Income inequality and mental illness-related morbidity and resilience: a systematic review and meta-analysis

Title: Income inequality in mental illness-related morbidity, resilience and use of mental health services: a systematic review and meta-analysis

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Abstract

Background: Studies on the association between income inequality and mental have shown mixed results, probably due to methodological heterogeneity. By dealing with such heterogeneity through a systematic review and meta-analysis, we examine the relationship between income inequality, mental health problems, use of mental health services, and resilience.

Methods: systematic review and meta-analysis. A search was carried out in the Global Health, PsychARTICLES, PsycINFO, Social Policy and Practice, Embase and MEDLINE databases through July 06, 2016. We included quantitative studies which assessed mental health problems through standardized instruments at the individual level, and income inequality at contextual level. Study characteristics, sampling, exposure, outcomes, statistical modelling and parameters were extracted from articles. Mental health problems were the main outcome in the random-effects meta-analysis. This study's registration number is CRD42016036377 (PROSPERO).

Results: From 15,615 references identified, 27 articles were included in the review. In nine articles included in the meta-analysis, pooled effect sizes were 0.06 (95% CI = 0.015 to 0.109) for any mental disorders, and 0.124 (95% CI = 0.052 to 0.197) for depressive disorders. None of the factors included in the meta-regression explained heterogeneity.

Interpretation: Despite our narrative synthesis' mixed results, its general trend suggests that there is a relationship between income inequality and mental health problems, which was confirmed by our meta-analysis. If this relationship is causal, growing income inequality might lead to increase in the prevalence of mental health problems, and its reduction could result in a significant improvement of population's well-being.

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Introduction

Mental disorders are highly prevalent and are associated with a significant proportion of the Global Burden of Disease (GBD). Pooled one-year prevalence of mental disorders is estimated to be 17.6% among adults[1] and 13.4% among children and adolescents[2]. It has been estimated that mental disorders account for 22.9% of all Years Lived with Disability (YLD) worldwide [3], and for 32.4% of YLD if mental health problems that are not clinically diagnosable[4] are considered. Studies have established that, along with genetic and biological factors, social determinants influence individual and population mental health[5-8], and that contextual factors, such as deprivation, poverty and violence negatively affect mental health. Analysing data from a study with twins, Caspi et al (2000) concluded that 20% of variance in children's behaviour problems were attributed to contextual factors, and that neighbourhood deprivation accounted for 5% of the contextual effect.

A theoretical framework proposes that income inequality affects health trough a material pathway and a psychosocial pathway. In the material pathway, income inequality affects health outcomes through poverty and deprivation, which are related to increases stress[9] and reduced access to health care[10], and are prevalent in highly unequal societies[11]. The psychosocial pathway relies on status competition and insecurity[12], leading to social problems[13], such as lack of social cohesion and violence, low levels of trust and weaker community life[12]. Evidence shows that these psychosocial factors can affect health through physiological effects of chronic stress and through their effects on health-related behaviours and individuals' self-esteem[14] Those, in turn, are known to cause psychosocial stress[5,6] and to increase the risk of developing mental health problems at an individual level[15-19].

Understanding the association between income inequality and mental health could have major public health implications, if evidence shows that the relationship is causal. A recent meta-analysis[11], for example, estimated that for each 0.05 unit increase in the Gini coefficient of income inequality the odds ratio for poor health and overall relative risk of mortality increased 4% and 8%, respectively. If income inequality has a similar effect on mental health, then a significant improvement on populations' well-being could be achieved with a reduction in inequality.

Empirical studies on the association between income inequality and mental health problems have shown mixed results. Pickett and Wilkson (2010)[12] reported a strong correlation (r = 0.73) in high-income countries. In the USA, the result was replicated among women and children, but not among men[12]. Other studies have shown that income inequality is negatively correlated with mental health in the USA at state level, but not at more proximal levels, such as community, nor in other countries[20]. Such mixed results might be attributed to methodological heterogeneity between studies, such as study design, instruments used to assess mental health problems or contextual levels at which income inequality was measured. Therefore, it is important to address these results in a systematic review and meta-analysis, as these techniques can deal with heterogeneity between studies and results through statistical tools and sensitivity analysis.
This review aims at investigating the association between income inequality and mental health related morbidity, defined as the prevalence or incidence of any mental health

problem. Specifically, we examine the relationship between income inequality and prevalence and incidence of mental disorder. Social capital and social cohesion, which are affected by income inequality, are thought to facilitate access to health care[21] and to increase resilience, defined as the ability to cope with adversity[22]. Therefore, we also investigated the relationship of income inequality with use of mental health services and resilience. We hypothesize that prevalence/incidence of mental disorder would be higher, and that resilience and use of mental health services would be lower among people living in regions with high income inequality as compared with those living in areas with low income inequality.

Methods

This systematic review followed the Centre for Review and Dissemination's guidance for reviews in health care (http://www.york.ac.uk/media/crd/Systematic_Reviews.pdf)http://www.york.ac.uk/media/crd/Systematic_Reviews.pdf), and the protocol was registered on PROSPERO International Prospective Register of Systematic Reviews (CRD42016036377).

We searched six electronic databases (Global Health, PsychARTICLES, PsycINFO, Social Policy and Practice, Embase and MEDLINE) We established no initial time limit and included references available until July 06, 2016, when the search was performed. The following subject heading and keywords were used: (income inequality-related terms) AND (mental health-related terms OR resilience) (Appendix 1). Studies not identified through the search were sought for by consulting with experts, and by checking reference lists of included articles and relevant review articles.

We included quantitative studies on the association of income inequality with: 1) prevalence or incidence of mental disorders or mental health problems; 2) resilience; and 3) use of mental health services. Inclusion criteria were: assessment of mental health problems at individual level through standardized instruments; assessment of income inequality at aggregated/contextual/ecological level. We chose mental health problems as primary outcomes and, if available, resilience and use of mental health services as secondary outcomes. There were no restrictions regarding age of participants or language in our literature search.

