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Title: Urban-Rural Differences in Older Adult Depression: A Systematic Review and Meta-analysis of Comparative Studies

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Abstract: Context: Depression among older adults (≥age 60) is a problem that could be exacerbated by global trends in urbanization and population aging. The study purpose was to assess whether urban, relative to rural, residence is associated with depression among older adults and whether associations differ in countries with developed versus developing economies.

Evidence Acquisition: In 2017, we identified and extracted information from comparative studies of urban-rural depression prevalence among older adults. Studies were identified in PubMed, PsychINFO, and Web of Science and limited to English language articles published after 1985. Eighteen studies met inclusion criteria. Random effects meta-analysis was conducted to produce weighted pooled odds ratios (ORs) estimating the association between urban-rural residence and depression for all study participants (N=31,598) and sub-analyses were conducted for developed (n=12,728) and developing (n=18,870) countries.

Evidence Synthesis: Depression prevalence was significantly higher among urban residents in ten studies and significantly higher among rural residents in three studies (all three conducted in China). Associations between urban-rural residence and depression generally remained significant after adjusting for covariates. In developed countries, the odds of depression were significantly higher among urban than rural residents (pooled OR=1.44, 95% CI=1.10, 1.88). However, in developing countries, this association was not observed (pooled OR=0.91, 95% CI=0.46, 1.77).

Conclusions: Converging trends of urbanization and population aging could increase the global burden of depression among older adults. The pathways through which urban-rural residence influences depression risk among older adults might differ by county context. Future research should focus on measuring variation in these contexts.

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Urban–Rural Differences in Older Adult Depression: A Systematic Review and Meta-analysis of Comparative Studies

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Context: Depression among older adults (aged 60 years or older) is a problem that could be exacerbated by global trends in urbanization and population aging. The study purpose was to assess whether urban, relative to rural, residence is associated with depression among older adults and whether associations differ in countries with developed versus developing economies.

Evidence acquisition: In 2017, the authors identified and extracted information from comparative studies of urban–rural depression prevalence among older adults. Studies were identified in PubMed, PsychINFO, and Web of Science and limited to English language articles published after 1985. Eighteen studies met inclusion criteria. Random effects meta-analysis was conducted to produce weighted pooled ORs estimating the association between urban–rural residence and depression for all study participants (N=31,598) and sub-analyses were conducted for developed (*n*=12,728) and developing (*n*=18,870) countries.

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Conclusions: Converging trends of urbanization and population aging could increase the global burden of depression among older adults. The pathways through which urban–rural residence influences depression risk among older adults might differ by country context. Future research should focus on measuring variation in these contexts.

CONTEXT

Human longevity is increasing, and the demographic composition of societies is aging. Between 2015 and 2050, global life expectancy at birth is projected to increase from 70 to 77 years.[1] By 2050, the proportion of the world's population aged more than 60 years is projected to double and the proportion aged more than 80 years is projected to triple.[2,3] In Europe, the proportion of the population aged more than 60 years is expected to increase from 24% to 34% between 2015 and 2050. Increasing trends are also expected in Latin America (from 11% to 26%), North America (from 21% to 28%), and Asia (from 12% to 25%).[3] These increases in longevity pose challenges for policymakers as they are forced to address the implications of population aging within the context of other societal changes. As Beard and Bloom describe, "Population ageing is not taking place in isolation. Other broad social changes are transforming society…. Understanding the interplay between these trends is crucial if policymakers are to make the best decisions to promote the health and wellbeing of older people."[4]

Urbanization and urban migration are social changes that are important to understand within the context of population aging. The proportion of the world's population living in cities increased from 43% to 54% between 1990 and 2014 and is projected to increase to 66% by 2050.[1] Rates of urbanization are accelerating fastest in countries with developing economies. For example, between 2014 and 2050, the proportion of people living in cities is projected to increase from 40% to 56% in Africa and from 48% to 66% in Asia, compared with increases from 73% to 82% in Europe and 80% to 86% in North America.[1] As trends in population aging, urbanization, and urban migration converge, there is an increasing need for evidence about how urban contexts can maximize the health benefits, and minimize the health risks, of cities for older adults.[5–8]

Although urban–rural differences in the physical health of older adults have been the focus of numerous initiatives,[5–8] questions regarding how city living influences the mental health of older adults have received less attention. Such questions are important because the risk and protective factors for mental health conditions change as people age.[9] Moreover, a substantive body of research suggests that urban residence increases risk for mental health conditions and that rates of mental health conditions are generally higher in urban than rural areas.[10–16]

However, the dynamics through which urban residence influences mental health are complex and likely to vary for different mental health conditions, populations, and country contexts.[10,17] Depression is one mental health condition for which the social and physical characteristics of cities could increase the risk for, or be protective against, depression among older adults.

Depression Among Older Adults

Systematic reviews and meta-analyses estimate that the global prevalence of major depressive disorder (MDD) is in the range of 1% to 5% among adults aged 65 years or older.[18–24] Global estimates of the prevalence of clinically significant depressive symptoms (CSDSs), which do not meet the full criteria for MDD, among adults aged 65 years or older hover around 15%.[18,23,25–27]

Although the prevalence of MDD and CSDS among older adults are similar to that of middle-aged adults, depression among older adults has widely been recognized as a public health priority for at least two reasons.[27,28] First, the consequences of depression are more severe among older adults than among their middle-aged counterparts. In addition to adversely affecting quality of life, depression among older adults substantially increases the risk for myriad adverse

outcomes—including physical health problems, suicide, mortality, and reduced physical, cognitive, and social functioning.[18,20,27,29–34] For example, the association between MDD and suicide is stronger among older adults than any other age group[18] and at least eight prospective studies have found that CSDSs increase risk for subsequent physical limitations.[27]

Second, depression is potentially more preventable among older adults than their younger counterparts. Approximately half of cases of MDD among older adults are new cases experienced by people who never had MDD earlier in life.[18,35,36] These older adults are also less likely to have a family history of depression.[18,37] This suggests that depression among older adults is less influenced by inherited genetic factors and more influenced by social and environmental factors.[9]

Potential Importance of Urban Versus Rural Residence

An integration of findings from the fields of geriatric psychiatry and urban health reveals numerous pathways through which features of cities could increase depression risk among older adults or, alternatively, be protective against depression. For example, urban environments could increase depression risk via disrupted sleep. Poor sleep is one of the strongest risk factors for depression among older adults[38,39] and could be exacerbated by urban environments because excessive exposure to artificial light at night is more prevalent in urban than rural areas and disrupts sleep quality.[10,40–43] Urban residence could also increase depression risk via direct and indirect exposure to neighborhood crime. Negative perceptions of neighborhood safety are strong risk factors for depression among older adults[44–48] and violent crime rates are generally higher in urban than rural areas.[49]

Alternatively, some features of urban environments could reduce depression risk among older adults. For example, physical inactivity[50–55] and social isolation[18,23,56] are strong risk factors for depression among older adults. Public transportation networks and walkable streetscapes, which are generally both more robust in urban than rural areas, could reduce these risk factors by facilitating physical activity, active transport, and social connectivity.[51,57–62]

Potential Differences Between Countries With Developed Versus Developing Economies

It is plausible that the direction of an association between urban–rural residence and depression differs in countries with developed versus developing economies because the characteristics of urban and rural environments might vary across these contexts. For example, residents of rural areas in developed countries are likely to have some access to mental health services, whereas residents of rural areas in developing countries might have no access because services are exclusively concentrated in urban areas.[63] Residents of urban areas in developed countries are likely to have access to public transportation, whereas residents of urban areas in developing counties might not have such access and rely on walking as their primary mode of transit.[64,65] The importance of country context when considering the pathways through which urban and rural environments influence mental health is highlighted by a 2018 study of 42 low- and middle-income countries which found no association between urban (versus rural) residence and psychosis—a finding contrary to the well-established relationships between urban residence and psychosis that is typically observed in high-income countries.[17] This and other findings have promoted calls for greater examination of how the influence of urban and rural environments on mental health might vary between country contexts.[66]

Study Purpose

Reviews have examined various aspects of depression among older adults and identified individual and neighborhood-level risk and protective factors.[23,25–27,30,32,38,44,50,67–70] However, with the exception of one meta-analysis of studies in China published nearly 20 years ago,[71] evidence of the association between urban–rural residence and depression among older adults has not been systematically assessed or integrated. The purpose of this study was to address this knowledge gap and provide directions for future research. A systematic review and meta-analysis were conducted of comparative studies focused on urban–rural differences in depression (including both MDD and CSDSs) among older adults aged 60 years or older. The specific aims are to: assess whether urban versus rural residence is associated with depression among older adults; identify factors that are significantly associated with depression among urban but not rural older adults, and vice versa; and assess whether the association between urban–rural residence and depression differs between developed and developing countries.

EVIDENCE ACQUISITION

Search Strategy

The present review was conducted in accordance with PRISMA guidelines. In July 2017, the authors searched PubMed, PsychINFO, and Web of Science for articles that mentioned any of the following combinations of terms in the title, abstract, or keywords: (*depression* OR *depressive*) AND (*elderly* OR *older adult* OR *late life*) AND (*urban* OR *city* OR *cities* OR *metropolitan* OR *urbanization*) AND (*rural* OR *countryside*). The selection of these terms was informed by those used in prior reviews of depression among older adults[23,25–27,30,32,38,44,50,67–71] and urban–rural differences in mental health.[10–16] The search was limited to articles published in

English since 1985. After removing duplicates, this search identified 170 articles that were screened for inclusion (Figure 1).

Inclusion/Exclusion Criteria

Two authors read the abstracts of the 170 articles and screened for inclusion. Articles were included if they assessed urban–rural differences in MDD and CSDSs among older adults aged ≥60 years. Studies that focused only on urban or rural populations, without considering urban–rural differences, were excluded. Moreover, non-empirical articles (e.g., commentaries), exclusively qualitative studies and studies limited to clinical interventions, institutionalized populations, or caregivers of older adults were excluded.

Thirty-nine articles met screening criteria. The full texts of these articles were obtained, reviewed by the two coders, and excluded if they did not meet screening criteria or did not present data on the prevalence of MDD or CSDSs among adults aged ≥60 years stratified by urban–rural residence. When articles met all inclusion criteria but did not present information on urban–rural differences in depression prevalence (n=2), the study's authors were contacted and the article was included if the information could be obtained (n=1). This process resulted in 18 articles that were included in the meta-analysis.

Data Extraction, Quality Assessment, and Analysis

For each article, information was extracted on the characteristics of study participants (e.g., age, country), instruments and scoring thresholds used to assess depression, definitions of urban–rural residence, and sample size. When available in studies that used multivariable regression, information was extracted on the AOR of urban–rural depression prevalence and the variables

that were adjusted for in the final model. Information was also extracted on variables that were significantly associated with depression risk among urban but not rural older adults, and vice versa.

Authors assessed the methodologic quality of each study on nine domains using a quality assessment instrument (Appendix 1) adapted from the review by Luppa and colleagues[69] of depression prevalence among older adults. Two authors independently reviewed the 18 studies and each domain was scored as 2 if criteria were fully met, 1 if partially met, and 0 if not met. An aggregate quality score was then calculated for each study. Studies in the >75th percentile (score ≥14) were coded a high quality, those in the 50th to 75th percentile (score 9–13 were coded as moderate quality, and those in the <50th percentile (score ≤8) were coded as low quality.

Using the definitions of depression and urban–rural residence from each study, information on the number of depressed and non-depressed older adults in the urban and rural populations, respectively, were extracted. Outcomes of MDD and CSDSs were combined because there were substantial differences in how these two outcomes were operationalized across studies and because this study's aims were focused on assessing the relative association between urban–rural residence and depression among older adults—not on estimating depression prevalence in urban and rural areas.

Using data on the number of depressed and non-depressed older adults in the urban and rural populations of each study, random effects meta-analysis was conducted using the "metan"

command in Stata, version 17 to produce weighted pooled ORs with 95% CIs estimating the association between urban–rural residence and depression. A random effects model was used because the characteristics of urban and rural environments and study populations were assumed to vary substantially between studies and because I^2 statistics demonstrated high heterogeneity between studies (i.e., >75%).[72] Weighted pooled ORs were produced for all studies together and also separately for studies conducted in countries with developed and developing economies, based on the UNs' World Economic Situation and Prospects classifications.[73] Forest plots were created to display results.

To conduct sensitivity analysis, authors systematically assessed the influence of each study on the pooled results by producing weighted pooled ORs without each individual study. This was carried out for all studies together and separately for countries with developed versus developing economies. To assess publication bias, funnel plots were created and Egger's tests were conducted.[74]

EVIDENCE SYNTHESIS

Study Characteristics

Appendix Table 1 summarizes the characteristics, methodologic quality, and results of the 18 studies.[75–92] Nine studies were conducted in developed countries (Japan, U.S., Sweden, Italy, Canada, Great Britain) and nine were conducted in developing countries (Iran, China, Taiwan, Peru, Mexico, Venezuela, South Korea, India). Study sample size ranged from 86 to 6,178 and the median sample size was 1,169.

Seven studies were coded as high quality, eight were moderate quality, and three were low quality. The quality of studies was similar for those conducted in developed and developing countries. There were substantial differences in how depression outcomes and urban–rural residence were operationalized across studies. Six different instruments were used to assess depression. The 15-item Geriatric Depression Scale was used most frequently (six studies), but five different scoring thresholds were used with the scale to classify older adults as having CSDSs (threshold range, ≥5 to ≥9). Five studies used the addresses of study participants and national urban–rural classification systems (e.g., U.S. Census Bureau definitions, Chinese Hukou System designations) to classify participants as urban or rural and four included information about the population density of urban–rural classifications.

