other two age demographics of developed countries, there were no significant effects of urbanicity and prevalence of depression for either the older adult (OR = 1.11, 95 % CI [0.79, 1.55], z = 0.62, p = .54; considerable heterogeneity, I^2 = 86 %, τ = 0.21, $p < .01$) or child/adolescent (OR = 1.17, 95 % CI [0.86, 1.59], z = 0.99, p = .32; substantial heterogeneity, I^2 = 55 %, τ = 0.04, p = .11) demographics. See Figs. 5 and 6.

Within developing countries, there was no significant effect of

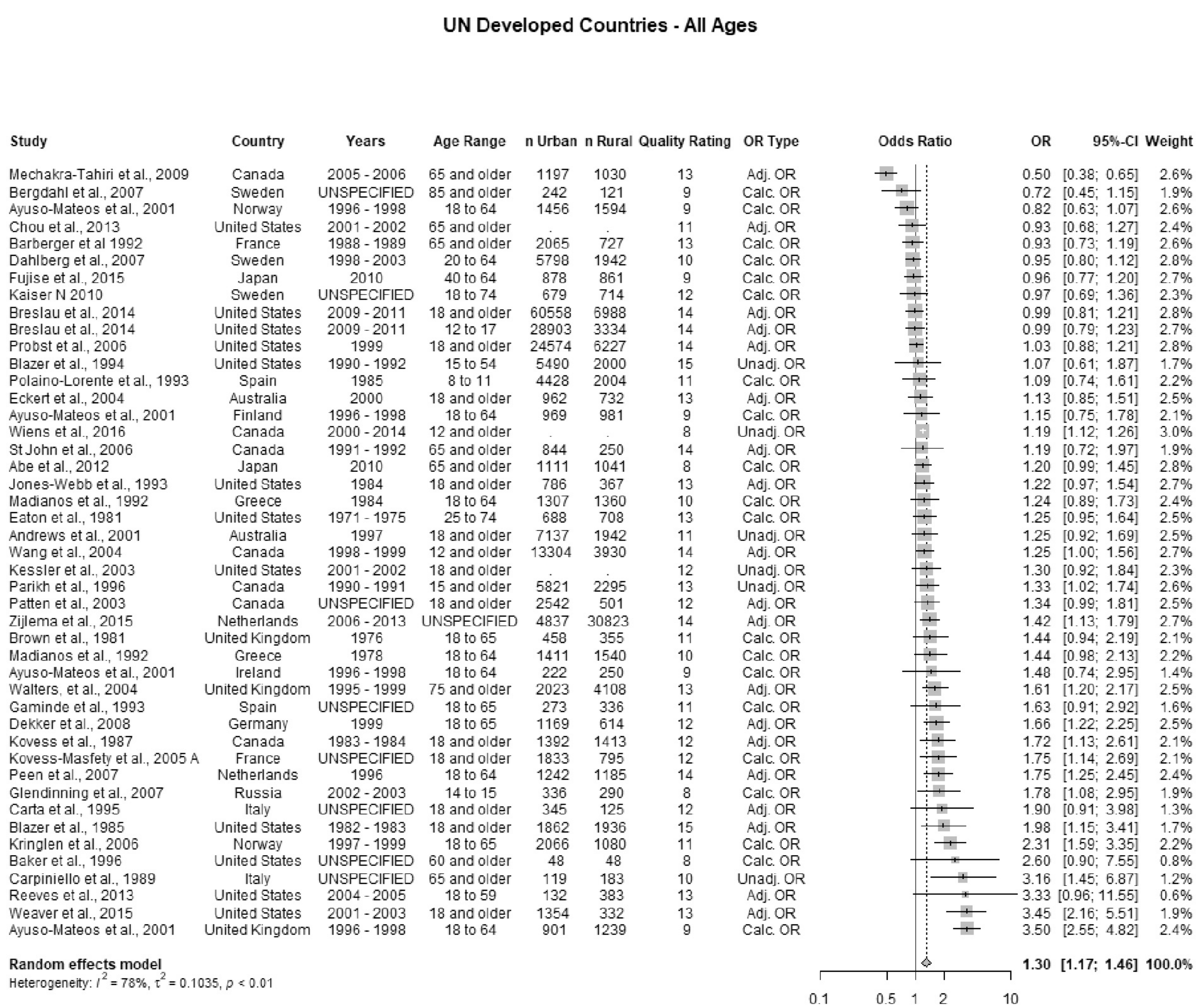

Fig. 2. Odd of depression between urban vs. rural residents. Developed Countries.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