Six reviewers (WSR, AB, MCRA, MYS, PMP and LP) participated in the screening and selection process. For reliability purposes, three sets of 300 references each were randomly selected from the non-duplicated references. Reviewers were grouped into three pairs. Each pair screened titles and abstracts of one of the 300-reference sets. Disagreements were resolved through group discussion. The remaining references were divided among reviewers, who screened titles and abstracts to identify potentially eligible studies in addition to those identified in the reliability phase. References selected in the screening phase were independently double-checked by two reviewers (WSR, SEL). Final eligibility assessment was performed by one reviewer (WSR) and double-checked by another (SEL).

Data extraction

Information extracted from articles was: 1) study design, methods and timing of data collection; 2) sample frame, sample size, attrition rate and subgroups; 3) income inequality indices and level at which they were obtained; 4) diagnosis/type of mental health problem and mental health assessment tools; 5) statistical modelling; and 6) statistical parameters.

Quality assessment

Five questions assessed quality: the first question assessed whether impact of missing data was taken into consideration, through sensitivity analysis or other adjustments methods (attrition bias). The second question assessed if confounding variables were considered (analytical bias). These two questions were derived from a framework developed by the US Agency for Health Care Research and Quality to ascertain risk of bias in observational studies[23]. A third question considered whether studies used a longitudinal design, which is the most appropriate design to determine causal relationships. The fourth question considered whether participants were selected through a randomized sampling strategy (selection bias). The fifth question verified whether multilevel analysis was used, as this is the most appropriate strategy to distinguish effects of contextual variables on outcomes[11,24]. For each question, studies were considered to have *low risk of bias* (L) if they were coded "yes", *high risk of bias* (H) if coded "no" and *unclear* (U) if they did not provide enough information. L was recoded as 1, whereas H and U were recoded as 0. Therefore, studies were attributed a total score ranging from zero (highest risk of bias) to 5 (lowest risk of bias).

Narrative synthesis and statistical analysis

Considering that several studies did not provide enough statistical information to be included in a meta-analysis, a narrative synthesis was performed[25] to summarise results. We grouped studies into three categories based on their results – positive association; mixed results; and no association – and we assessed whether groups of studies differed in relation to outcome, design, quality score, type of income inequality variable (continuous vs. categorical), stratification, income inequality area-level, and instruments.

Our statistical analysis included studies that reported income inequality and outcomes as categorical variables. We converted association parameters and standard errors (SE) into Cohen's d Effect Sizes (ES), and then we estimated pooled effect sizes for any mental disorders, depressive disorders and common mental disorders. Due to heterogeneity between studies, we used a random-effects approach and performed sensitivity analyses. In the first sensitivity analysis, we excluded studies that did not control their analyses for individual income; in the second, we excluded studies which scored 2 or less in the quality assessment. We ran a random-effect meta-regression analysis to evaluate factors that could account for heterogeneity between studies, based on a 5% significance level ($p<0.05$). Variables included in the meta-regression were: sample-size, income inequality area-level, quality assessment, use of diagnostic vs. screening instruments, inclusion of individual-level income in the statistical modelling. We used Egger's test to assess bias. Analyses were performed using Stata 13.0.

Results:

Our search identified 15,615 non-duplicate references (Figure 1), from which 113 were considered potentially relevant and were assessed for eligibility, leading to the inclusion of 19 articles. Five articles were found in reference lists, and three were suggested by experts, resulting in a total of 27 articles, from which 21 were derived from cross-sectional studies, two were ecological analysis[12,26-28] and two cohort studies[29,30].

FIGURE 1 ABOUT HERE

Eight articles reported results from multi-country studies[12,27,29,31-35]; ten studies were conducted in the USA[28,30,36-43]; three studies were carried out in the UK[44-46]; two articles reported results from a study carried out in Brazil[47,48]; one study was conducted in Australia[49], one in Mexico[50], one in Spain[51], and one in South Africa[26] (Table 1).

TABLE 1 ABOUT HERE

Most articles focused on adult populations. One article included university students[35], one included 11, 13 and 15-year-old students[31] and one sampled women with infant children[40]. Twenty-two articles assessed psychiatric diagnoses[12,26-30,32,34-37,39-47], whereas three assessed psychological distress/symptoms or mental well-being/functioning[31,33,49]. One article assessed both psychiatric diagnosis and psychological symptoms[38], and one article reported use of mental health services[48]. Twenty-three articles assessed income inequality using the Gini index[12,27-38,42,45,49] – one of them[49] also included Thail and Atkinson indexes. One article reported area percentage of households with income over $150,000 as a measure of income inequality[43], and one article reported the ration of mean income of the top 10% to the bottom 10% earners[26]. Income inequality was assessed at different contextual levels – community/neighbourhood, region/area of residence, city, state and country.

In the quality assessment (Appendix 2), ten studies[12,26-28,32,35,39,40,42,45] scored two or less; the remaining 17 scored 3 or 4. The main problems identified were use of cross-sectional and ecological study design and absence of missing data assessment.

Nine articles[26-28,31,32,35,40,45,49] reported that the prevalence/incidence of mental health problems was higher in areas with greater income inequality. These studies assessed depression[28,37,41,51], psychological distress/symptoms[31] and psychosis[26,27,32,45]. Ten articles reported mixed results: four of them found that greater income inequality was associated with higher prevalence/incidence of mental health problems in some population subgroups[29,30,36,40], such as females[30] or low-income groups[36] or countries with high HDI[29]; one article[47] reported that income inequality was associated with depression, but not with anxiety or any mental disorders; one article[44] reported that greater income inequality was associated with lower prevalence of common mental disorders at community level, and higher prevalence at region level; one article [12] found association at country level, and only among women and children at state level; in one article[46] greater income inequality was associated with higher prevalence of common mental disorders in high-income areas, and with lower prevalence in low-income areas. Eight articles[34,38,39,42,43,49-51] found non-significant associations.