Unadjusted Associations From Individual Studies

The study prevalence of depression was significantly higher among urban residents in ten studies, significantly higher among rural residents in three studies, and there was no significant difference between the urban and rural residents in five studies. All studies in which depression was significantly higher among rural residents were conducted in China, which was classified as a developing country. The strength of the association between urban–rural residence and depression varied dramatically between studies. Among individual studies conducted in developed countries, the unadjusted OR of depression between urban and rural (ref) residents ranged from 0.72 (95% CI=0.45, 1.15)[78] to 4.29 (95% CI=1.84, 9.99).[89] Among individual studies conducted in developing countries, the ORs ranged from 0.09 (95% CI=0.06, 0.15)[82] to 16.36 (95 % CI=2.19, 122.28).[76]

Pooled Analyses

When the results of all 18 studies were pooled (N=31,598), the study prevalence of depression was not significantly different between urban (10.2%) and rural (10.7%) residents (chi-square p=0.168). The pooled OR from random effects meta-analysis was 1.18 (95% CI=0.84, 1.65). I^2 was 93.4% (chi-square p<0.001), indicating high heterogeneity between studies. A funnel plot (Figure 2) demonstrates that studies fall on both sides of zero with moderate symmetry, suggesting the absence of major publication bias. Egger's test suggested that there was no significant small studies effect (Egger's test p=0.356). In the sensitivity analyses that assessed influence of individual studies, pooled ORs ranged from 1.10 (95% CI=0.78, 1.56) to 1.32 (95% CI=1.01, 1.74).

When the results of all studies conducted in developed countries were pooled (n=12,728), the study prevalence of depression was significantly higher among urban (16.0%) than rural (11.8%) residents (chi-square p<0.001). The pooled OR from random effects meta-analysis was 1.44 (95% CI=1.10, 1.88) with high heterogeneity between studies (I^2=75.3%, chi-square p<0.001; Figure 3). In the sensitivity analysis, pooled ORs for developed countries ranged from 1.32 (95% CI=1.03, 1.68) to 1.56 (95% CI=1.18, 2.07).

When the results of all studies conducted in developing countries were pooled (n=18,870), the study prevalence of depression was significantly lower among urban (7.5%) than rural (9.6%) residents (chi-square p<0.001). The pooled OR from random effects meta-analysis was 0.91 (95% CI=0.46, 1.77) with high heterogeneity (I^2=96.2%, chi-square p<0.001; Figure 4). In the sensitivity analysis, pooled ORs for developing countries ranged from 0.76 (95% CI=0.38, 1.50) to 1.17 (95% CI=0.69, 1.99).

Adjusted Associations From Individual Studies

Nine studies conducted multivariable regression and presented AORs of the association between urban residence and depression.[82,83,85–87,89–92] The variables most frequently included in these models were age (seven studies), gender (six studies), marital status/widowhood (six studies), functional impairment/disability (five studies), education (four studies), income/financial strain (four studies), and housing (four studies). The magnitude, direction, and significance of unadjusted and adjusted ORs were similar in most studies. For example, in the study by Walters et al.[92] of older adults in Great Britain, the odds of depression among urban versus rural residents only increased from 1.40 (95% CI=1.16, 1.69) to 1.61 (95% CI=1.20, 2.17) after adjusting for age, gender, financial strain, housing, physical symptoms, unmet needs in activity of daily living, living alone, and impaired cognition.

Eight studies examined interactions between urban–rural residence and factors associated with depression (i.e., identified factors associated with depression risk among urban but not rural older adults, and vice versa).[75,78,81,83,85,86,88,91] In five of these studies, interactions between rural residence and factors related to social isolation (e.g., living alone, not having any close friends) were present in which isolation-related factors were independently and significantly associated with depression among rural, but not the urban, residents.[75,83,85,86,91] For example, after adjusting for covariates, the study by Abe and colleagues[75] of older adults in Japan found that the odds of depression were 1.28 times higher among older adults with poor social support in rural areas, whereas the association between social support and depression was not significant among those residing in urban areas. Associations between social isolation and depression among rural older adults were identified in studies conducted in developed[75,83,91] as well as developing[85,86]

countries. Results were mixed for other known risk factors for depression among older adults (e.g., poor physical health, financial stress, female gender).

DISCUSSION

Considered holistically, the results of this review and meta-analysis suggest that urban residence might increase depression risk among older adults. Of the 18 included studies, depression prevalence was significantly higher among urban residents in ten studies and significantly higher among rural residents in only three studies (all three conducted in China). Although the review was not designed to elucidate the mechanisms through which urban–rural residence might influence depression, the magnitude of unadjusted and adjusted ORs of urban–rural depression were generally similar in the nine studies that controlled for potential confounders. This suggests that urban and rural environments might have independent effects on depression risk among older adults.

In the pooled sub-analysis of studies conducted in developed countries, the present study found that the odds of depression were significantly higher among older adults residing in urban, as opposed to rural, areas. This finding is very similar to the pooled results of the meta-analysis by Peen et al.[16] of urban–rural differences of depression among people of all ages in developed countries. In the pooled sub-analysis of studies conducted in developing countries, however, the present study found that the odds of depression were not significantly higher among older adults residing in urban than rural areas. This finding is consistent with the results of the meta-analysis by Chen and colleagues[71] (published in 1999) of risk factors for depression among older adults in

China and two more recent studies conducted in China both found that symptom mean scores were significantly higher among rural than urban residents.[93,94]

The finding that the odds of depression appear to be significantly lower among older adults in rural than urban areas of China could partially be the result of mass migration of older adults with greater socioeconomic resources (i.e., lower depression risk) from rural to urban areas.[93,95] Li et al.[93] found that the association between rural residence and depression among older adults in China lost significance after adjusting for socioeconomic factors at household- and community-levels. It is also possible that the elevated prevalence of depression among older adults in rural China could be the result of an "empty nest" trend in which the children of rural older adults are leaving home to work in cities at an accelerated rate.[96] In a sample drawn from older adult empty nest households in China, Su and colleagues[94] found that depression symptoms scores were significantly higher for those in rural than urban areas.

Future research in countries other than China that have rapidly developing economies and are experiencing major trends in rural–urban migration (e.g., India, Nigeria)[1] should test the hypothesis that rural residence is associated with depression among older adults. Relatedly, future research should integrate measures of urban–rural residence and depression into longitudinal studies of older adults to examine how the age at which migration occurs might affect depression risk. In their cross-sectional study of older adults in South Korea, Kim and colleagues[86] retrospectively assessed past urban–rural residence via self-report and found that depression prevalence was higher among those who moved from rural to urban areas between the

ages of 21 and 60 years (20.3%), and after age 60 years (25.5%) than those who lived in urban areas their entire lives (19.3%).

Given the large heterogeneity in the magnitude of associations between urban–rural residence and depression, additional research is needed to understand how social and economic factors might interact with features of urban and rural environments to influence depression risk among older adults. For example, a significant interaction was identified between social isolation, rural residence, and depression in five studies[75,83,85,86,91] and future research should test the hypothesis that social isolation meditates the relationship between rural residence and depression in countries with developing economies. Relatedly, more research is needed about how macro-level factors that vary across countries (e.g., public transportation infrastructure, pensions, access to health care services) might meditate and moderate associations between urban–rural residence and depression.

Limitations

This review and meta-analysis has seven main limitations. First, urban and rural residence was not operationalized consistently between studies. Even within a single country, an inherent challenge to reviews of urban–rural differences in health is the fact that various definitions of urban and rural exist and are accepted—ranging from measures of population density to algorithm-based definitions produced by government agencies.[97,98] This challenge is exacerbated in cross-national reviews because definitions of urban and rural vary dramatically between countries.[99,100] However, country definitions of urban are similar to standardized UN definitions.[17]

Second, there are many different types of urban and rural areas (e.g., agriculture communities versus indigenous communities in the case of rural) and this review did not assess these distinctions. Third, this review was limited to comparative studies that presented data on the prevalence of depression among both urban and rural older adults. Authors limited the review to comparative studies because a wide range of depression instruments and scoring thresholds are used in the literature and limiting the review to comparative studies, in which the same instrument and scoring threshold were applied to both urban and rural groups, allowed authors to ensure that the pooled measures of association would not be biased by systematic differences in how depression was measured between urban and rural groups. This study was also limited to English language peer-reviewed literature and did not include grey literature (e.g., government reports).

Fourth, authors did not differentiate between MDD and CSDSs because there were substantial differences in how these outcomes were operationalized across studies and because the study's aims were focused on assessing the relative association between urban–rural residence and depression among older adults—not estimating depression prevalence in urban and rural areas. Fifth, studies included in this review were only conducted in six developed countries and eight developing countries and the results are not representative of all developed or developing countries.

Sixth, the studies included in the review were published over a 26-year period and pooled results might not reflect recent changes in urban and rural environments. For example, in the U.S., suicide rates are increasing at a faster pace in rural than urban counties and such a trend could

indicate that features of rural environments related to mental health are changing.[101] Finally, it should be emphasized all 18 studies included in the review were cross-sectional and only nine articles presented adjusted estimates of urban–rural depression risk. Thus, the results demonstrate associations between urban–rural residence and depression among older adults but should not be interpreted as implying causality.

CONCLUSIONS

This review of comparative studies generally suggests that converging trends of urbanization, urban migration, and population aging could increase the global burden of depression among older adults. The heterogeneity of results between studies suggests that the nature of the relationship between urban–rural residence and depression among older adults varies across contexts. Future research is needed to identify the specific factors that moderate the impact of urban living on depression and the most effective intervention strategies.

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LIST OF FIGURES

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Figure 2. Funnel plot of urban–rural differences in depression among older adults, 18 studies.

Figure 3. Odds of depression among urban versus rural older adults in developed countries (*n*=12,728).

Notes: Weights are from random effects model. Arrows indicate that the 95% CIs are truncated.

Figure 4. Odds of depression among urban versus rural older adults in developing countries (*n*=18,870).

Notes: Weights are from random effects model.

Figure

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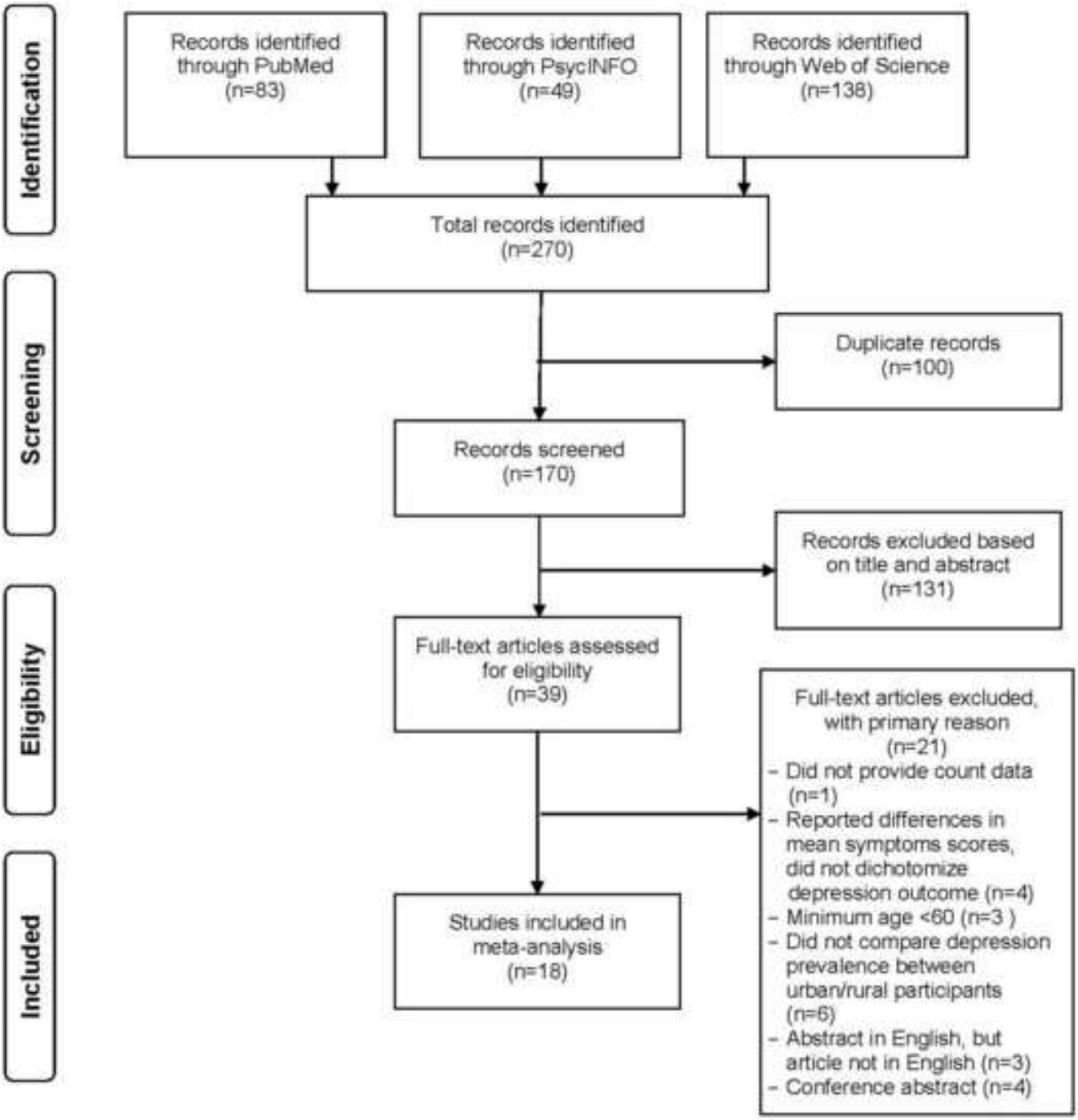