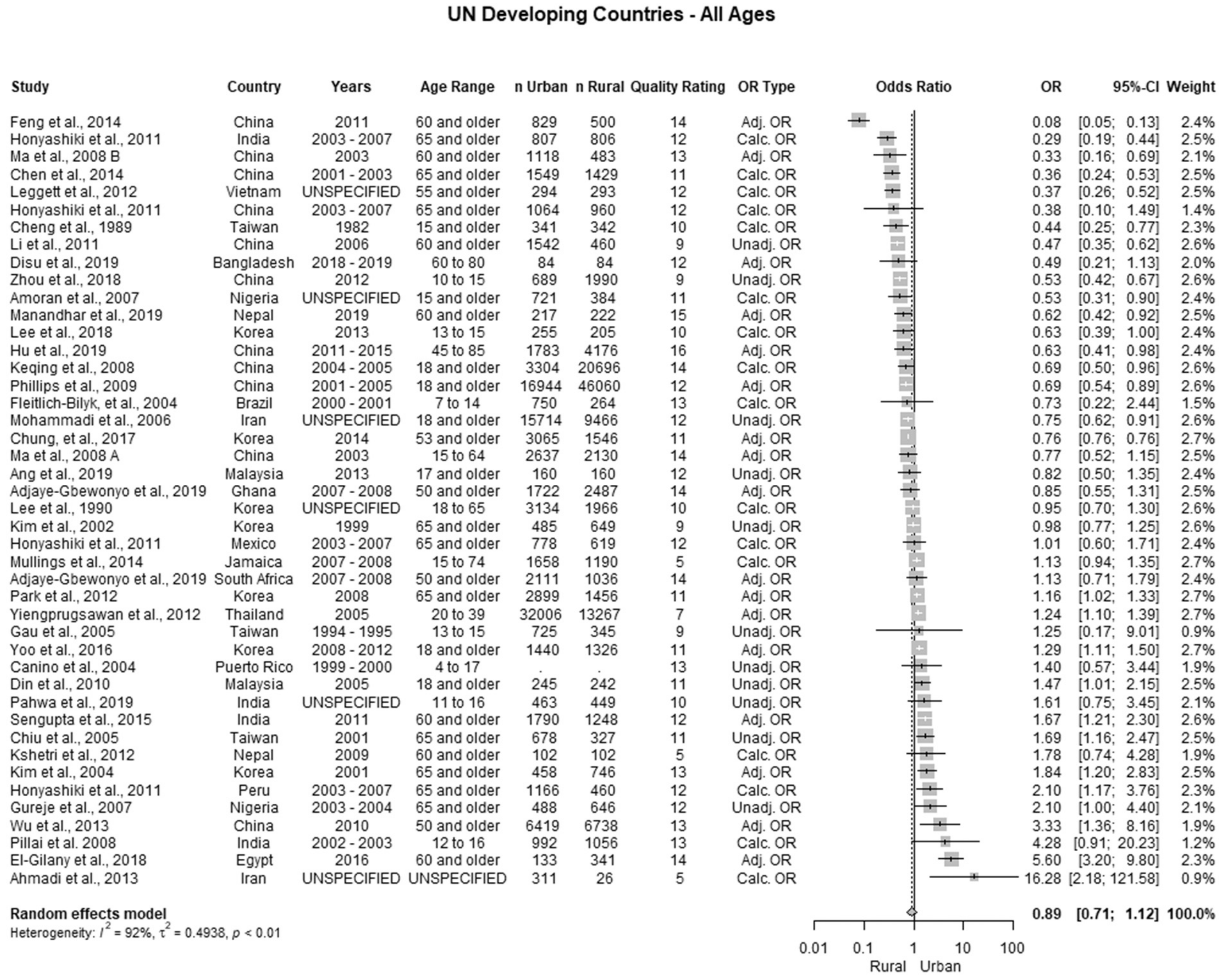

Fig. 3. Odd of depression between urban vs. rural residents. Developing Countries.

Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

urbanicity on depression for the general population ($OR = 0.89$, 95 % CI [0.72, 1.09], $z = -1.15$, $p = .25$; considerable heterogeneity, $I^2 = 85$ %, $\tau = 0.09$, $p < .01$), older adults ($OR = 0.90$, 95 % CI [0.62, 1.31], $z = -0.53$, $p = .59$; considerable heterogeneity, $I^2 = 93$ %, $\tau = 0.84$, $p < .01$), or child/adolescent ($OR = 0.90$, 95 % CI [0.60, 1.33], $z = -0.54$, $p = .59$; substantial heterogeneity, $I^2 = 61$ %, $\tau = 0.16$, $p < .01$) age demographics. See Figs. 7-9.