One study investigated the relationship between income inequality and resilience[36] by assessing the association between income inequality and depression in the aftermath of a disaster. It operationalised resilience as absence of depression after exposure to a potentially traumatic experience, and tested the hypothesis that residents of New York City living in areas with greater inequality would be more vulnerable to developing depressive disorder in the aftermath of the 2001 terrorist attacks. Greater income inequality was associated with higher prevalence of depression only among individuals with low income.

One article[48] reported the role of income inequality as a determinant of use of mental health services. No association was found with use of mental health services, whereas presence of a regular physician was less common in areas with greater inequality.

When articles were grouped into three categories based on the type of association (i.e., positive, mixed or none) between income inequality and outcomes (Appendix 3), the only difference between the three groups was that, in contrast to the mixed and no significant groups, there was no population stratification in the positive association group. When other key study characteristics were considered, the three groups were similarly heterogeneous.

Nine articles[30,36-40,44,46,47] were included in our meta-analysis. One of them[37] reported positive association between income inequality and mental health problems, six[30,36,40,44,46,47] reported mixed results and two[38,39] reported no association. Pooled Cohen's d effect sizes for the association between income inequality and any mental disorder/mental health problems was found to be 0.059 (95% CI = 0.015 to 0.103; p = 0.009), ranging from -0.478 to 0.733 (Figure 2). Nearly 90% of the variation across estimates was due to heterogeneity between studies (I-square=89.3%, p<0.0001).

FIGURE 2 ABOUT HERE

Pooled Cohen's d effect size for the association between income inequality and depression was estimated to be 0.124 (95% CI = 0.052 to 0.197; p = 0.0001), ranging from -0.213 to 0.733. Nearly 90% of the variation was attributable to heterogeneity across studies (I-square=88.7%, p<0.0001) (Appendix 4). Pooled Cohen's d effect size for the association between income inequality and common mental disorders was -0.037 (95% CI=-0.108 to 0.034; p = 0.307), ranging from -0.478 to 0.149, being over 80% of variation attributed to heterogeneity (I-square = 84.4%, p <0.0001) (Appendix 5). In the alternative model, which included studies reporting inequality as a linear predictor (data not shown), there were nine effect sizes from seven studies. The pooled effect size was not statistically significant (ES: 0.068; 95% CI = -0.011 to 0.147; p = 0.092).

Our meta-regression analysis showed that none of the factors considered (sample size, contextual level at which income inequality was assessed, quality assessment, type of instruments and individual income as control variable) explained heterogeneity between studies. In our sensitivity analyses exclusion of studies did not change the results of the primary meta-analyses (data not shown). Egger's test for studies included in the meta-analysis were: bias = -1.181; 95% CI = -1.968 to -0.393; p = 0.004.

Discussion

Our systematic review and meta-analysis provides a comprehensive synthesis of the evidence on the association between income inequality and mental health problems, and found that pooled effect sizes for the association of income inequality, as categorical variables, with any mental health problem and with depressive disorder were statistically significant, albeit small (0.06 and 0.12, respectively). These results have important political implications as the well-documented growth in income inequality worldwide[52,53] could lead to an increase in the incidence of mental health problems and disability.

Our narrative synthesis provides some insights on mechanisms and pathways between income inequality and mental health problems. Studies which found an interaction between income inequality with neighbourhood deprivation[44], area income[36] and country-level human development index[29], suggests that these factors might mediate the association between income inequality and mental health problems supporting the material pathway mechanism[9-11]. One study[33] provided evidence that income inequality may affect mental health through a psychosocial pathway[12-14] by finding that status anxiety and social capital mediated the association between income inequality and mental health problems. These results are based on individual studies and are not necessarily generalizable to all countries or contexts. They support the need for studies specifically designed to better understand such interactions.

Other studies have shown that income inequality is associated with an increased risk of self-rated poor health and mortality[11]. By focusing on mental health problems, our review provides evidence on which outcomes income inequality might affect the most. It is noteworthy that our meta-analysis models found the largest pooled effect size for depression, which is now considered the leading cause of disability[54].

Some limitations of this systematic review and meta-analysis should be considered. First, only two out of 24 articles reported results based on cohort studies, which a better design than cross-sectional analysis to explore associations between exposure and outcome. Reverse causality should not be discarded in cross-sectional studies, as ill-mental health can undermine productivity and earning capacity[20], leading to high levels of unemployment and very low income in areas with high prevalence of mental health problems. Considering that income inequality tends to be relatively stable over time, cross-sectional studies could minimise the likelihood of reverse causality by collecting information on the onset of mental health problems and date when participants first moved to their neighbourhood of residence, though these assessments would still be vulnerable to recall bias. Secondly, only nine articles provided the necessary information to be included in the meta-analysis. Therefore, one should be cautious when considering our pooled effect sizes. Third, we included a broad definition of mental health problems, rather than using the specific terminology, for feasibility purposes. It may be that our key words were not precise enough to identify articles that used more specific terms, such as psychosis, resulting in publication bias. To minimise publication bias, we performed a comprehensive search in seven different scientific databases, and we also searched reference lists of included articles to identify potentially missed references. Finally, none of the studies were specifically designed to

address the association between income inequality and mental health problems. Therefore, there are methodological issues which limit our understanding of this relationship, particularly its direction of the relationship, mechanisms which might lead to poor mental health and the pathways to specific disorders.

Even though our narrative synthesis showed mixed results, its general trend seems to support the hypothesis that income inequality might negatively impact mental health, which is, to some degree, confirmed by our meta-analysis. Therefore, our findings support the inclusion of income inequality in the public health agenda, as reducing income inequality could improve population mental health and well-being. Reducing inequalities has been recognized as a key priority by the global community as one of 17 goals in the United Nations Agenda for sustainable development[55], and could lead to a virtuous cycle if it leads to improved population mental health and well-being, providing individuals with more psychosocial resources to engage in education and employment, achieving better economic circumstances, and hence further reducing the income inequality gap.