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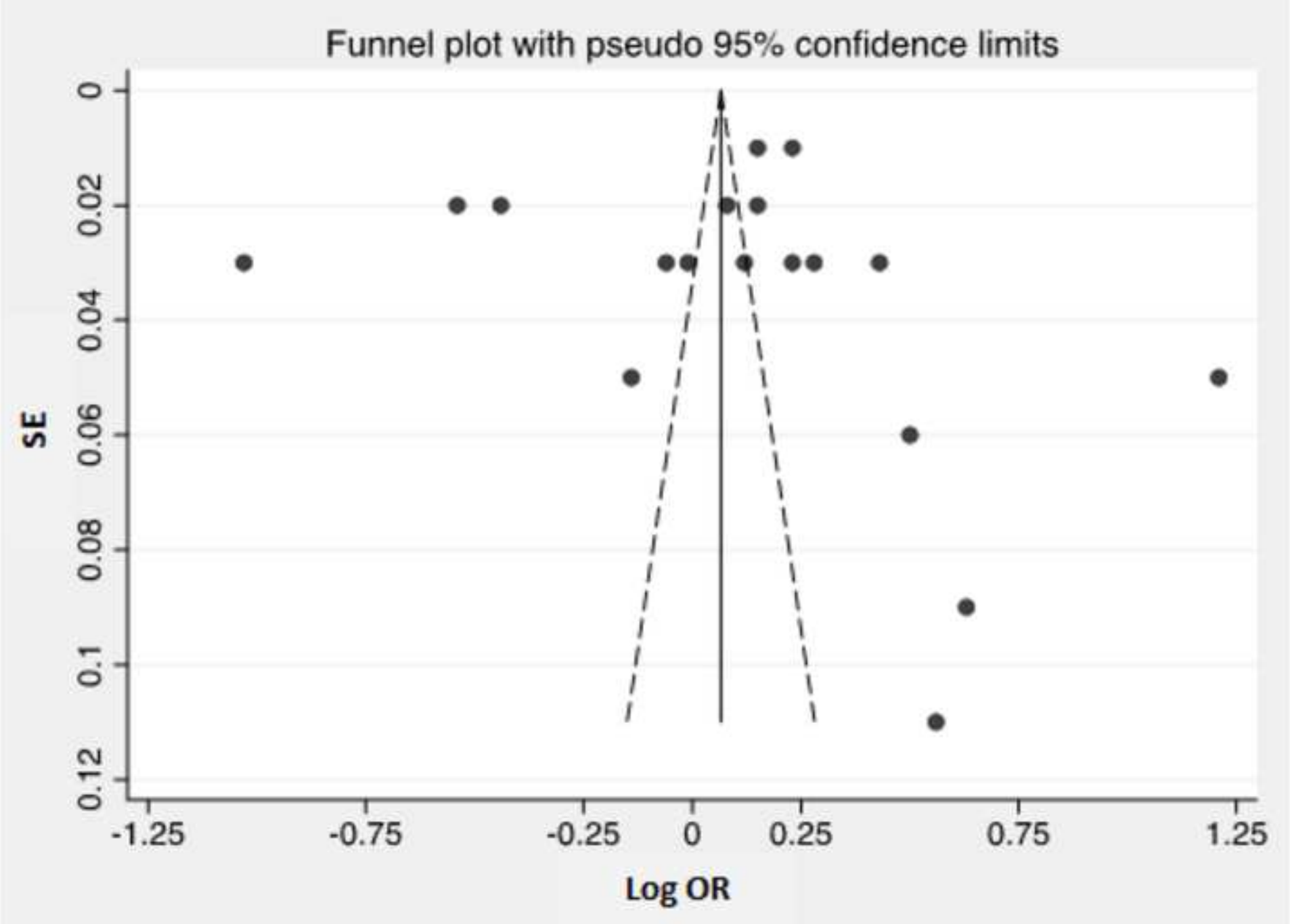

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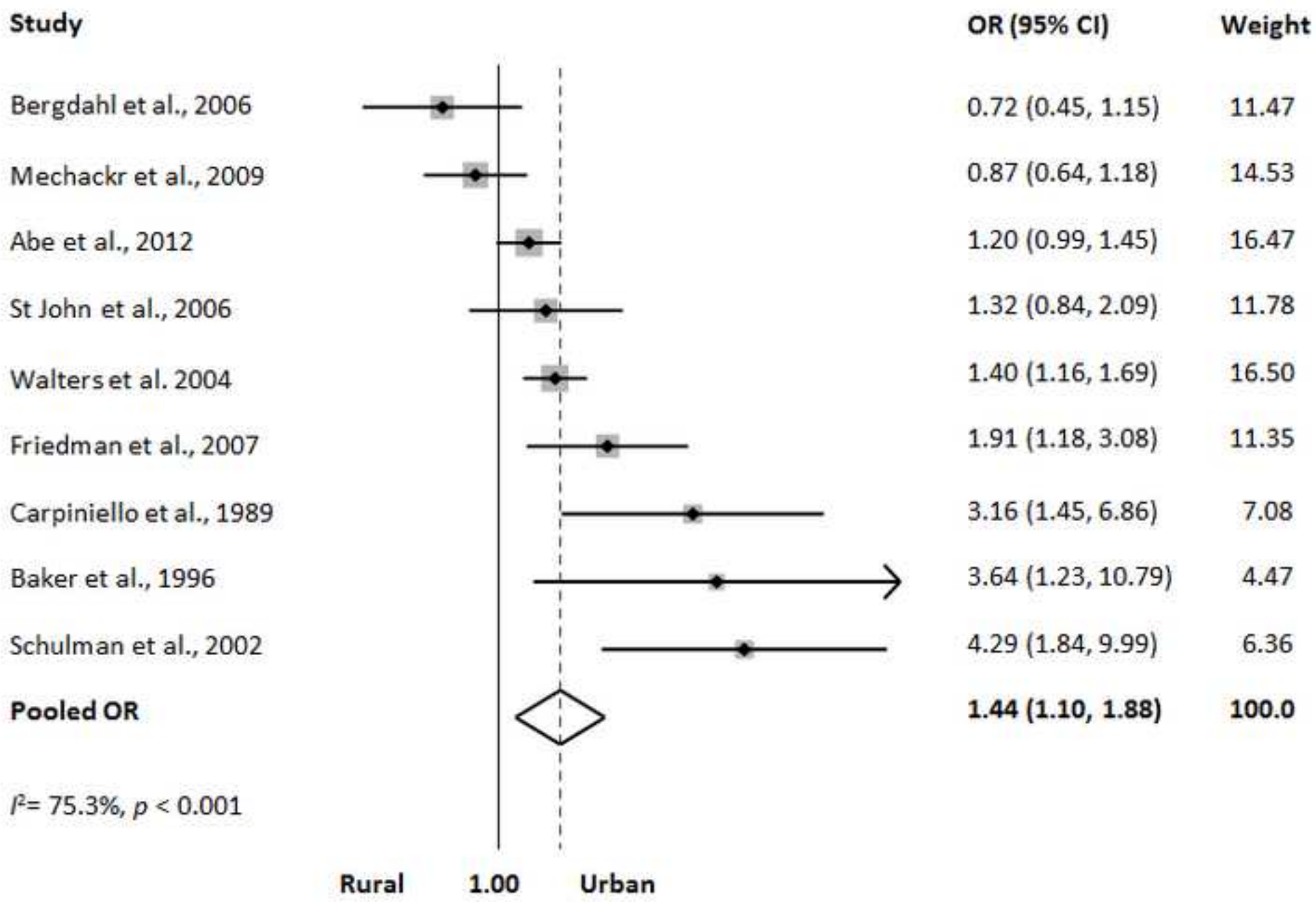

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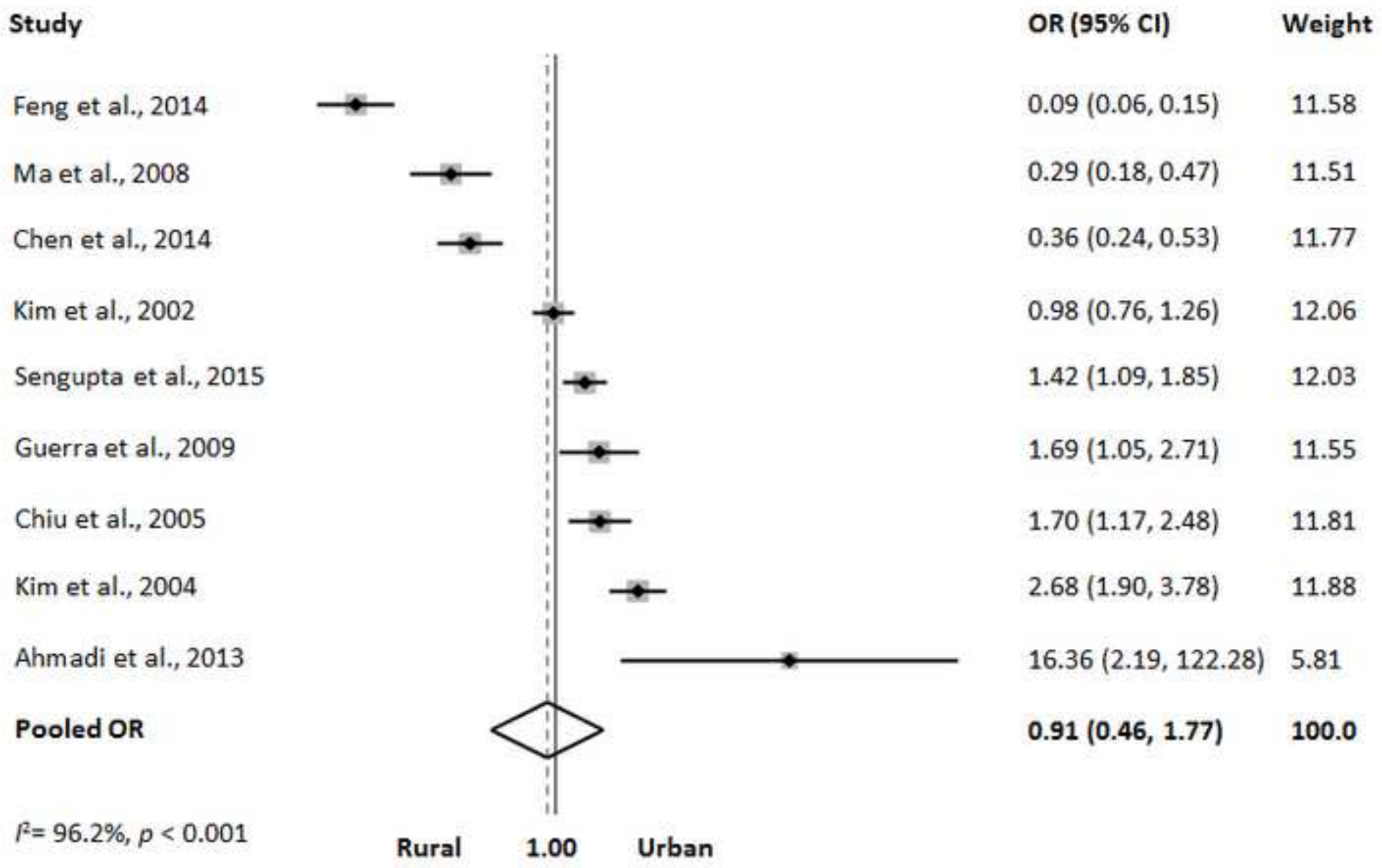

Appendix 1. Methodological Quality Assessment Instrument, Studies of Urban–Rural Differences in Depression Among Older Adults

1. Socio-demographic characteristics are described (e.g., age, gender, education).
2. Parameters for classifying participants as urban or rural are clearly defined.
    - 0=not defined
    - 1=subjectively defined (e.g., population density information provided, name of jurisdiction provided)
    - 2=defined according to government classification system
3. Study inclusion and/or exclusion criteria are clearly described.
4. Information about cognitive status of participants is provided and/or addressed in analysis.
    - 2=explicitly excluded or addressed in analysis
5. Detailed description of methods and instruments is provided.
6. Participation and response rates are adequate.
    - No information provided or participation/response rate <50%=0 points
    - Response/participation rate between 50 and 75%=1 point
    - Response/participation over 75%=2 points
7. Adjusted associations between urban-rural residence and depression provided.
8. Diagnostic procedure is described:
    - For MDD: valid instrument/criteria
    - For CSDS: valid cut-off score
9. The handling of missing values is described.