3.2. Meta-regression findings

14 studies did not report a year of data collection and were thus excluded from the meta-regression analyses.

For developed countries, there was no statistically significant effect of year of data collection on the relationship between urbanicity and depression ($b = -0.006$, 95 % CI [−0.018, 0.006], $z = -1.02$, $p = .30$). Neither were there significant effects for the general population ($b = -0.004$, 95 % CI [−0.017, 0.010], $z = -0.52$, $p = .60$), older adult ($b = -0.013$, 95 % CI [−0.058, 0.032], $z = -0.55$, $p = .58$), or child/adolescent ($b = 0.001$, 95 % CI [−0.047, 0.048], $z = 0.02$, $p = .98$) age demographics of developed countries.

For developing countries, there was no statistically significant effect of year of data collection on the relationship between urbanicity and depression overall ($b = 0.0045$, 95 % CI [−0.033, 0.042], $z = 0.23$, $p = .81$). However, within the general population demographic of developing countries, there was a statistically significant effect of year of data collection on the relationship between urbanicity and depression, such that urban living was associated with an increasingly greater prevalence of depression the more recently data was collected ($b = 0.046$, 95 % CI [0.018, 0.073], $z = 3.24$, $p = .001$). See Fig. 10, and refer to Appendix C for sensitivity analyses.

The effect of year of data collection on the relationship between urbanicity and depression for the child/adolescent age demographic ($b = -0.055$, 95 % CI [−0.108, −0.002], $z = -2.03$, $p = .04$) did not reach significance when corrected for multiple comparisons at the Bonferroni corrected alpha level of $\alpha = 0.00625$. There was no significant effect of year of data collection on the relationship between urbanicity and depression for older adults ($b = 0.003$, 95 % CI [−0.066, 0.071], $z = 0.072$, $p = .94$).

3.3. Funnel plot analyses

Funnel plot analyses revealed heterogeneity between studies, justifying the use of random effects models. Further, we saw no asymmetries that indicated systematic publication bias. See Supplemental Figures. Trim-and-fill sensitivity analyses are reported in Appendix D.

3.4. Study quality ratings

The median quality rating was 12 points out of a possible 16. Most studies lost quality rating points on the description of the handling of missing values and the adjustment of confounding variables. Many studies did not include detailed description of how they handled missing