Panel: Research in context

Evidence before this study

A theoretical framework has been proposed to explain mechanisms through which income inequality could affect health in general, and mental health in particular. A recent meta-analysis has shown that income inequality increases the odds ratio for poor health and the relative risk of mortality. Empirical studies on the association between income inequality and mental health problems, however, have shown mixed results, with some studies finding that greater income inequality is associated with higher prevalence of mental health problems, whereas other studies have found no association. Methodological heterogeneity between studies might be responsible for such mixed results. Pooling studies together in a systematic review and meta-analysis might address such mixed results, as this techniques can deal with heterogeneity between studies and results through statistical tools and sensitive analysis.

Aiming at investigating the association with income inequality and mental health problems, we searched six electronic databases (Global Health, PsychARTICLES, PsycINFO, Social Policy and Practice, Embase and MEDLINE), using the following subject heading and keywords were used: (income inequality-related terms) AND (mental health-related terms OR resilience)

Added value of this study

Our systematic review and meta-analysis provides a comprehensive synthesis of the available empirical evidence on the association between income inequality and mental health problems. Our results show that, when studies are pooled together in a meta-analysis, the association between income inequality and any mental health problems, and between income inequality and depressive disorder are statistically significant, albeit the overall effect sizes were small (0.06 and 0.12 respectively). Our narrative synthesis identified three groups of studies based on the type of association (i.e., positive, mixed or none), and found that some methodological factors might be associated with identifying a positive relationship between income inequality and mental health problems. In our meta-regression, none of the factors included in the model explained heterogeneity between studies, suggesting that such heterogeneity might be attributed to unreported methodological features.

Implication of all the available evidence

Our systematic review provides evidence that, when studies are pooled together, greater income inequality is associated with higher prevalence and incidence of mental health problems, particularly with depressive disorders. This evidence supports the inclusion of income inequality in the public health agenda, as reducing income inequality could improve population's mental health and well-being. If population's mental health improves, individuals will have more psychosocial resources to engage in education and employment, achieving better economic circumstances, and hence further reducing the income inequality gap. Our narrative synthesis highlights some methodological features which might be responsible for heterogeneity between studies and for the mixed results, providing some

insights on how further studies should be designed to better understand the relationship between income inequality and mental health problems.

Contributors

WSR and SEL conceived the systematic review and search strategy; WSR ran the search strategy; WSR, AB, MCRA, MYS, PMP and LP screened references retrieved from the search strategy, and selected eligible studies based on the inclusion and exclusion criteria; WSR, SEL conceived and ran the statistical modelling; ESFC supervised and reviewed the statistical analysis; WSR wrote the manuscript with inputs from AB, MCRA, MYS, PMP, LP, MK, ESFC and SEL; AB MCRA, MYS, PMP, LP, MK, ESFC and SLE revised the final manuscript and contributed significantly with the interpretation of the results.

Declaration of interests

WSR, AB, MCRA, MYS, PMP, LP, MK, ESFC declare no competing interests. SEL has received consulting fees from Lundbeck unrelated to this work. SEL and WSR are funded by the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ERC grant agreement n^{o} [337673]; PMP is in receipt of research support from the Brazilian National Council for Scientific and Technologic Development (CNPq).

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Figure 1: PRISMA flow Diagram