Point assignment (except as noted above):

- Criterion was not met=0 points
- Criterion was partially met=1 point
- Criterion was fully met=2 points

Appendix Table 1. Articles Included in Systematic Review of Urban–Rural Differences in Depression Among Older Adults

Study characteristics	Measures	Results
Abe et al., 2012[1] Country: Japan Economy: Developed N: 2,152 Age range: 65+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥6) Urban: Kumamoto City, population of "about" 730,000, capital of Kumamoto Prefecture Rural: Aso District, population of "about" 70,000, mountainous area of Kumamoto Prefecture	No statistically significant difference in depression prevalence between urban and rural groups. Urban depression prevalence=28.2% Rural depression prevalence=24.7% Unadjusted OR=1.20 (95% CI=0.99, 1.45) AOR for urban–rural depression risk=n/a Variables adjusted for in fully adjusted models: Age, gender, medical history, sleep disturbance, morale, living alone, poor social support, financial strain, employment Urban-specific risk factors in fully adjusted models: - Sleep disturbance (AOR=1.48, 95% CI=1.04, 2.10) Rural-specific risk factors in fully adjusted models: - Poor social support (AOR=1.28, 95% CI=1.08, 1.52) Moderate methodological quality (score=9)
Ahmadi et al., 2013[2] Country: Iran	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥9) Urban: Based on "regional municipality"	Depression prevalence higher in urban group. Urban depression prevalence=39.5%

		Rural depression prevalence=3.6%
Economy: Developing	Rural: Based on "regional municipality"	
		Unadjusted OR=16.36 (95% CI=2.19, 122.28)
N: 337		
		Moderate methodological quality (score=10)
Age range: 60+		
Baker et al., 1996[3]	Depression measure: Center for Epidemiologic Studies-Depression Scale (CES-D) (threshold score ≥16)	Depression prevalence higher in urban group.
		Urban depression prevalence=27.1%
Country: U.S.		
	Rural: one "rural" county in Tennessee	Rural depression prevalence=12.5%
Economy: Developed	Urban: one "urban" county in Tennessee	Unadjusted OR=3.64 (95% CI=1.23, 10.79)
N: 86		
		Moderate methodological quality (score=11)
Age range: 60+		
Bergdahl et al., 2006[4]	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥5 or anyone previously diagnosed with depression or receiving ongoing treatment with antidepressants)	No statistically significant difference in depression prevalence between urban and rural groups.
Country: Sweden		Urban depression prevalence=26.9%
Economy: Developed		Rural depression prevalence=33.9%
	Urban: Residents of a university city in northern Sweden with approximately 105,000 inhabitants covering an area of 2,316 square kilometers	Unadjusted OR=0.72 (95% CI=0.45, 1.15)
N: 363		
		AOR for urban-rural depression risk=n/a
Age range: 85+		

	Rural: Residents of five communities in the rural part of northern Sweden with a total of 24,523 inhabitants in an area of 27,507 square kilometers	Variables adjusted for in fully adjusted models: Age, gender, use of analgesics, experienced loneliness, heart failure, loss of a child, minimal nutritional assessment, not going outside independently Urban-specific risk factors in fully adjusted models: - Loss of a child (AOR=2.88, 95% CI=1.15, 7.21) - Not going outdoors independently (AOR=3.53, 95% CI=1.43, 8.68) Rural-specific risk factors in fully adjusted models: - Use of analgesics (AOR=6.39, 95% CI=1.05, 38.98) Moderate methodological quality (score=11)
Carpiniello et al., 1989[5] Country: Italy Economy: Developed N: 302 Age range: 65+	Depression measure: Beck Depression Inventory (information on threshold score not provided) Urban: Cagliari, 3rd district, Sardinia Rural: Two small villages (Ilbono and Ales) on the island of Sardinia	Depression prevalence higher in urban group. Urban depression prevalence=17.0% Rural depression prevalence=6.0% Unadjusted OR=3.16 (95% CI=1.45, 6.86) Low methodological quality (score=8)
Chen et al., 2014[6] Country: China	Depression measure: Geriatric Mental State Automated Geriatric Examination for Computer Assisted Taxonomy (GMS-AGECAT) (threshold score ≥3)	Depression prevalence higher in rural group. Urban depression prevalence=2.1% Rural depression prevalence=5.7%

Economy: Developing N: 3,336 Age range: 65+ (urban); 60+ (rural)	Urban: Yiming sub-district of Hefei city Rural: six villages in Tangdian District of Yingshang County	Unadjusted OR=0.36 (95% CI=0.24, 0.53) Low methodological quality (score=8)
Chiu et al., 2005[7] Country: Taiwan Economy: Developing N: 1,005 Age range: 65+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥8) Urban: Kaohsiung City, the second ranking metropolitan area in Taiwan Rural: A town (San-Lin) one hour drive from Kaohsiung City	Depression prevalence higher in urban group. Urban depression prevalence=20.1% Rural depression prevalence=12.8% Unadjusted OR=1.70 (95% CI=1.17, 2.48) AOR for urban–rural depression risk=n/a Variables adjusted for in fully adjusted models: Age, gender, marital status/widowhood, education, disability, chronic conditions, living alone Urban-specific risk factors in fully adjusted models: - Chronic conditions (AOR= 1.76, 95% CI=1.07, 2.90) - Living alone (AOR=2.14, 95% CI=1.05, 4.36) Rural-specific risk factors in fully adjusted models: - Widowhood (AOR=5.69, 95% CI=2.42, 13.38) Low methodological quality (score=7)

Feng et al., 2014[8] Country: China Economy: Developing N: 1,329 Age range: 60+	Depression measure: Geriatric Mental State Schedule) (threshold score ≥3) Urban: Address classified as urban (i.e., "non-farmer") in Hukou database Rural: Address classified as rural (i.e., "farmer") in Hukou database	Depression prevalence higher in rural group. Urban depression prevalence=2.8% Rural depression prevalence=23.6% Unadjusted OR=0.09 (95% CI=0.06, 0.15) AOR for urban–rural depression risk=0.07 (95% CI=0.04, 0.12) Variables adjusted for in fully adjusted models: Age, gender High methodological quality (score=17)
Friedman et al., 2007[9] Country: U.S. Economy: Developed N: 926 Age range: 65+	Depression measure: Mini International Neuropsychiatric Interview (information on threshold score not provided) Urban: Address classified as being in Metropolitan Statistical Area by U.S. Census Bureau Rural: Address classified as being in Non-Metropolitan Statistical Area by U.S. Census Bureau	Depression prevalence higher in urban group. Urban depression prevalence=14.8% Rural depression prevalence=8.3% Unadjusted OR=1.91 (95% CI=1.18, 3.08) AOR for urban-rural depression risk=8.33 (95% CI=2.63, 25.0) Variables adjusted for in fully adjusted models: Age, marital status, income, financial strain, physical limitations, health status, chronic conditions, anxiety symptoms, obesity status, widowhood, supplemental health insurance, past year ambulatory procedure, ≥2 emergency room visits in past 6 months, ≤1 close friends

		Rural-specific risk factors in fully adjusted models: - Financial strain (AOR=1.50, 95% CI=1.01, 2.23) - ≤1 close friends (AOR=6.86, 95% CI=2.18, 21.58) - ≥2 emergency room visits is past 6 months (AOR=4.00, 95% CI=1.19, 13.43) - Physical limitations (AOR=1.08, 95% CI=1.01, 1.14) High methodological quality (score=14)
Guerra et al., 2009[10] Country: Peru, Mexico, Venezuela Economy: Developing N: 5,886 Age range: 65+	Depression measure: Geriatric Mental State, structured clinical interview (information on threshold score not provided) Urban: - Peru: Two districts in the city of Lima - Mexico: Six districts in the suburb of Tlalpan, south of Mexico City - Venezuela: One district in the southwest of the city of Caracas Rural: - Peru: Six districts in the coastal province of Canete - Mexico: Nine villages in the north of the mountainous state of Morelos	Depression prevalence higher in urban group. Urban depression prevalence (pooled)=2.3% Rural depression prevalence(pooled)=1.4% Unadjusted OR=1.71 (95% CI=1.05, 2.71) Moderate methodological quality (score=12)
Kim et al., 2002[11] Country: South Korea	Depression measure: Geriatric Depression Scale, Korean Form (threshold score ≥14)	No statistically significant difference in depression prevalence between urban and rural groups. Urban depression prevalence=32.8%

Economy: Developing N: 1,134 Age range: 65+	Urban: Residents of Songjeong, Kwangju, a city with a total of 9,866 inhabitants in an area of 17.3 square kilometers Rural: Residents of Samto, Kwangju, area with a total of 4,120 inhabitants in an area of 38.3 square kilometers	Rural depression prevalence=33.3% Unadjusted OR=0.98 (95% CI=0.76, 1.26) AOR for urban–rural depression risk=1.84 (95% CI=1.20, 2.83) Variables adjusted for in fully adjusted models: Age, gender, marital status, education, housing, unemployment, disability, social support, religion, past manual occupation Urban-specific risk factors in fully adjusted models: - Older age (AOR=1.26, 95% CI=1.04, 1.52) - Past manual occupation (AOR=1.79, 95% CI=1.13, 2.83) - Renting housing (AOR=2.14, 95% CI=1.30, 3.53) Moderate methodological quality (score=11)
Kim et al., 2004[12] Country: South Korea Economy: Developing N: 1,204 Age range: 65+	Depression measure: Geriatric Mental State Schedule (information on threshold score not provided) Urban: Residents of Songjeong, Kwangju, a city with a total of 9,866 inhabitants in an area of 17.3 square kilometers Rural: Residents of Samto, Kwangju, area with a total of 4,120 inhabitants in an area of 38.3 square kilometers	Depression prevalence higher in urban group. Urban depression prevalence=21.0% Rural depression prevalence=8.6% Unadjusted OR=2.68 (95% CI=1.90, 3.78) AOR for urban-rural depression risk=1.84 (95% CI=1.20-2.83) Variables adjusted for in fully adjusted models: Age, gender, marital status, education, housing, unemployment, disability,

		social support, religion, living alone, seeing friends less than monthly, having no close friends, seeing neighbors less than monthly Urban-specific risk factors in fully adjusted models: - Older age (AOR=1.40, 95% CI=1.08, 1.81) - Female gender (AOR=1.99, 95% CI=1.02, 3.86) Rural-specific risk factors in fully adjusted models: - Seeing friends less than monthly (p=0.042)* - Having no close friends (p=0.027)* *Significance of variable × rural residence interaction term; information on AORs not provided. Moderate methodological quality (score=13)
Ma et al., 2008[13] Country: China Economy: Developing N: 1,601 Age range: 60+	Depression measure: Composite International Diagnostic Interview (CIDI 1.0) (information on threshold score not provided) Urban: Not specified Rural: Not specified	Depression prevalence higher in rural group. Urban depression prevalence=2.6% Rural depression prevalence=8.4% Unadjusted OR=0.29 (95% CI=0.18, 0.47) AOR for urban-rural depression risk=0.33 (95% CI=0.16, 0.69) Variables adjusted for in fully adjusted models: Age, gender, marital status, income, education, housing, major medical conditions High methodological quality (score=14)

Mechakra-Tahiri et al., 2009[14] Country: Canada Economy: Developed N: 1,471 Age range: 65+	Depression measure: ESA Diagnostic Questionnaire(ESA-Q) (threshold score ≥2) Urban: Quebec province address designated urban by Institut de la Statistique du Quebec Rural: Quebec province address designated rural by Institut de la Statistique du Quebec	No statistically significant difference in depression prevalence between urban and rural groups. Urban depression prevalence=15.1% Rural depression prevalence=17.0% Unadjusted OR=0.87 (95% CI=0.64, 1.18) AOR for urban–rural depression risk=n/a Variables adjusted for in fully adjusted models: Age, gender, income, self-rated health, chronic conditions Urban-specific risk factors in fully adjusted models: - n/a Rural-specific risk factors in fully adjusted models: - Female gender (AOR=3.22, 95% CI=2.14, 4.86) - Chronic condition (AOR=1.30, 95% CI=1.04, 1.61) - Poor self-rated health (AOR=1.24, 95% CI=1.02, 1.51) Moderate methodological quality (score=13)
Schulman et al., 2002[15] Country: U.S.	Depression measure: Geriatric Depression Scale (GSD-30) (threshold score ≥11) Urban: Residents of a city with a population >250,000, classified by U.S. Census Bureau definition	Depression prevalence higher in urban group. Urban depression prevalence=54.3% Rural depression prevalence=21.9%

Economy: Developed N: 118 Age range: 65+	Rural: Residents of an area "outside of incorporated areas" with a population ≥2,500, classified by U.S. Census Bureau definition	Unadjusted OR=4.29 (95% CI= 1.84, 9.99) AOR for urban–rural depression risk=3.8 (95% CI=1.5, 10.1) Variables adjusted for in fully adjusted models: Assistance in activities of daily living, living arrangement High methodological quality (score=15)
Sengupta et al., 2015[16] Country: India Economy: Developing N: 3,038 Age range: 60+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥5) Urban: Not specified Rural: Not specified	Depression prevalence higher in urban group. Urban depression prevalence=10.1% Rural depression prevalence=7.3% Unadjusted OR=1.42 (95% CI=1.09, 1.85) AOR for urban–rural depression risk=1.67 (95% CI=1.21, 2.29) Variables adjusted for in fully adjusted models: Age, gender, marital status, income, education, functional impairment, type of family, occupation, cognitive impairment High methodological quality (score=14)
St John et al., 2006[17] Country: Canada	Depression measure: Center for Epidemiologic Studies Depression scale (CES-D) (threshold score ≥16)	No statistically significant difference in depression prevalence between urban and rural groups. Urban depression prevalence=11.6% Rural depression prevalence=9.0%

Economy: Developed N: 1,132 Age range: 65+	Urban: Resident of urban area (population >19,999) defined by Canadian Beale codes Rural: Resident of rural area (population <2,500) defined by Canadian Beale codes	Unadjusted OR=1.32 (95% CI=0.84, 2.09) AOR for urban–rural depression risk=n/a Variables adjusted for in fully adjusted models: Age, gender, education, living arrangement, financial strain, self-rated health, functional impairment, number of companions Urban-specific risk factors in fully adjusted models: - Self-rated health (AOR=3.39, 95% CI=2.06, 5.56) Rural-specific risk factors in fully adjusted models: - Living alone (AOR=3.40, 95% CI=1.25, 9.26) - Financial strain (AOR=3.64, 95% CI=1.32, 10.08) High methodological quality (score=16)
Walters et al., 2004[18] Country: Great Britain Economy: Developed N: 6,178 Age range: 75+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥6) Urban: ZIP code with highest density quartile (≥2,467 people/km) Rural: ZIP code with lowest density quartile (0–355 people/km)	Depression prevalence higher in urban group. Urban depression prevalence=9.5% Rural depression prevalence=7.0% Unadjusted OR=1.40 (95% CI=1.16, 1.69) AOR for urban–rural depression risk=1.61 (95% CI=1.20, 2.17)

		Variables adjusted for in fully adjusted models: Age, gender, financial strain, housing, physical symptoms, unmet needs in activity of daily living, living alone, impaired cognition High methodological quality (score=15)

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October 27, 2018

Matthew L. Boulton, MD, MPH,
Editor-in-Chief
William Wadland, MD, MS
Deputy Editor

Dear Drs. Boulton and Wadland:

We hereby submit for consideration as a Review Article in the *American Journal of Preventive Medicine* a revision our manuscript entitled "Urban-Rural Differences in Older Adult Depression: A Systematic Review and Meta-Analysis of Comparative Studies" (#18-0205-0143R) by Jonathan Purtle, Katherine L. Nelson, Yong Yang, Brent Langellier, Ivana Stankov, and Ana V. Diez Roux.