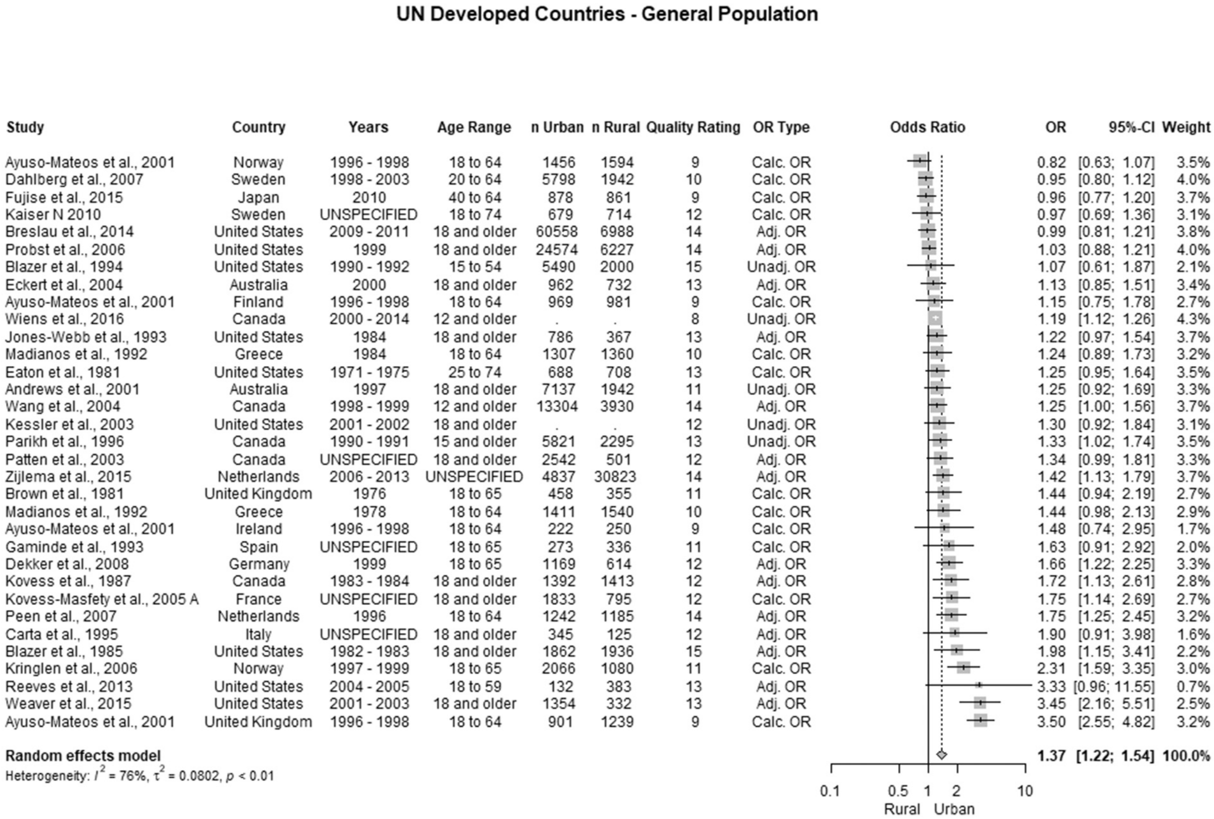

Fig. 4. Odd of depression between urban vs. rural residents. Developed countries, general population.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

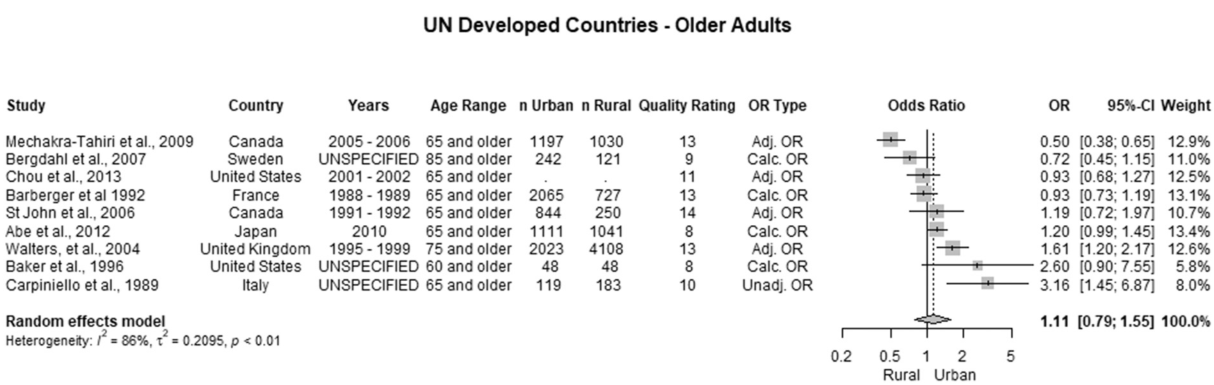

Fig. 5. Odd of depression between urban vs. rural residents. Developed countries, older adults.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

data. Many studies that reported raw prevalences of depression across rural and urban areas as part of demographics did not adjust for confounding covariates in the relationship between urbanicity and depression. Study quality was not significantly associated with the effect of urbanicity on the prevalence of depression (all *ps* > 0.05). Study quality ratings are reported in Figs. 2-9.

4. Discussion

The present study finds evidence that, in developed countries, urban living is associated with a greater prevalence of major depressive disorder than rural living. This effect appears to be primarily driven urban-rural differences in the general population demographic of developed countries, where urban residence was associated with a 1.37 times greater odds of depression compared to rural residence. This effect of urbanicity on the prevalence of depression was not detected for the general population of developing countries, or for older adult or child/adolescent samples.

This relationship between urbanicity and prevalence of depression appears to remain unchanged over time for developed countries. Interestingly, we found that this effect shifted over time for the general population demographic of developing countries, such that studies using older data showed a greater prevalence of depression in rural areas, while studies using more recent data showed a greater prevalence of depression in urban areas.