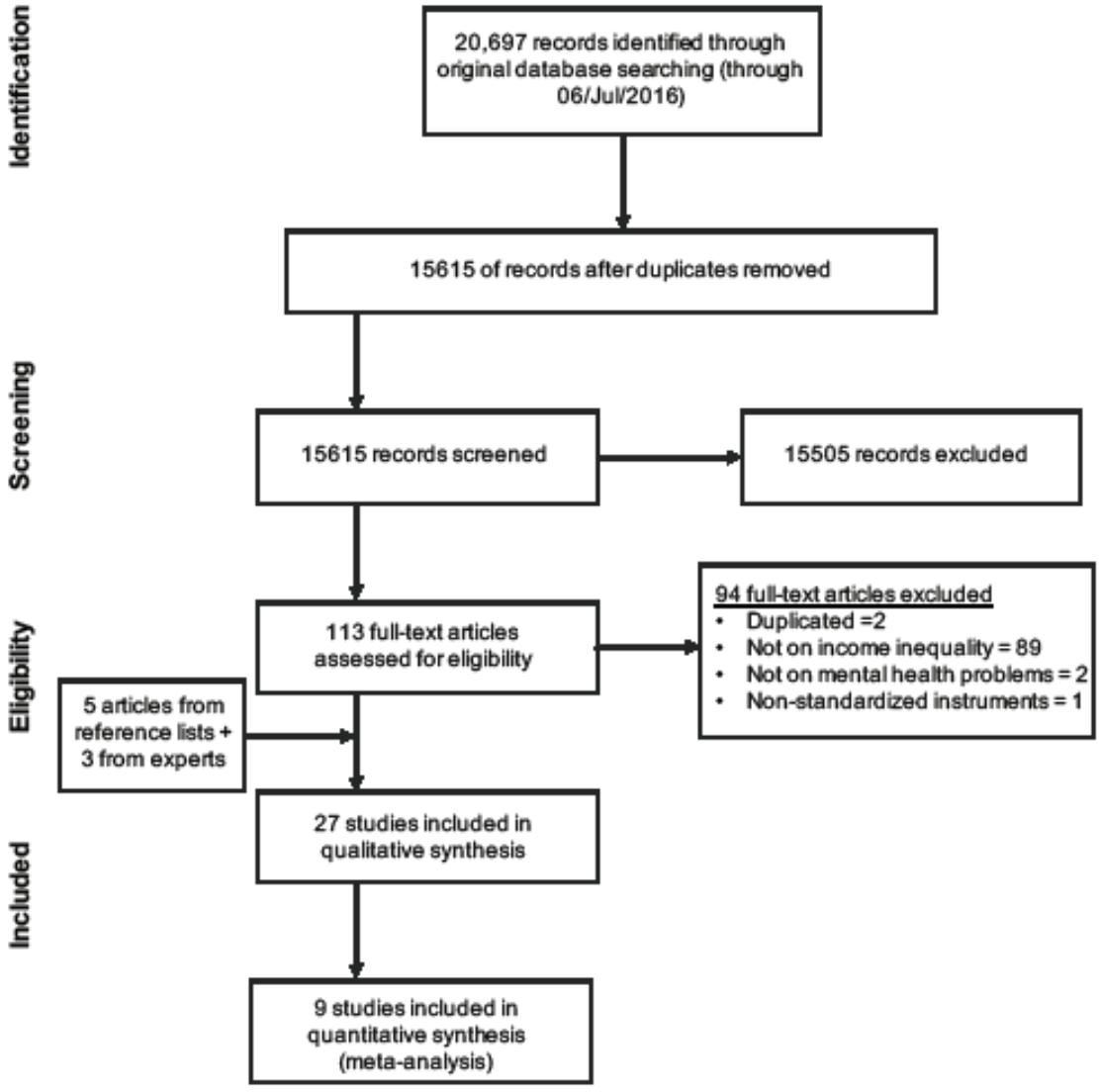


Table 1: Characteristics of studies included in the systematic review and meta-analysis

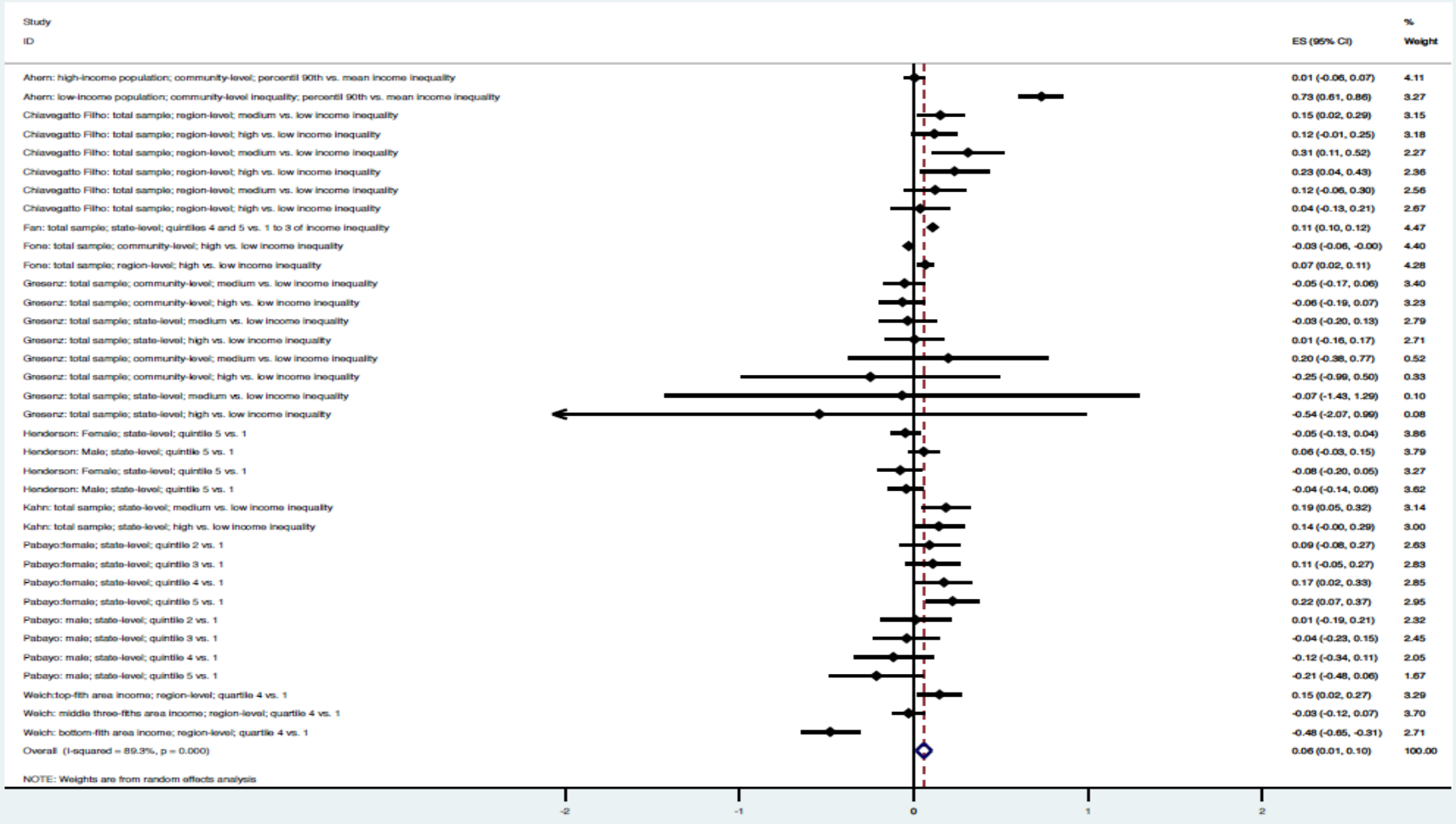
	Characteristics of studies	Age	Outcome	Measure of income inequality	Area level variable	Statistical analysis	Adjusted variables
Ahern, 2006*	**Design**: cross-sectional **Setting**: USA **Population**: general population **Sample size**: 1355	≥18 years	Past six-month depression	Gini	59 community districts in NYC	Multilevel analysis	Median income, individual income, age, ethnicity
Bechtel, 2012	**Design**: Cohort **Setting**: Australia **Population**: general population **Sample size**: 67305	≥15 years	Mental health functioning	Gini Theil Atkinson	Neighbourhood; Major statistical region; city	Multilevel analysis	Age, number of children, country of birth, education
Chiavegatto Filho, 2013*	**Design**: cross-sectional **Setting**: Brazil **Population**: general population **Sample size**: 3,542	≥18 years	Depression; anxiety; any mental disorder	Gini	Area of residence	Multilevel analysis	Age, gender, education, individual income, marital status
Chiavegatto Filho, 2015	**Design**: cross-sectional **Setting**: Brazil **Population**: general population **Sample size**: 3,542	≥18 years	Use of mental health services	Gini	Area of residence	Multilevel analysis	Age, gender, education, individual income, marital status
Cifuentes, 2008	**Design**: cross-sectional **Setting**: 65 countries **Population**: general population **Sample size**: 280,563	≥18 years	Major depressive episode	Gini	65 countries	Multilevel analysis	Age, gender, marital status, education, country level of development
Elgar, 2015	**Design**: cross-sectional time series **Setting**: 34 North-American and European countries **Population**: students **Sample size**: 492,788	11, 13 and 15 years	Psychological symptoms	Gini	34 countries	Multilevel analysis	Age, gender, socioeconomic status, survey cycle
Fan, 2011*	**Design**: cross-sectional time series **Setting**: USA **Population**: general population **Sample size**: 293,405	≥18 years	Current depression	Gini	All USA states; districts of Columbia, Guam, Puerto Rico and US Virgin islands	Multilevel analysis	Age, gender, ethnicity, marital status, education, household income, number of chronic conditions, survey year
Fernandez-Niño, 2014	**Design**: cross-sectional **Setting**: Mexico **Population**: general population **Sample size**: 7,867	≥60 years	Depressive symptoms	Gini	Municipality, state	Multilevel analysis	Age, gender, paid work, education, not consulted in household decision-making, number of illnesses, impairment, accident, violence, household assets, living alone, deprivation index
Fone, 2013*	**Design**: cross-sectional **Setting**: Wales **Population**: general population **Sample size**: 88,858	18-74 years	Common mental disorder	Gini	1896 LSOA as proxy for neighbourhood; 22 unitary authority	Multilevel analysis	Income deprivation, gender, social class, employment status, education, housing tenure