A point-by-point response to each of the reviewer comments is provided below.

The manuscript has been submitted solely to the *American Journal of Preventive Medicine* and it has not been previously published, either in whole or in part, nor have the findings been posted online. I have full access to all aspects of the research and writing process, and take final responsibility for the paper.

Thank you for considering our manuscript.

Sincerely,

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Response to Review
18-0205-0143R: Urban-Rural Differences in Older Adult Depression: A Systematic Review and Meta-Analysis of Comparative Studies

Reviewer #2:
I appreciated the attempts to streamline the paper and tighten arguments, which I believe have strengthened the manuscript. I have the remaining suggestions for further clarification or improvement.

R.2.1. P. 7, lines 84-85: Can the authors elaborate on how spatial characteristics of cities differ in countries with developed versus developed economies, and in turn affect depression levels?

Response: We have revised this statement so that it is more specific and concrete. The new sentence appears on line 84 and reads: "Residents of urban areas in developed counties are likely to have access to public transportation, whereas residents of urban areas in developing counties might not have such access and rely on walking as their primary mode of transit.[64,65]"

R.2.2. P. 8: With regarding to the aims, the authors should develop hypotheses from the literature review on the expected relationships, particularly with regard to aim 3.

Response: The study was exploratory and we did not begin the study with *a priori* hypothesis and do not feel that it is appropriate to develop and state hypotheses after the results are known. However, we believe that the results of the study inform the development of hypotheses that can be tested in future research. We have revised the Discussion section of manuscript to explicitly identify two of these hypotheses.

The first appears on line 298 and reads: "Future research in countries other than China that have rapidly developing economies and are experiencing major trends in rural-urban migration (e.g., India, Nigeria)[1] should test the hypothesis that rural residence is associated with depression among older adults."

The second appears on line 312 and reads: "For example, a significant interaction was identified between social isolation, rural residence, and depression in five studies[75,83,85,86,91] and future research should test the hypothesis that social isolation meditates the relationship between rural residence and depression in counties with developing economies."

R.2.3. (Reviewer Comment R3.2) I agree with this reviewer that some adjustment for clustering should be made in the pooled models (paragraph in lines 169-173). The current manuscript contains little detail on the methods used.

Response: We re-ran the pooled analyses using random-effects meta analyses to address this comment. We have revised the Methods section to detail how and why we did this. This new text reads: "Using data on the number of depressed and non-depressed older adults in the urban and rural populations of each study, random-effects meta-analysis was conducted using the "metan" command in Stata 17 to produce weighted pooled odds ratios (ORs) with 95% confidence intervals (CIs) estimating the association between urban-rural residence and depression. A random effects model was used because the characteristics of urban and rural environments and study populations were assumed to vary substantially between studies and because I^2 statistics demonstrated high heterogeneity between studies (i.e., >75%).[72] Weighted pooled odds ratios were produced for all studies together and also separately for studies conducted in countries with developed and developing economies, based on United Nations' World Economic Situation and Prospects classifications.[73] Forest plots were created to display results."

We have updated the text and pooled odds ratios throughout the entire manuscript and Figures to reflect this change.

Reviewer #3:

R.3.1. Most of the issues that (the numerous) reviewers made have been addressed. On a minor note, there are some small wording issues (e.g., Great Britain instead of UK) which the authors may want to change.

Response: We have retained the word "Great Britain" because it is the word that the authors use in the study we cite [Walters K, Breeze E, Wilkinson P, Price GM, Bulpitt CJ, Fletcher A. Local area deprivation and urban-rural differences in anxiety and depression among people older than 75 years in Britain. American Journal of Public Health. 2004;94(10):1768-1774]. The study does not name the specific regions of Great Britain (e.g., England, Scotland, or Wales) where the study took place. We are hesitant to change the wording to "United Kingdom" because it typically implies inclusion of Northern Ireland, whereas Great Britain does not.

*Manuscript (text, refs, fig legend)
Click here to view linked References

Urban-Rural Differences in Older Adult Depression: A Systematic Review and Meta-Analysis of Comparative Studies

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ABSTRACT

Context: Depression among older adults (≥age 60) is a problem that could be exacerbated by global trends in urbanization and population aging. The study purpose was to assess whether urban, relative to rural, residence is associated with depression among older adults and whether associations differ in countries with developed versus developing economies.

Evidence Acquisition: In 2017, we identified and extracted information from comparative studies of urban-rural depression prevalence among older adults. Studies were identified in PubMed, PsychINFO, and Web of Science and limited to English language articles published after 1985. Eighteen studies met inclusion criteria. Random effects meta-analysis was conducted to produce weighted pooled odds ratios (ORs) estimating the association between urban-rural residence and depression for all study participants (N=31,598) and sub-analyses were conducted for developed (n=12,728) and developing (n=18,870) countries.

Evidence Synthesis: Depression prevalence was significantly higher among urban residents in ten studies and significantly higher among rural residents in three studies (all three conducted in China). Associations between urban-rural residence and depression generally remained significant after adjusting for covariates. In developed countries, the odds of depression were significantly higher among urban than rural residents (pooled OR=1.44, 95% CI=1.10, 1.88). However, in developing countries, this association was not observed (pooled OR=0.91, 95% CI=0.46, 1.77).

Conclusions: Converging trends of urbanization and population aging could increase the global burden of depression among older adults. The pathways through which urban-rural residence influences depression risk among older adults might differ by county context. Future research should focus on measuring variation in these contexts.

KEYWORDS

Depression, older adults, urban, rural, systematic review, meta-analysis

CONTEXT

Human longevity is increasing and the demographic composition of societies is aging. Between 2015 and 2050, global life expectancy at birth is projected to increase from 70 to 77 years.[1] By 2050, the proportion of the world's population over age 60 is projected to double and the proportion over age 80 is projected to triple.[2,3] In Europe, the proportion of the population over age 60 is expected to increase from 24% to 34% between 2015 and 2050. Increasing trends are also expected in Latin America (from 11% to 26%), North America (from 21% to 28%), and Asia (from12% to 25%).[3] These increases in longevity pose challenges for policymakers as they are forced to address the implications of population aging within the context of other societal changes. As Beard and Bloom describe, "Population ageing is not taking place in isolation. Other broad social changes are transforming society… Understanding the interplay between these trends is crucial if policymakers are to make the best decisions to promote the health and wellbeing of older people."[4 (p.659)]

Urbanization and urban migration are social changes that are important to understand within the context of population aging. The proportion of the world's population living in cities increased from 43% to 54% between 1990 and 2014 and is projected to increase to 66% by 2050.[1] Rates of urbanization are accelerating fastest in countries with developing economies. For example, between 2014 and 2050, the proportion of people living in cities is projected to increase from 40% to 56% in Africa and from 48% to 66% in Asia, compared with increases from 73% to 82% in Europe and 80% to 86% in North America.[1] As trends in population aging, urbanization, and urban migration converge, there is an increasing need for evidence about how urban contexts can maximize the health benefits, and minimize the health risks, of cities for older adults.[5-8]

While urban-rural differences in the *physical health* of older adults have been the focus of numerous initiatives,[5-8] questions regarding how city living influences the mental health of older adults have received less attention. Such questions are important because the risk and protective factors for mental health conditions change as people age.[9] Moreover, a substantive body of research suggests that urban residence increases risk for mental health conditions and that rates of mental health conditions are generally higher in urban than rural areas.[10-16]

However, the dynamics through which urban residence influences mental health are complex and likely to vary for different mental health conditions, populations, and country contexts.[10,17] Depression is one mental health condition for which the social and physical characteristics of cities could increase the risk for, or be protective against, depression among older adults.

Depression among Older Adults

Systematic reviews and meta-analyses estimate that the global prevalence of major depressive disorder (MDD) is in the range of 1 to 5% among adults age ≥65.[18-24] Global estimates of the prevalence of clinically significant depressive symptoms (CSDS), which do not meet the full criteria for MDD, among adults age ≥65 hover around 15%.[18,23,25-27]

Although the prevalence of MDD and CSDS among older adults are similar to that of middle-aged adults, depression among older adults has widely been recognized as a public health priority for at least two reasons. [27,28] First, the consequences of depression are more severe among older adults than among their middle-aged counterparts. In addition to adversely affecting

quality of life, depression among older adults substantially increases risk for myriad adverse outcomes—including physical health problems, suicide, mortality, and reduced physical, cognitive, and social functioning.[18,20,27,29-34] For example, the association between MDD and suicide is stronger among older adults than any other age group[18] and at least eight prospective studies have found that CSDS increases risk for subsequent physical limitations.[27]

Second, depression is potentially more preventable among older adults than their younger counterparts. Approximately half of cases of MDD among older adults are new cases experienced by people who never had MDD earlier in life.[18,35,36] These older adults are also less likely to have a family history of depression.[18,37] This suggests that depression among older adults is less influenced by inherited genetic factors and more influenced by social and environmental factors.[9]

The Potential Importance of Urban Versus Rural Residence

An integration of findings from the fields of geriatric psychiatry and urban health reveals numerous pathways through which features of cities could increase depression risk among older adults or, alternatively, be protective against depression. For example, urban environments could increase depression risk via disrupted sleep. Poor sleep is one of the strongest risk factors for depression among older adults[38,39] and could be exacerbated by urban environments because excessive exposure to artificial light at night is more prevalent in urban than rural areas and disrupts sleep quality.[10,40-43] Urban residence could also increase depression risk via direct and indirect exposure to neighborhood crime. Negative perceptions of neighborhood safety are strong

risk factors for depression among older adults[44-48] and violent crime rates are generally higher in urban than rural areas.[49]

Alternatively, some features of urban environments could reduce depression risk among older adults. For example, physical inactivity[50-55] and social isolation[18,23,56] are strong risk factors for depression among older adults. Public transportation networks and walkable streetscapes, which are generally both more robust in urban than rural areas, could reduce these risk factors by facilitating physical activity, active transport, and social connectivity.[51,57-62]

Potential Differences between Countries with Developed versus Developing Economies

It is plausible that the direction of an association between urban-rural residence and depression differs in countries with developed versus developing economies because the characteristics of urban and rural environments might vary across these contexts. For example, residents of rural areas in developed countries are likely to have some access to mental health services, while residents of rural areas in developing countries might have no access because services are exclusively concentrated in urban areas.[63] Residents of urban areas in developed counties are likely to have access to public transportation, whereas residents of urban areas in developing counties might not have such access and rely on walking as their primary mode of transit.[64,65] The importance of country context when considering the pathways through which urban and rural environments influence mental health is highlighted by a 2018 study of 42 low- and middle-income countries which found no association between urban (versus rural) residence and psychosis—a finding contrary to the well-established relationships between urban residence and psychosis that is typically observed in high-income countries.[17] This and other findings have

promoted calls for greater examination of how the influence of urban and rural environments on mental health might vary between country contexts.[66]

Study Purpose

Reviews have examined various aspects of depression among older adults and identified individual and neighborhood-level risk and protective factors.[23,25-27,30,32,38,44,50,67-70] However, with the exception of one meta-analysis of studies in China published nearly 20 years ago,[71] evidence of the association between urban-rural residence and depression among older adults has not been systematically assessed or integrated. The purpose of this study was to address this knowledge gap and provide directions for future research. A systematic review and meta-analysis was conducted of comparative studies focused on urban-rural differences in depression (including both MDD and CSDS) among older adults ≥ age 60. The specific aims were to:

1. Assess whether urban versus rural residence is associated with depression among older adults;
2. Identify factors that are significantly associated with depression among urban but not rural older adults, and vice versa; and
3. Assess whether the association between urban-rural residence and depression differs between developed and developing countries.

EVIDENCE ACQUISITION

Search Strategy

We conducted our review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. In July 2017, we searched PubMed,

PsychINFO, and Web of Science for articles that mentioned any of the following combinations of terms in the title, abstract, or keywords: ["depression" OR "depressive"] AND ["elderly" OR "older adult" OR "late life"] AND ["urban" OR "city" OR "cities" OR "metropolitan" OR "urbanization"] AND ["rural" OR "countryside."] The selection of these terms was informed by those used in prior reviews of depression among older adults[23,25-27,30,32,38,44,50,67-71] and urban-rural differences in mental health.[10-16] The search was limited to articles published in English since 1985. After removing duplicates, this search identified 170 articles that were screened for inclusion (Figure 1).

Inclusion/Exclusion Criteria

Two authors (JP, KN) read the abstracts of the 170 articles and screened for inclusion. Articles were included if they assessed urban-rural differences in MDD and/or CSDS among older adults ≥ 60 years. Studies that focused only on urban or rural populations, without considering urban-rural differences, were excluded. Moreover, non-empirical articles (e.g., commentaries), exclusively qualitative studies and studies limited to clinical interventions, institutionalized populations, or caregivers of older adults were excluded.

Thirty-nine articles met screening criteria. The full texts of these articles were obtained, reviewed by the two coders, and excluded if they did not meet screening criteria or did not present data on the prevalence of MDD or CSDS among adults age ≥60 stratified by urban-rural residence. When articles met all inclusion criteria but did not present information on urban-rural differences in depression prevalence (n=2), the study's authors were contacted and the article

was included if the information could be obtained (n=1). This process resulted in 18 articles that were included in the meta-analysis.

Data Extraction, Quality Assessment, and Analysis

For each article, information was extracted on the characteristics of study participants (e.g., age, country), instruments and scoring thresholds used to assess depression, definitions of urban-rural residence, and sample size. When available in studies that used multivariable regression, we extracted information on the adjusted odds ratio (AOR) of urban-rural depression prevalence and the variables that were adjusted for in the final model. We also extracted information on variables that were significantly associated with depression risk among urban but not rural older adults, and vice versa.