We saw high heterogeneity between included studies, which is

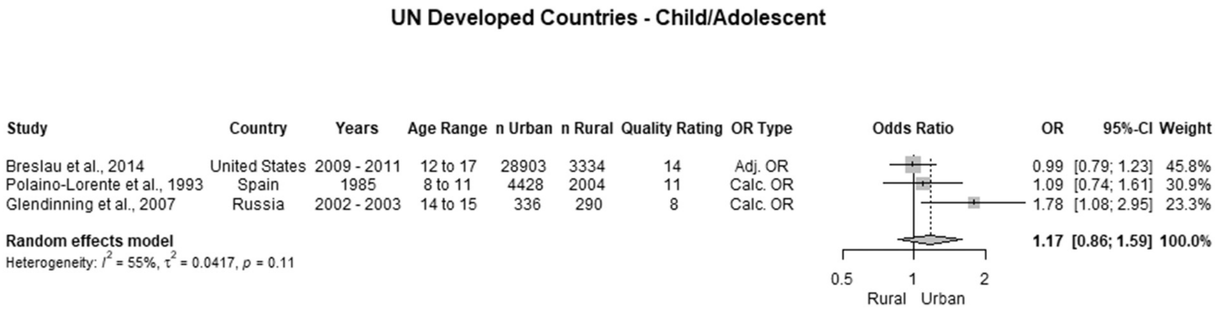

Fig. 6. Odd of depression between urban vs. rural residents. Developed countries, child/adolescent.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

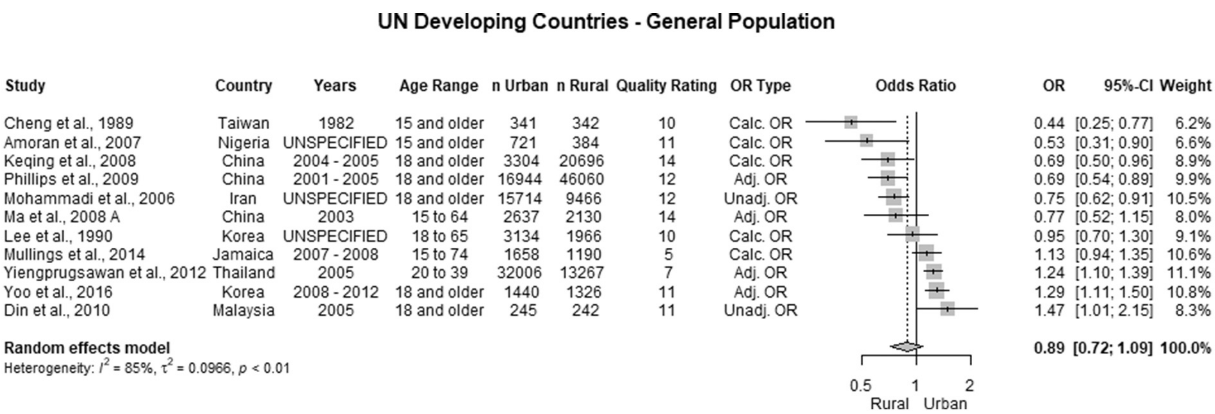

Fig. 7. Odd of depression between urban vs. rural residents. Developing countries, general population.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