Gresenz, 2001*	**Design**: cross-sectional **Setting**: USA **Population**: general population **Sample size**: 6,925	<65 years	Anxiety or depression; psychological distress	Gini	60 US Census primary statistical area; State	Multilevel analysis	Age, gender, ethnicity, family size
Henderson, 2004*	**Design**: cross-sectional **Setting**: USA **Population**: older adults **Sample size**: 42,862	≥18 years	Depression; Alcohol dependence	Gini	State	Multilevel analysis	Gender, age, ethnicity, education, family income, family size, urbanity, beer tax
Johnson, 2015	**Design**: cross-sectional **Setting**: 27 countries **Population**: adults **Sample size**: 27,831	Not informed	Psychotic symptoms	Gini	Country	Regression analysis	Per capita income
Kahn, 2000*	**Design**: cross-sectional **Setting**: USA **Population**: women with infant children **Sample size**: 8,285	≥15 years	Depression	Gini	State	Multilevel analysis	Age, marital status, education, ethnicity, household size
Layte, 2011	**Design**: Cross-sectional **Setting**: 27 countries **Population**: adults **Sample size**: 27,831	≥18 years	Mental well-being	Gini	Country	Multilevel analysis	Age, gender, health status, income, education, employment status
Messias, 2011	**Design**: Ecological **Setting**: USA **Population**: adults **Sample size**: 235,067	Not informed	Depression	Gini	State	Regression analysis	Income per capita, percentage with college degree, percentage over age 65
Muramatsu, 2003	**Design**: cross-sectional **Setting**: USA **Population**: older adults **Sample size**: 6,640	≥ 70 years	Depression	Gini	County	Multilevel analysis	Gender, age, ethnicity, marital status, education, individual income, physical illnesses
Pabayo, 2015*	**Design**: cohort **Setting**: USA **Population**: general population **Sample size**: 34,653	≥18 years	Major depressive disorder	Gini	50 US states and District of Columbia	Multilevel analysis	Age, gender, education, marital status, ethnicity, household income, education, urbanity, perception of health, family history of depression, life events
Pickett, 2010	**Design**: ecological **Setting**: 8 developed countries **Population**: general population **Sample size**: not informed	Not informed	Mental illness	Gini	9 developed countries and USA states	Pearson's correlation	None
Rai, 2013	**Design**: cross-sectional **Setting**: 53 countries **Population**: general population **Sample size**: 187,496	≥18 years	Depressive episode	Gini	53 countries	Multilevel analysis	Age, gender, area type, marital status, education, material assets, spending, occupational class
Rocha, 2015	**Design**: cross-sectional **Setting**: Spain **Population**: adults	>16 years	Common mental disorders	Gini	53 countries	Multilevel analysis	Age, gender, area type, marital status, education, material assets,