We assessed the methodological quality of each study on nine domains using a quality assessment instrument (Appendix A) adapted from Luppa and colleagues' review of depression prevalence among older adults.[69] Two authors (JP, KN) independently reviewed the 18 studies and each domain was scored as 2 if criteria were fully met, 1 if partially met, and 0 if not met. We then calculated an aggregate quality score for each study. Studies in the >75th percentile (score ≥14) were coded a "high quality," those in the 50th to 75th percentile (9≥ score ≤13 were coded as "moderate quality," and those in the <50th percentile (score ≤8) were coded as "low quality."

Using the definitions of depression and urban-rural residence from each study, information on the number of depressed and non-depressed older adults in the urban and rural populations,

respectively, were extracted. Outcomes of MDD and CSDS were combined because there were substantial differences in how these two outcomes were operationalized across studies and because our aims were focused on assessing the relative association between urban-rural residence and depression among older adults—not on estimating depression prevalence in urban and rural areas.

Using data on the number of depressed and non-depressed older adults in the urban and rural populations of each study, random effects meta-analysis was conducted using the "metan" command in Stata 17 to produce weighted pooled odds ratios (ORs) with 95% confidence intervals (CIs) estimating the association between urban-rural residence and depression. A random effects model was used because the characteristics of urban and rural environments and study populations were assumed to vary substantially between studies and because I^2 statistics demonstrated high heterogeneity between studies (i.e., >75%).[72] Weighted pooled odds ratios were produced for all studies together and also separately for studies conducted in countries with developed and developing economies, based on United Nations' World Economic Situation and Prospects classifications.[73] Forest plots were created to display results.

To conduct sensitivity analysis, we systematically assessed the influence of each study on the pooled results by producing weighted pooled ORs without each individual study. This was carried out for all studies together and separately for countries with developed versus developing economies. To assess publication bias, we created funnel plots and conducted Egger's tests.[74]

EVIDENCE SYNTHESIS

Study Characteristics

The table in Appendix 2 summarizes the characteristics, methodological quality, and results of the 18 studies.[75-92] Nine studies were conducted in developed countries (Japan, United States, Sweden, Italy, Canada, Great Britain) and nine were conducted in developing countries (Iran, China, Taiwan, Peru, Mexico, Venezuela, South Korea, India). Study sample size ranged from 86 to 6,178 and the median sample size was 1,169.

Seven studies were coded as high quality, eight were moderate quality, and three were low quality. The quality of studies was similar for those conducted in developed and developing countries. There were substantial differences in how depression outcomes and urban-rural residence were operationalized across studies. Six different instruments were used to assess depression. The 15-item Geriatric Depression Scale was used most frequently (six studies), but five different scoring thresholds were used with the scale to classify older adults as having CSDS (threshold range=$\geq 5, \geq 9$). Five studies used the addresses of study participants and national urban-rural classification systems (e.g., U.S. Census Bureau definitions, Chinese Hukou System designations) to classify participants as urban-rural and four included information about the population density of urban- rural classifications.

Unadjusted Associations from Individual Studies

The study prevalence of depression was significantly higher among urban residents in ten studies, significantly higher among rural residents in three studies, and there was no significant difference between the urban and rural residents in five studies. All studies in which depression

was significantly higher among rural residents were conducted in China, which was classified as a developing country. The strength of the association between urban-rural residence and depression varied dramatically between studies. Among individual studies conducted in developed countries, the unadjusted OR of depression between urban and rural (referent) residents ranged from 0.72 (95% CI=0.45, 1.15)[78] to 4.29 (95% CI=1.84, 9.99).[89] Among individual studies conducted in developing countries, the ORs ranged from 0.09 (95% CI=0.06, 0.15)[82] to 16.36 (95 % CI=2.19, 122.28).[76]

Pooled Analyses

When the results of all eighteen studies were pooled (N=31,598), the study prevalence of depression was not significantly different between urban (10.2%) and rural (10.7%) residents (χ^2 p=.168). The pooled OR from random effects meta-analysis was 1.18 (95% CI=0.84, 1.65). I^2 was 93.4% (χ^2 p<.001), indicating high heterogeneity between studies. A funnel plot (Figure 2) demonstrates that studies fall on both sides of zero with moderate symmetry, suggesting the absence of major publication bias. Egger's test suggested that there was no significant small studies effect (Egger's test p=.356). In sensitivity analysis that assessed influence of individual studies, pooled ORs ranged from 1.10 (95% CI=0.78, 1.56) to 1.32 (95% CI=1.01, 1.74).

When the results of all studies conducted in *developed countries* were pooled (n=12,728), the study prevalence of depression was significantly higher among urban (16.0%) than rural (11.8%) residents (χ^2 p<.0001). The pooled OR from random effects meta-analysis was 1.44 (95% CI=1.10, 1.88) with high heterogeneity between studies (I^2=75.3%, χ^2 p<.001) (Figure 3). In

sensitivity analysis, pooled ORs for developed countries ranged from 1.32 (95% CI=1.03, 1.68) to 1.56 (95% CI=1.18, 2.07).

When the results of all studies conducted in *developing countries* were pooled (n=18,870), the study prevalence of depression was significantly lower among urban (7.5%) than rural (9.6%) residents (χ^2 p<.000). The pooled OR from random effects meta-analysis was 0.91 (95% CI=0.46, 1.77) with high heterogeneity (I^2=96.2%, χ^2 p<.001) (Figure 4). In sensitivity analysis, pooled ORs for developing countries ranged from 0.76 (95% CI=0.38, 1.50) to 1.17 (95% CI=0.69, 1.99).

Adjusted Associations from Individual Studies

Nine studies conducted multivariable regression and presented AORs of the association between urban residence and depression.[82,83,85-87,89-92] The variables most frequently included in these models were age (seven studies), gender (six studies), marital status/widowhood (six studies), functional impairment/disability (five studies), education (four studies), income/financial strain (four studies), and housing (four studies). The magnitude, direction, and significance of unadjusted and adjusted ORs were similar in most studies. For example, in Walters and colleagues'[92] study of older adults in Great Britain, the odds of depression among urban versus rural residents only increased from 1.40 (95% CI=1.16, 1.69) to 1.61 (95% CI=1.20, 2.17) after adjusting for age, gender, financial strain, housing, physical symptoms, unmet needs in activity of daily living, living alone, impaired cognition.

Eight studies examined interactions between urban-rural residence and factors associated with depression (i.e., identified factors associated with depression risk among urban but not rural older adults, and vice versa).[75,78,81,83,85,86,88,91] In five of these studies, interactions between rural residence and factors related to social isolation (e.g., living alone, not having any close friends) were present in which isolation-related factors were independently and significantly associated with depression among rural, but not the urban, residents.[75,83,85,86,91] For example, after adjusting for covariates, Abe and colleagues'[75] study of older adults in Japan found that the odds of depression were 1.28 times higher among older adults with poor social support in rural areas, while the association between social support and depression was not significant among those residing in urban areas. Associations between social isolation and depression among rural older adults were identified in studies conducted in developed[75,83,91] as well as developing[85,86] countries. Results were mixed for other known risk factors for depression among older adults (e.g., poor physical health, financial stress, female gender),

DISCUSSION

Considered holistically, the results of this review and meta-analysis suggest that urban residence might increase depression risk among older adults. Of the eighteen included studies, depression prevalence was significantly higher among urban residents in ten studies and significantly higher among rural residents in only three studies (all three conducted in China). Although the review was not designed to elucidate the mechanisms through which urban-rural residence might influence depression, the magnitude of unadjusted and adjusted ORs of urban-rural depression were generally similar in the nine studies that controlled for potential confounders. This suggests

that urban and rural environments might have independent effects on depression risk among older adults.

In the pooled sub-analysis of studies conducted in *developed* countries, we found that the odds of depression were significantly higher among older adults residing in urban, as opposed to rural, areas (OR=1.44, 95% CI=1.10, 1.88). This finding is very similar to the pooled results of Peen and colleagues' meta-analysis of urban-rural differences of depression among people of all ages in developed countries (OR=1.39, 95% CI=1.17, 1.64).[16] In the pooled sub-analysis of studies conducted in *developing* countries, however, we found that the odds of depression were not significantly higher among older adults residing in urban than rural areas (OR=0.91, 95% CI=0.46, 1.77). This finding is consistent with the results of Chen and colleagues' 1999 meta-analysis of risk factors for depression among older adults in China[71] and two more recent studies conducted in China both found that symptom mean scores were significantly higher among rural than urban residents.[93,94]

The finding that the odds of depression appear to be significantly lower among older adults in rural than urban areas of China could partially be the result of mass migration of older adults with greater socioeconomic resources (i.e., lower depression risk) from rural to urban areas.[93,95] Li and colleagues found that the association between rural residence and depression among older adults in China lost significance after adjusting for socioeconomic factors at household- and community-levels.[93] It is also possible that the elevated prevalence of depression among older adults in rural China could be the result of an "empty nest" trend in which the children of rural older adults are leaving home to work in cities at an accelerated rate.[96] In a sample drawn from

older adult empty nest households in China, [94] Su and colleagues found that depression symptoms scores were significantly higher for those in rural than urban areas.

Future research in countries other than China that have rapidly developing economies and are experiencing major trends in rural-urban migration (e.g., India, Nigeria)[1] should test the hypothesis that rural residence is associated with depression among older adults. Relatedly, future research should integrate measures of urban-rural residence and depression into longitudinal studies of older adults to examine how the age at which migration occurs might affect depression risk. In their cross-sectional study of older adults in South Korea, Kim and colleagues[86] retrospectively assessed past urban-rural residence via self-report and found that depression prevalence was higher among those who moved from rural to urban areas between the ages of 21 and 60 (20.3%), and after age 60 (25.5%) than those who lived in urban areas their entire lives (19.3%).

Given the large heterogeneity in the magnitude of associations between urban-rural residence and depression, additional research is needed to understand how social and economic factors might interact with features of urban and rural environments to influence depression risk among older adults. For example, a significant interaction was identified between social isolation, rural residence, and depression in five studies[75,83,85,86,91] and future research should test the hypothesis that social isolation meditates the relationship between rural residence and depression in counties with developing economies. Relatedly, more research is needed about how macro-level factors that vary across countries (e.g., public transportation infrastructure, pensions, access to health

care services) might meditate and moderate associations between urban-rural residence and depression.

Limitations

Our review and meta-analysis has seven main limitations. First, urban and rural residence was not operationalized consistently between studies. Even within a single country, an inherent challenge to reviews of urban-rural differences in health is the fact that various definitions of urban and rural exist and are accepted—ranging from measures of population density to algorithm-based definitions produced by government agencies.[97,98] This challenge is exacerbated in cross-national reviews because definitions of urban and rural vary dramatically between countries.[99,100] However, country definitions of urban are similar to standardized United Nations definitions.[17]

Second, there are many different types of urban and rural areas (e.g., agriculture communities versus indigenous communities in the case of rural) and our review did not assess these distinctions. Third, our review was limited to comparative studies that presented data on the prevalence of depression among both urban and rural older adults. We limited our review to comparative studies because a wide range of depression instruments and scoring thresholds are used in the literature and limiting our review to comparative studies, in which the same instrument and scoring threshold were applied to both urban and rural groups, allowed us to ensure that our pooled measures of association would not be biased by systematic differences in how depression was measured between urban and rural groups. Our study was also limited to

English language peer-reviewed literature and did not include grey literature (e.g., government reports).

Fourth, we did not differentiate between MDD and CSDS because there was substantial differences in how these outcomes were operationalized across studies and because our aims were focused on assessing the relative association between urban-rural residence and depression among older adults—not estimating depression prevalence in urban and rural areas. Fifth, studies included in our review were only conducted in six developed countries and eight developing countries and the results are not representative of all developed or developing countries.

Sixth, the studies included in the review were published over a 26 year period and pooled results might not reflect recent changes in urban and rural environments. For example, in the United States, suicide rates are increasing at a faster pace in rural than urban countries and such a trend could indicate that features of rural environments related to mental health are changing.[101] Finally, it should be emphasized all 18 studies included in the review were cross-sectional and only nine articles presented adjusted estimates of urban-rural depression risk. Thus, our results demonstrate associations between urban-rural residence and depression among older adults but should not be interpreted as implying causality.

CONCLUSION

Our review of comparative studies generally suggests that converging trends of urbanization, urban migration, and population aging could increase the global burden of depression among older adults. The heterogeneity of results between studies suggests that the nature of the

relationship between urban-rural residence and depression among older adults varies across contexts. Future research is needed to identify the specific factors that moderate the impact of urban living on depression and the most effective intervention strategies.

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FIGURE LEGEND

Figure 1. PRISMA Flow Diagram to Identify Comparative Studies of Urban-Rural Differences in Depression among Older Adults

Figure 2. Funnel Plot of Urban-Rural Differences in Depression among Older Adults, 18 Studies

Figure 3. Odds of Depression among Urban Versus Rural Older Adults in Developed Countries (n=12,728)

Figure 4. Odds of Depression among Urban Versus Rural Older Adults in Developing Countries (n=18,870)

Figure 1

Figure 1.