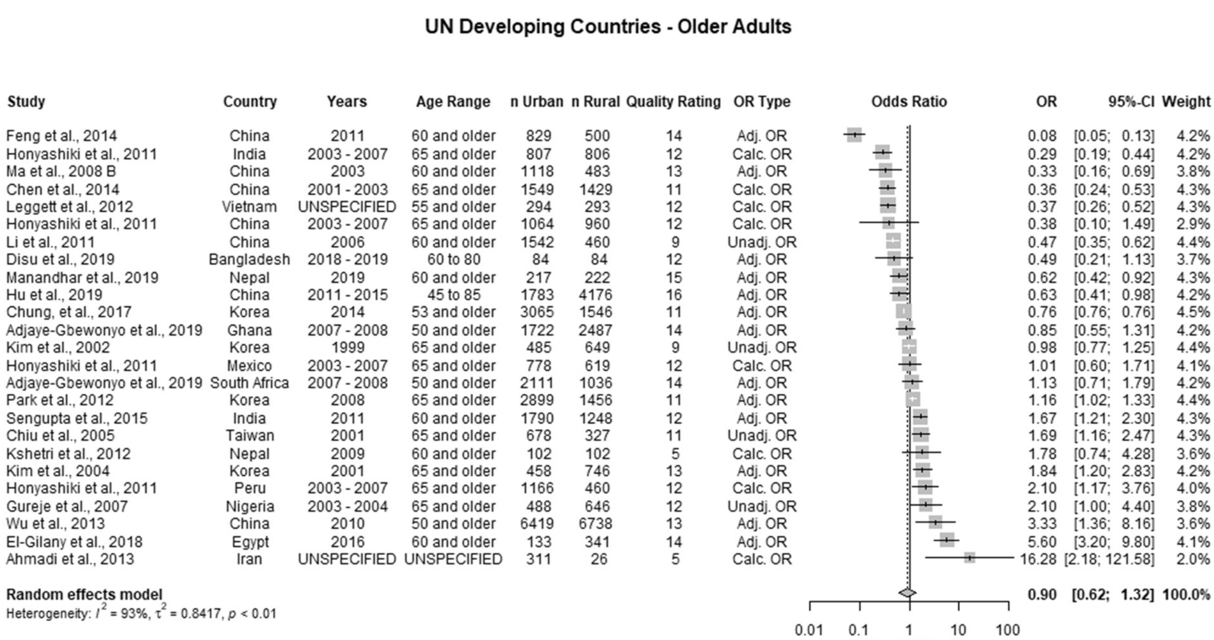

Fig. 8. Odd of depression between urban vs. rural residents. Developing countries, older adults.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

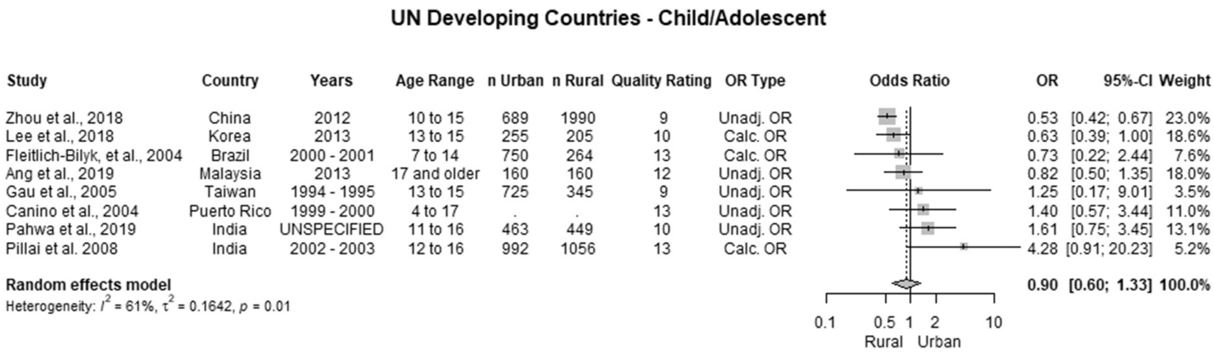

Fig. 9. Odd of depression between urban vs. rural residents. Developing countries, older adults.
Note: Weights are from random effects model. Years refers to reported years of data collection. OR Type: Adj. OR, published adjusted odds ratio; Unadj. OR, published unadjusted odds ratio; Calc. OR, odds ratio calculated from reported depression prevalences and sample sizes. See heterogeneity test statistics in the bottom left.

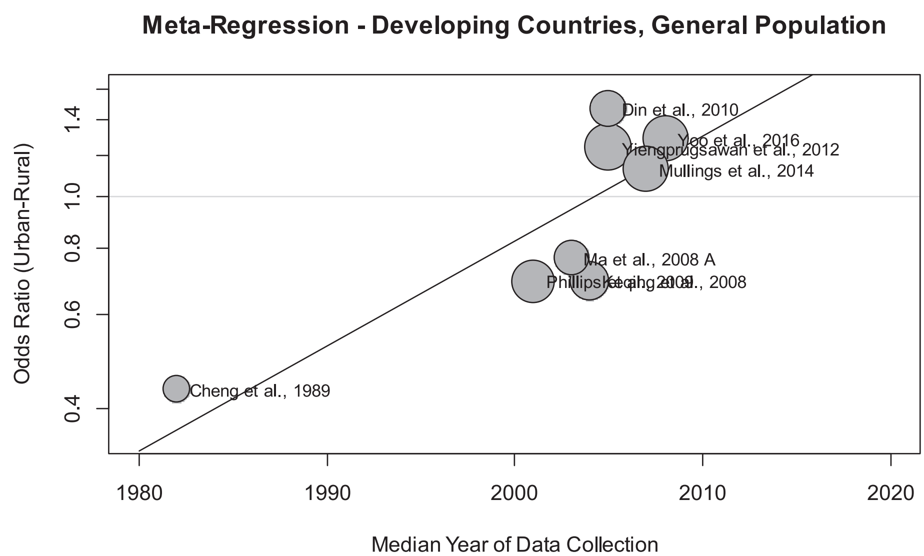

Fig. 10. Meta-regression analyses, effect of reported year of data collection on the observed relationship between urbanicity and depression prevalence. Studies without reported year(s) of data collection are excluded. Developing countries, general population.

understandable given the diversity of measures used and countries included. Trim-and-fill analyses (see Appendix D) revealed that the primary finding – that urban areas are associated with a greater prevalence of depression for the general population demographic of developed countries – remained consistent in spite of adjustments for publication bias. Nevertheless, given the substantial heterogeneity observed between studies, one is to be cautioned in the interpretation of trim-and-fill analyses; specifically, the Cochrane manual explicitly warns that "[this] method is known to perform poorly in the presence of substantial between-study heterogeneity." (Peters et al., 2007; Sterne et al., 2017).