	Sample size: 229,476						spending, occupational class
Steptoe, 2007	**Design**: cross-sectional **Setting**: 23 countries **Population**: university students **Sample size**: 17,348	17-30 years	Depressive symptoms	Gini	23 countries	Multilevel analysis	Age, gender, family wealth, parental education, sense of control, GDP, tertiary education access, individualism/collectivism
Sturm, 2002	**Design**: cross-sectional **Setting**: USA **Population**: general population **Sample size**: 3,460	Adults	Depressive disorder; depressive or anxiety disorder	Gini	60 communities	Multilevel analysis	Age, gender, ethnicity, family size
Weich, 2001*	**Design**: cross-sectional **Setting**: England, Wales and Scotland **Population**: general population **Sample size**: 8,191	16-75 years	Common mental disorder	Gini	18 regions	Multilevel analysis	Age, gender, social class, housing tenure, social class by head of household
Zimmerman, 2006	**Design**: cross-sectional **Setting**: USA **Population**: general population **Sample size**: 4,817	40-45 years	Depression	County level percentage of households with income over $ 150,000	County	Multilevel analysis	Gender, ethnicity, urbanity, region, income, education, poverty status, insurance status, marital status
Burns, 2008	**Design**: ecological **Setting**: South-Africa **Population**: general population **Sample size**: 508,275	15-49 years	First episode of psychosis	Ration of income top 10% / bottom 10%	Municipality	Partial Pearson's correlation	Urbanization
Burns, 2014	**Design**: ecological **Setting**: 26 countries **Population**: general population **Sample size**: not informed	Not informed	Schizophrenia	Gini	Country	Multi-level Analysis	Migration, Population density, unemployment, GDP per capita
Kirkbride, 2014	**Design**: cross-sectional **Setting**: UK **Population**: general population **Sample size**: not informed	18-64 years	Psychotic syndromes	Gini	LSOA as proxy for neighbourhood	Multi-level analysis	Age, gender, ethnicity, individual-level SES, and contextual-level deprivation, population density, social fragmentation, and voter turnout
Karriker-Jaffe, 2013	**Design**: cross-sectional **Setting**: USA **Population**: general population **Sample size**: 13,991	25-69 years	Alcohol dependence	Gini	State	Multi-level analysis	gender, age, marital status, education, employment, ethnicity, state median income, neighbourhood disadvantage

* Studies which were included in the meta-analysis

Figure 2: Meta-analysis of the association between income inequality and any mental health problems



Appendix 1: search strategy using OvidSP® search tool

1	income.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
2	inequalit*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
3	gini.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
4	gini index.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
5	concentration index.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
6	1 or 2 or 3 or 4 or 5
7	mental disorder*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
8	mental illness*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
9	mental disease*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
10	mental disabilit*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
11	7 or 8 or 9 or 10
12	psychiatr* disorder*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
13	psychiatr* illness*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
14	psychiatr* disease*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
15	psychiatr* diagnos*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
16	12 or 13 or 14 or 15
17	behav* disorder*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
18	11 or 16 or 17
19	6 and 18
20	resilien*.mp. [mp=ab, ti, ot, bt, hw, id, cc, tx, ct, sh, tc, tm, pt, an, ui, tn, dm, mf, dv, kw, nm, kf, px, rx]
21	18 or 20
22	6 and 21

Appendix 2: Quality assessment of included studies

Study reference	Study design	Random sample	Missing data assessment	Confounding	Statistical modelling	Score
Ahern, 2006	H	L	H	L	L	3
Becntel, 2012	L	L	H	L	L	4
Chiavegatto Filho, 2013	H	L	H	L	L	3
Chiavegatto Filho, 2015	H	L	H	L	L	3
Cifuentes, 2008	H	L	H	L	L	3
Elgar, 2015	H	L	H	L	L	3
Fan, 2011	H	L	H	L	L	3
Fernandez-Nino, 2014	H	L	U	L	L	3
Fone, 2013	H	L	H	L	L	3
Gresenz, 2001	H	L	L	L	L	3
Henderson, 2004	H	L	U	L	H	2
Johnson, 2015	H	L	U	H	U	1
Kahn, 2000	H	L	U	L	H	2
Layte, 2011	H	L	U	L	L	3
Messias, 2011	H	L	U	L	H	2
Muamatsu, 2003	H	L	U	L	L	3
Pabayo, 2015	L	L	H	L	L	3
Pickett, 2006	H	L	U	H	H	1
Rai, 2013	H	L	U	L	L	3
Rocha, 2015	H	L	U	L	L	3
Steptoe, 2007	H	H	U	L	L	2
Sturm, 2002	H	L	U	L	H	2
Weich, 2001	H	L	U	L	L	3
Zimmerman, 2006	H	L	U	L	L	3
Burns, 2008	H	H	U	L	L	2
Burns, 2014	H	U	U	L	L	2
Kirkbride, 2014	H	H	U	L	L	2