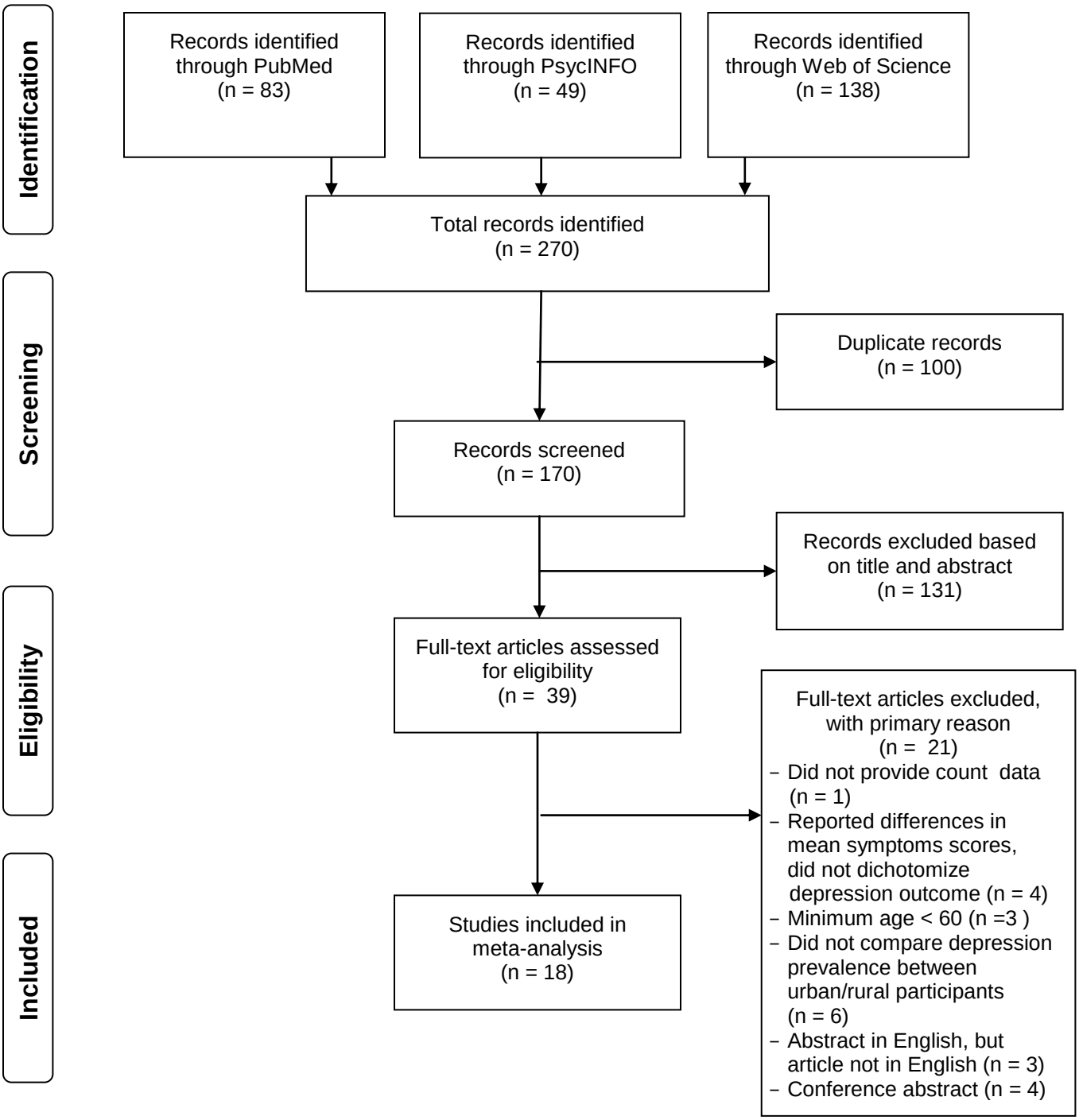
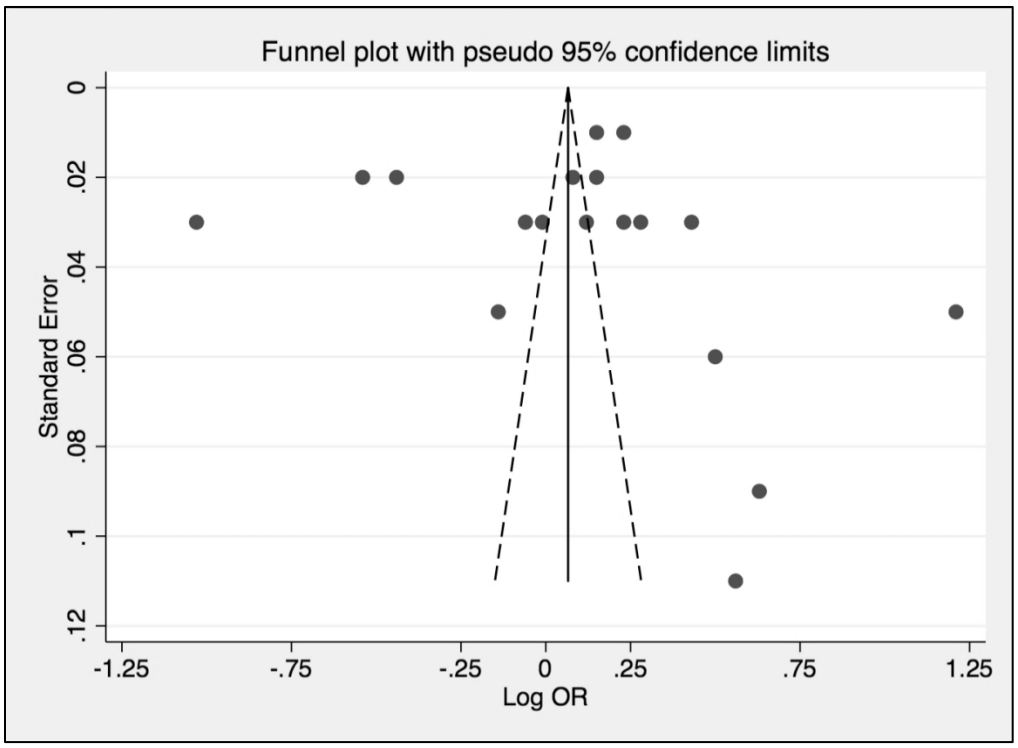


Figure 2

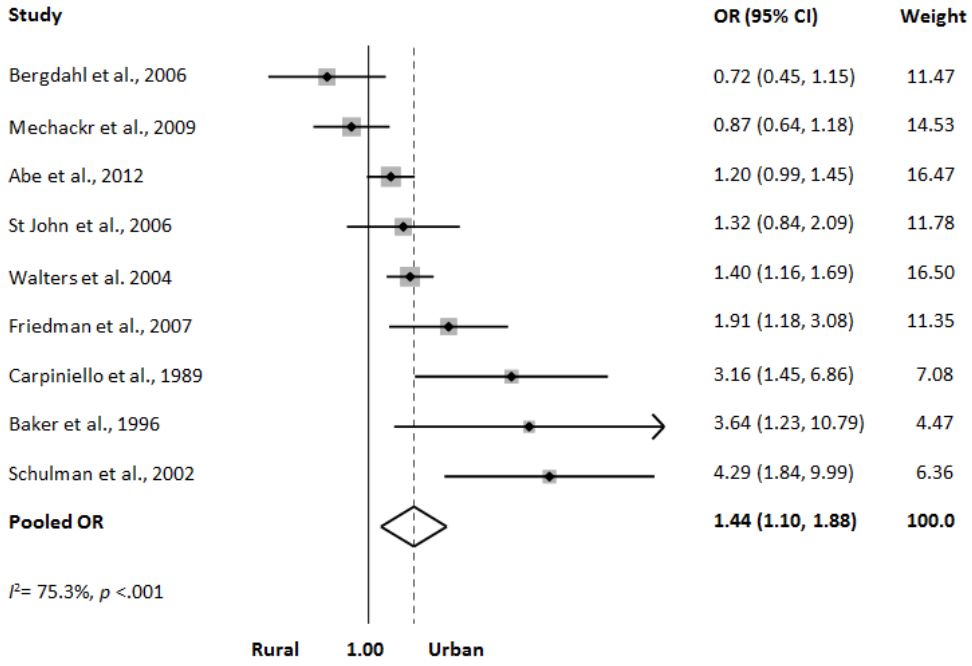
Figure 2.



OR= odds ratio

Figure 3

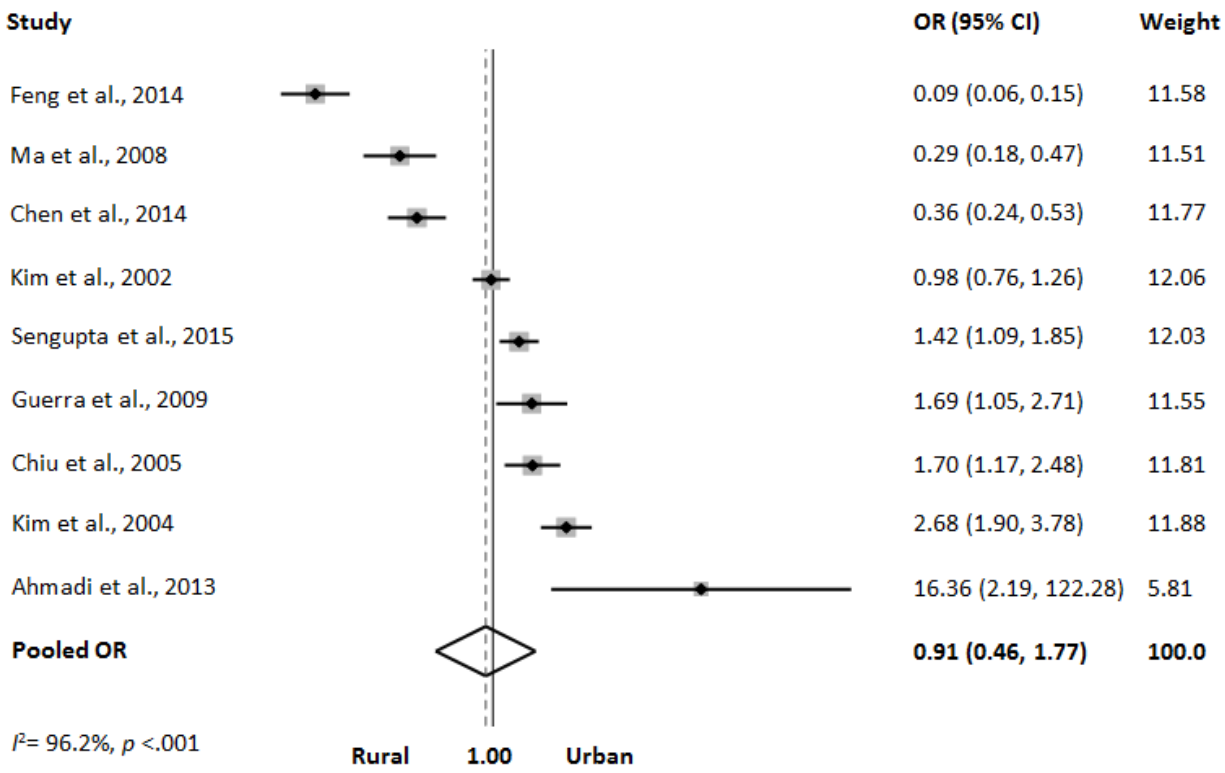
Figure 3.



Weights are from random-effects model. OR= odds ratio, CI= confidence interval. Arrows indicate that the 95% CIs are truncated.

Figure 4

Figure 4.



Weights are from random-effects model. OR= odds ratio, CI= confidence interval.

Appendix A. Methodological Quality Assessment Instrument, Studies of Urban-Rural Differences in Depression among Older Adults

1. Socio-demographic characteristics are described (e.g., age, gender, education)

2. Parameters for classifying participants as urban or rural are clearly defined
   - 0= not defined
   - 1= subjectively defined (e.g., population density information provided, name of jurisdiction provided)
   - 2= defined according to government classification system

3. Study Inclusion and/or exclusion criteria are clearly described

4. Information about cognitive status of participants is provided and/or addressed in analysis
   - 2= explicitly excluded or addressed in analysis

5. Detailed description of methods and instruments is provided

6. Participation and response rates are adequate
   - No information provided or participation/response rate < 50%= 0 points
   - Response/participation rate between 50 and 75%= 1 point
   - Response/participation over 75%= 2 points

7. Adjusted associations between urban-rural residence and depression provided

8. Diagnostic procedure is described:
   - For MDD: valid instrument/criteria
   - For CSDS: valid cut-off score

9. The handling of missing values is described

Criterion was not met= 0 points Criterion was partially met= 1 point Criterion was fully met= 2 points

Appendix B. Articles Included in Systematic Review of Urban-Rural Differences in Depression among Older Adults