According to our funnel plot analyses, we saw no indication of systematic publication biases. This is unsurprising, given that a large number of studies that we included were not interested in examining the effect of urbanicity on prevalence of depression as a primary question. That is, the risk of publication bias is greater when conducting a meta-analysis of studies where researchers are actively looking for an effect. For example, in the case of treatment studies, where the goal of each individual study is typically to detect or measure the effect of treatment against a comparison group, the risk of publication bias is greater because null results are less likely to be published (Cuijpers et al., 2010; Sterne et al., 2011).

However, in our case, many of the studies included in our meta-analysis were already examining depression prevalence as part of a general population survey, and simply recorded urbanicity among the many assessed demographic features. Because the effects of urbanicity on depression was not a primary question of many of these surveys, we can assume that the risk of publication bias is minimized (relative to treatment studies), as the detection or non-detection of an urbanicity effect on depression is likely to not have significantly impacted the likelihood of publication of these surveys.

One limitation is that we used UN categories to categorize countries as developed or developing. We had one study conducted in Russia, which is defined as an economy in transition. While we treated Russia as a developed country for the purposes of our analyses, this decision was arbitrary. That said, the only study in Russia was of a child/adolescent sample, and because there were few studies of urban-rural differences in depression for children/adolescents, reclassifying Russia as either or a developed or developing country did not significantly impact our findings or conclusions in any appreciable way.

Our study is the first meta-analysis to examine the global relationship between urban vs rural living on the prevalence of depression across all age demographics. We replicated Peen et al.'s (2010) finding that, for the general population among developed countries, urban living is associated with a greater prevalence of major depressive disorder. (There were slight differences in our study; for instance, the ESEMeD study (Kovess-Masféty et al., 2005) included by Peen et al. was excluded in our present meta-analysis because it reported urban-rural differences in depression in aggregate with mood disorders). However, we failed to replicate Purtle et al.'s (2019) finding that depression among older adults was higher in urban areas than rural areas. This replication failure is explained in detail in Appendix E, but in short, it is attributed to differences in study inclusion criteria, data processing, and the addition of more research reports in our study.

Previous studies have attempted to quantify urban-rural differences in depression prevalence within individual countries on a finer scale. For instance, urban-rural differences in depression have been examined using Geographical Information Systems (GIS) techniques, with studies conducted in Spain (Salinas-Pérez et al., 2012), South Africa (Tomita et al., 2017), and Belgium (Pelgrims et al., 2021), generally finding that proximity to urban areas is associated with greater odds of depression. Finer geographic analyses on the effects of urbanicity on depression in the United States remain mixed. For example, Stier et al. (2021) created a model using geographical data from Twitter and the National Survey on Drug Use and Health, arguing that larger cities are protective from depression. However, Huth et al. (2022) showed that, using the same dataset, different model parameter specifications can reveal an opposite effect: such that closer proximity to urban areas can be associated with an increased risk of depression.

Nevertheless, the relationship between urban living and poorer mental health outcomes has long been recognized by a breadth of researchers (Dohrenwend and Dohrenwend, 1974; Faris and Dunham, 1939; Kaczynski, 1995; Marsella, 1998; Mueller, 1981; Pollock, 1925; Verheij, 1996). As Peen et al. (2010) explain, there are two main theoretical concepts for explaining disparities in mental health outcomes between urban and rural areas: a drift hypothesis, where movement of healthy and unhealthy individuals explains the urban-rural disparity in prevalence of psychiatric disorders; and the other, a breeder hypothesis, where features of urban living are inextricably tied to causal risk factors for psychiatric disorders.

Regarding the drift hypothesis, it is possible that people with depression are more likely to actively move from rural areas to urban areas, for example, (a) due to greater availability of psychological treatment services in urban areas (Morales et al., 2020), or (b) from reduced stigma around psychiatric illness in urban areas (Rost et al., 1993; Stewart et al., 2015). To address (a), our meta-analysis criteria specifically excluded studies that measured treatment utilization. To address (b), we included only studies that assessed prevalence using standardized measures or formal diagnoses of depression, such that reporting biases due to stigma should be minimized. Nevertheless, we had no way to account for possible historic migration to and from urban or rural areas, as the majority of studies simply reported participant's current urban or rural residence.