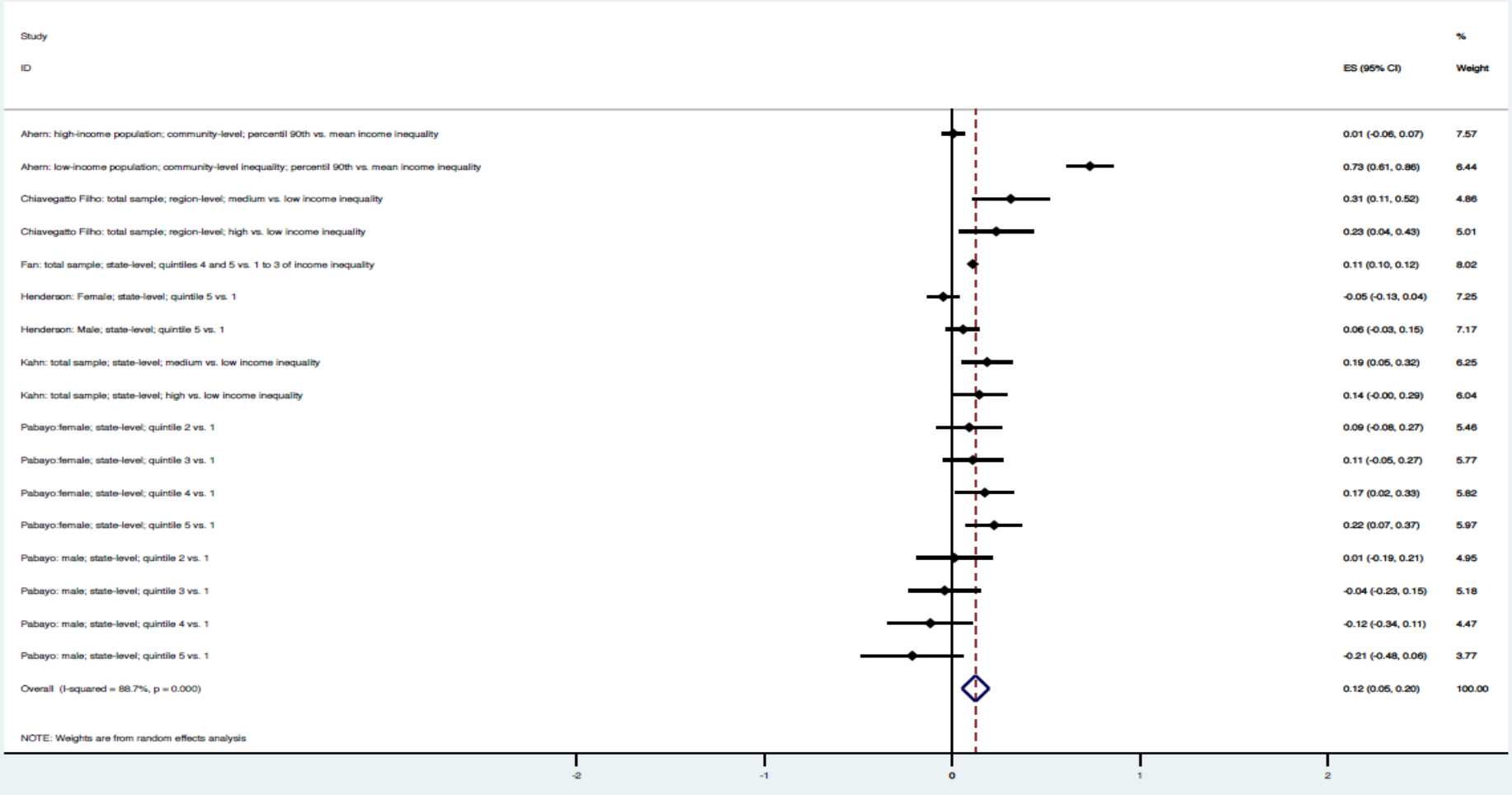
Notes: H = high risk of bias; L = low risk of bias; U = unclear

Appendix 3: Studies' stratification based on the direction of association between income inequality and outcomes

Study	Outcome	Design	Quality	Inequality variable	Stratification	Area-level	Instrument
Positive association:							
Messias, 2011	Depression	Ecological	2	Continuous	No	State	PHQ-8
Elgar, 2015	Psychological distress	Cross-sectional	3	Continuous	No	Country	4 Psychological symptoms
Steptoe, 2011	Depression	Cross-sectional	2	Continuous	No	Country	BDI
Johnson, 2015	Psychotic symptoms	Cross-sectional	1	Continuous	No	Country	CIDI 3.0
Fan, 2011	Depression	Cross-sectional	3	Categorical	No	State	PHQ-8
Muramatsu, 2003	Depression	Cross-sectional	3	Continuous	No	Region	CES-D
Burns 2008	First episode of psychosis	Ecological	2	Continuous	No	Municipality	Clinical records – DSM-IV
Burns 2014	Schizophrenia	Ecological	2	Continuous	No	Country	Not informed
Kirkbride 2014	Psychotic syndromes	Cross-sectional	2	Continuous	No	Neighbourhood	SCAN
Mixed results							
Cifuentes, 2008	Depression	Cross-sectional	3	Continuous	No	Country	WHS questionnaire
Layte, 2011	Mental Well-being	Cross-sectional	3	Continuous	No	Country	WHO5
Pickett, 2010	Any mental disorders	Ecological	1	Continuous	No	Country; State	WMH-CIDI
Pabayo, 2014	Depression	Cohort	3	Categorical	Gender	State	AUDADIS-IV
Ahern, 2011	Depression	Cross-sectional	3	Categorical	Area income	Community	NWS depression module
Khan, 2000	Depression	Cross-sectional	2	Categorical	No	State	CES-D
Fone, 2013	Common mental disorders	Cross-sectional	3	Categorical	No	Community/region	MHI-5
Weich, 2001	Common mental disorders	Cross-sectional	3	Categorical	Area income	Region	GHQ
Chiavegatto Filho, 2013	Depression, anxiety, any mental disorders	Cross-sectional	3	Categorical	No	Region	CIDI 3.0
Chiavegatto Filho, 2015	Use of mental health services	Cross-sectional	3	Categorical	No	Region	CIDI 3.0
No association							
Bechtel, 2012	Psychological distress	Cohort	4	Continuous	No	Region/city	SF-36
Rai, 2013	Depression	Cross-sectional	3	Continuous	Country income	Country	WMH-CIDI
Gresenz, 2001	CMD; psychological distress	Cross-sectional	3	Categorical	No	Region/state	CIDI-SF; MHI-5
Sturm, 2002	Depression	Cross-sectional	2	Categorical	No	Region	CIDI-SF
Zimmerman, 2006	Depression	Cross-sectional	3	Continuous	Ethnicity	Region	CES-D
Henderson, 2004	Depression; alcohol dependence	Cross-sectional	2	Categorical	Gender	State	AUDADIS-IV
Fernandez-Niño, 2014	Depression	Cross-sectional	3	Continuous	No	City/state	CES-D
Rocha, 2015	Common mental disorders	Cross-sectional	3	Continuous	Gender	State	GHQ-12

PHQ-8: Patient Health Questionnaire; WHO5: World Health Organization measure of well-being; CES-D: Center for Epidemiologic Studies Depression Scale; AUDADIS-IV: Alcohol Use Disorder and Associated Disability Interview Schedule-IV; NWS: National Women Study; MHI-5: Mental Health Inventory; GHQ: General Health Questionnaire; SF-36: Short Form 36;

Appendix 4: Meta-analysis of the association between income inequality and depressive disorder



Appendix 5: Meta-analysis of the association between income inequality and common mental disorders