Study Characteristics	Measures	Results
Abe et al., 2012 [1] Country: Japan Economy: Developed N: 2,152 Age range: 65+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥ 6) Urban: Kumamoto City, population of "about" 730,000, capital of Kumamoto Prefecture Rural: Aso District, population of "about" 70,000, mountainous area of Kumamoto Prefecture	No statistically significant difference in depression prevalence between urban and rural groups Urban depression prevalence= 28.2% Rural depression prevalence= 24.7% Unadjusted OR= 1.20 (95% CI= 0.99, 1.45) Adjusted OR for urban-rural depression risk= n/a Variables adjusted for in fully adjusted models: Age, gender, medical history, sleep disturbance, morale, living alone, poor social support, financial strain, employment Urban-specific risk factors in fully adjusted models: - Sleep disturbance (AOR= 1.48, 95% CI= 1.04, 2.10) Rural-specific risk factors in fully adjusted models: - Poor social support (AOR= 1.28, 95% CI= 1.08, 1.52) Moderate methodological quality (score= 9)
Ahmadi et al., 2013 [2] Country: Iran Economy: Developing N: 337 Age range: 60+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥ 9) Urban: Based on "regional municipality" Rural: Based on "regional municipality"	Depression prevalence higher in urban group Urban depression prevalence= 39.5% Rural depression prevalence= 3.6% Unadjusted OR= 16.36 (95% CI= 2.19, 122.28) Moderate methodological quality (score= 10)
Baker et al., 1996 [3] Country: United States Economy: Developed N: 86 Age range: 60+	Depression measure: Center for Epidemiologic Studies-Depression Scale (CES-D) (threshold score ≥ 16) Rural: one "rural" county in Tennessee Urban: one "urban" county in Tennessee	Depression prevalence higher in urban group Urban depression prevalence= 27.1% Rural depression prevalence= 12.5% Unadjusted OR= 3.64 (95% CI= 1.23, 10.79) Moderate methodological quality (score= 11)
Bergdahl et al., 2006 [4] Country: Sweden Economy: Developed N: 363 Age range: 85+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥5 or anyone previously diagnosed with depression or receiving ongoing treatment with antidepressants) Urban: Residents of a university city in northern Sweden with approximately 105,000 inhabitants covering an area of 2,316 square kilometers Rural: Residents of five communities in the rural part of northern Sweden with a total of 24,523 inhabitants in an area of 27,507 square kilometers	No statistically significant difference in depression prevalence between urban and rural groups Urban depression prevalence= 26.9% Rural depression prevalence= 33.9% Unadjusted OR= 0.72 (95% CI= 0.45, 1.15) Adjusted OR for urban-rural depression risk= n/a Variables adjusted for in fully adjusted models: Age, gender, use of analgesics, experienced loneliness, heart failure, loss of a child, minimal nutritional assessment, not going outside independently Urban-specific risk factors in fully adjusted models: - Loss of a child (AOR= 2.88, 95% CI= 1.15, 7.21) - Not going outdoors independently (AOR= 3.53, 95% CI= 1.43, 8.68) Rural-specific risk factors in fully adjusted models: - Use of analgesics (AOR= 6.39, 95% CI= 1.05, 38.98) Moderate methodological quality (score= 11)
Carpiniello et al., 1989 [5]	Depression measure: Beck Depression Inventory (information on threshold score not	Depression prevalence higher in urban group

Country: Italy Economy: Developed N: 302 Age range: 65+	provided) Urban: Cagliari, 3rd district, Sardinia Rural: Two 2 small villages (Ilbono and Ales) on the island of Sardinia	Urban depression prevalence= 17.0% Rural depression prevalence= 6.0% Unadjusted OR= 3.16 (95% CI= 1.45, 6.86) Low methodological quality (score= 8)
Chen et al., 2014 [6] Country: China Economy: Developing N: 3,336 Age range: 65+ (urban) 60+ (rural)	Depression measure: Geriatric Mental State Automated Geriatric Examination for Computer Assisted Taxonomy (GMS-AGECAT) (threshold score ≥ 3) Urban: Yiming sub-district of Hefei city Rural: 6 villages in Tangdian District of Yingshang County	Depression prevalence higher in rural group Urban depression prevalence= 2.1% Rural depression prevalence= 5.7% Unadjusted OR= 0.36 (95% CI= 0.24, 0.53) Low methodological quality (score= 8)
Chiu et al., 2005 [7] Country: Taiwan Economy: Developing N: 1005 Age range: 65+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥ 8) Urban: Kaohsiung City, the second ranking metropolitan area in Taiwan Rural: A town (San-Lin) one hour drive from Kaohsiung City	Depression prevalence higher in urban group Urban depression prevalence= 20.1% Rural depression prevalence= 12.8% Unadjusted OR= 1.70 (95% CI= 1.17, 2.48) Adjusted OR for urban-rural depression risk= n/a Variables adjusted for in fully adjusted models: Age, gender, marital status/widowhood, education, disability, chronic conditions, living alone Urban-specific risk factors in fully adjusted models: - Chronic conditions (AOR= 1.76, 95% CI= 1.07, 2.90) - Living alone (AOR= 2.14, 95% CI= 1.05, 4.36) Rural-specific risk factors in fully adjusted models: - Widowhood (AOR=5.69, 95% CI=2.42, 13.38) Low methodological quality (score= 7)
Feng et al., 2014 [8] Country: China Economy: Developing N: 1329 Age range: 60+	Depression measure: Geriatric Mental State Schedule) (threshold score ≥ 3) Urban: Address classified as urban (i.e., "non-farmer") in Hukou database Rural: Address classified as rural (i.e., "farmer") in Hukou database	Depression prevalence higher in rural group Urban depression prevalence= 2.8% Rural depression prevalence= 23.6% Unadjusted OR= 0.09 (95% CI= 0.06, 0.15) Adjusted OR for urban-rural depression risk= 0.07 (95% CI=0.04, 0.12) Variables adjusted for in fully adjusted models: Age, gender High methodological quality (score= 17)
Friedman et al., 2007 [9] Country: United States Economy: Developed N: 926 Age range: 65+	Depression measure: Mini International Neuropsychiatric Interview (information on threshold score not provided) Urban: Address classified as being in Metropolitan Statistical Area by U.S. Census Bureau Rural: Address classified as being in Non-Metropolitan Statistical Area by U.S. Census Bureau	Depression prevalence higher in urban group Urban depression prevalence= 14.8% Rural depression prevalence= 8.3% Unadjusted OR= 1.91 (95% CI= 1.18, 3.08) Adjusted OR for urban-rural depression risk= 8.33 (95% CI= 2.63, 25.0) Variables adjusted for in fully adjusted models: Age, marital status, income, financial strain, physical limitations, health status, chronic conditions, anxiety symptoms, obesity status, widowhood, supplemental health insurance, past year ambulatory procedure, ≥ 2 emergency room visits in past 6 months, ≤ 1 close friends Rural-specific risk factors in fully adjusted models: - Financial strain (AOR= 1.50, 95% CI= 1.01, 2.23)

		- ≤ 1 close friends (AOR= 6.86, 95% CI= 2.18, 21.58) - ≥ 2 emergency room visits is past 6 months (AOR= 4.00, 95% CI= 1.19, 13.43) - Physical limitations (AOR= 1.08, 95% CI= 1.01, 1.14) High methodological quality (score= 14)
Guerra et al., 2009 [10] Country: Peru, Mexico, Venezuela Economy: Developing N: 5,886 Age range: 65+	Depression measure: Geriatric Mental State, structured clinical interview (information on threshold score not provided) Urban: - Peru: Two districts in the city of Lima - Mexico: Six districts in the suburb of Tlalpan, south of Mexico City - Venezuela: One district in the south west of the city of Caracas Rural: - Peru: Six districts in the coastal province of Canete - Mexico: Nine villages in the north of the mountainous state of Morelos	Depression prevalence higher in urban group Urban depression prevalence (pooled)= 2.3% Rural depression prevalence(pooled)= 1.4% Unadjusted OR= 1.71 (95% CI= 1.05, 2.71) Moderate methodological quality (score= 12)
Kim et al., 2002 [11] Country: South Korea Economy: Developing N: 1,134 Age range: 65+	Depression measure: Geriatric Depression Scale, Korean Form (threshold score ≥ 14) Urban: Residents of Songjeong, Kwangju, a city with a total of 9,866 inhabitants in an area of 17.3 square kilometers Rural: Residents of Samto, Kwangju, area with a total of 4,120 inhabitants in an area of 38.3 square kilometers	No statistically significant difference in depression prevalence between urban and rural groups Urban depression prevalence= 32.8% Rural depression prevalence= 33.3% Unadjusted OR= 0.98 (95% CI= 0.76, 1.26) Adjusted OR for urban-rural depression risk= 1.84 (95% CI= 1.20, 2.83) Variables adjusted for in fully adjusted models: Age, gender, marital status, education, housing, unemployment, disability, social support, religion, past manual occupation Urban-specific risk factors in fully adjusted models: - Older age (AOR= 1.26, 95% CI= 1.04, 1.52) - Past manual occupation (AOR= 1.79, 95% CI= 1.13, 2.83) - Renting housing (AOR= 2.14, 95% CI= 1.30, 3.53) Moderate methodological quality (score= 11)
Kim et al., 2004 [12] Country: South Korea Economy: Developing N: 1,204 Age range: 65+	Depression measure: Geriatric Mental State Schedule (information on threshold score not provided) Urban: Residents of Songjeong, Kwangju, a city with a total of 9,866 inhabitants in an area of 17.3 square kilometers Rural: Residents of Samto, Kwangju, area with a total of 4,120 inhabitants in an area of 38.3 square kilometers	Depression prevalence higher in urban group Urban depression prevalence= 21.0% Rural depression prevalence= 8.6% Unadjusted OR= 2.68 (95% CI= 1.90, 3.78) Adjusted OR for urban-rural depression risk= 1.84 (95% CI= 1.20-2.83) Variables adjusted for in fully adjusted models: Age, gender, marital status, education, housing, unemployment, disability, social support, religion, living alone, seeing friends less than monthly, having no close friends, seeing neighbors less than monthly Urban-specific risk factors in fully adjusted models: - Older age (AOR= 1.40, 95% CI= 1.08, 1.81) - Female gender (AOR= 1.99, 95% CI= 1.02, 3.86) Rural-specific risk factors in fully adjusted models: - Seeing friends less than monthly (p=.042)* - Having no close friends (p=.027)* *Significance of variable x rural residence

		interaction term, information on AORs not provided Moderate methodological quality (score= 13)
Ma et al., 2008 [13] Country: China Economy: Developing N: 1,601 Age range: 60+	Depression measure: Composite International Diagnostic Interview (CIDI 1.0) (information on threshold score not provided) Urban: Not specified Rural: Not specified	Depression prevalence higher in rural group Urban depression prevalence= 2.6% Rural depression prevalence= 8.4% Unadjusted OR= 0.29 (95% CI= 0.18, 0.47) Adjusted OR for urban-rural depression risk= 0.33 (95% CI= 0.16, 0.69) Variables adjusted for in fully adjusted models: Age, gender, marital status, income, education, housing, major medical conditions High methodological quality (score= 14)
Mechakra-Tahiri et al., 2009 [14] Country: Canada Economy: Developed N: 1,471 Age range: 65+	Depression measure: ESA Diagnostic Questionnaire(ESA-Q) (threshold score ≥ 2) Urban: Quebec province address designated urban by Institut de la Statistique du Quebec Rural: Quebec province address designated rural by Institut de la Statistique du Quebec	No statistically significant difference in depression prevalence between urban and rural groups Urban depression prevalence= 15.1% Rural depression prevalence= 17.0% Unadjusted OR= 0.87 (95% CI= 0.64, 1.18) Adjusted OR for urban-rural depression risk= n/a Variables adjusted for in fully adjusted models: Age, gender, income, self-rated health, chronic conditions Urban-specific risk factors in fully adjusted models: - n/a Rural-specific risk factors in fully adjusted models: - Female gender (AOR= 3.22, 95% CI= 2.14, 4.86) - Chronic condition (AOR= 1.30, 95% CI= 1.04, 1.61) - Poor self-rated health (AOR= 1.24, 95% CI= 1.02, 1.51) Moderate methodological quality (score= 13)
Schulman et al., 2002 [15] Country: United States Economy: Developed N: 118 Age range: 65+	Depression measure: Geriatric Depression Scale (GSD-30) (threshold score ≥11) Urban: Residents of a city with a population >250,000, classified by U.S. Census Bureau definition Rural: Residents of an area “outside of incorporated areas” with a population ≥ 2,500 classified by U.S. Census Bureau definition	Depression prevalence higher in urban group Urban depression prevalence= 54.3% Rural depression prevalence= 21.9% Unadjusted OR= 4.29 (95% CI= 1.84, 9.99) Adjusted OR for urban-rural depression risk= 3.8 (95% CI=1.5, 10.1) Variables adjusted for in fully adjusted models: Assistance in activities of daily living, living arrangement High methodological quality (score= 15)
Sengupta et al., 2015 [16] Country: India Economy: Developing N: 3,038 Age range: 60+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥ 5) Urban: Not specified Rural: Not specified	Depression prevalence higher in urban group Urban depression prevalence= 10.1% Rural depression prevalence= 7.3% Unadjusted OR= 1.42 (95% CI= 1.09, 1.85) Adjusted OR for urban-rural depression risk= 1.67 (95% CI= 1.21, 2.29) Variables adjusted for in fully adjusted models: Age, gender, marital status, income, education, functional impairment type of family, occupation, cognitive impairment

		High methodological quality (score= 14)
St John et al., 2006 [17] Country: Canada Economy: Developed N: 1,132 Age range: 65+	Depression measure: Center for Epidemiologic Studies Depression scale (CES-D) (threshold score ≥16) Urban: Resident of urban area (population >19,999) defined by Canadian Beale codes Rural: Resident of rural area (population <2,500) defined by Canadian Beale codes	No statistically significant difference in depression prevalence between urban and rural groups Urban depression prevalence= 11.6% Rural depression prevalence= 9.0% Unadjusted OR= 1.32 (95% CI= 0.84, 2.09) Adjusted OR for urban-rural depression risk= n/a Variables adjusted for in fully adjusted models: Age, gender, education, living arrangement, financial strain, self-rated health, functional impairment, number of companions Urban-specific risk factors in fully adjusted models: - Self-rated health (AOR=3.39, 95% CI= 2.06, 5.56) Rural-specific risk factors in fully adjusted models: - Living alone (AOR=3.40, 95% CI= 1.25, 9.26) - Financial strain (AOR=3.64, 95% CI= 1.32, 10.08) High methodological quality (score= 16)
Walters et al., 2004 [18] Country: Great Britain Economy: Developed N: 6,178 Age range: 75+	Depression measure: Geriatric Depression Scale (GDS-15) (threshold score ≥6) Urban: Zip code with highest density quartile (≥ 2,467 people/km) Rural: Zip code with lowest density quartile (0–355 people/km)	Depression prevalence higher in urban group Urban depression prevalence= 9.5% Rural depression prevalence= 7.0% Unadjusted OR= 1.40 (95% CI= 1.16, 1.69) Adjusted OR for urban-rural depression risk= 1.61 (95% CI= 1.20, 2.17) Variables adjusted for in fully adjusted models: Age, gender, financial strain, housing, physical symptoms, unmet needs in activity of daily living, living alone, impaired cognition High methodological quality (score= 15)

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