Regarding the breeder hypothesis, as Ventriglio et al. (2021) summarize in their review, urban living is associated with social disparities, economic insecurity, pollution, and a lack of contact with nature, all of which can adversely affect mental health. Indeed, psychiatrists have long recognized the impact of social and economic inequalities on mental health (Patel et al., 2018). Newer evidence further suggests that fundamental features of urban living, such as proximity to roads (Orban et al., 2016; Pun et al., 2019), lack of greenspace (Gonzales-Inca et al., 2022; Kondo et al., 2018), light pollution (Cao et al., 2023; Kumar et al., 2019), noise pollution (Hegewald et al., 2020; Seidler et al., 2017), and air pollution (Gładka et al., 2018; Pelgrims et al., 2021) are associated with poorer mental health outcomes, including risk for depression. Other factors unique to urban and not rural living, such as overcrowding, which have long been known to produce deleterious effects in animal models (Calhoun, 1962), have now recently been found to correlate with depression in people (Pengcheng et al., 2021; Sarkar et al., 2021; Wang and Liu, 2023).

More research is needed to disentangle whether the drift or breeder effect – or both together – are driving the differences in depression prevalence between urban and rural areas. It is also worth considering that differences in the *prevalence* of depression between urban and rural populations does not necessarily reflect differences in *incidence* of depression. For a given incidence of a disorder, differences in prevalence between populations may be observed when the duration of a disorder is longer one population than another, indicating a greater individual disorder burden in the population with a greater prevalence (Celentano and Szklo, 2018).

Nevertheless, our findings reveal an interesting difference between developed and developing countries. Whether a drift or breeder effect, it appears the factors contributing to higher prevalences of depression in urban areas is predominantly concentrated in the general adult population of developed countries, and not that of developing countries. The reason for why a relationship between urbanicity and depression is observed in developed countries, but not developing countries remains unclear. Previous research has suggested that the risk factors and protective factors for depression may differ between developing and developed countries (Bromet et al., 2011; Kessler and Bromet, 2013). For instance, Bromet et al. (Bromet et al., 2011) found that the correlations between age, income, and marital status and depression varied between low-, middle-, or high-income counties. Van der Wal et al. (van der Wal et al., 2021) also suggest that differences in the degree of urban-rural divide between developed and developing countries may contribute to differential exposure to risk factors (e.g., poor housing) and protective factors (e.g., treatment availability). For instance, a stronger drift effect could emerge in developed countries where individual incomes are high enough to facilitate freedom of movement from rural to urban areas (Purtle et al., 2019). Alternatively, the general dearth of mental health treatment services in lower income countries may reduce potential drift effects if it is difficult to obtain mental health services regardless of whether an individual lives in an urban or rural area (Eaton et al., 2011; Rathod et al., 2017). Curiously, other researchers have noted that, compared to richer countries, urban living in poorer countries may be associated with a greater exposure to public health risk factors such as poverty, poor diet, and other environmental hazards (Kuddus et al., 2020). This suggests that the existence of an urbanicity effect in developed countries – but not in developing countries – is likely due to a complicated relationship between both drift and breeder effects. More research is needed to identify how the factors that contribute to an association between urbanicity and depression in developed countries (Hoare et al., 2019; Sampson et al., 2020; Ventriglio et al., 2021) may differ in developing countries.

Curiously, we found that the relationship between urbanicity and depression within developing countries appears to be changing over time, such that, while older studies reveal a greater prevalence of depression in rural populations, newer studies show a greater prevalence of depression in urban populations. If this finding is not spurious, it suggests that the risks of modern living that have contributed to the greater urban depression in developed countries may be gradually beginning to impact developing countries as these countries modernize.

CRediT authorship contribution statement

Colin Xu: Study Conceptualization, Study Design, Meta-Analysis Data Collection, Data analysis, Writing – original draft, review & editing,

Lucille Miao: Meta-Analysis Data Collection, Study Design, Data Analysis, Writing – original draft, review & editing.

Devon Turner: Meta-Analysis Data Collection, Study Design, Data Analysis, Writing – review & editing.

Robert DeRubeis: Supervision, Study Design, Writing – review & editing.

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Declaration of competing interest

The authors report no conflicts of interest directly related to this work.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2023.08.030.

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