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# Neighborhood characteristics and mental disorders in three large Chinese cities: Multilevel mixed models from the cross-sectional World Mental Health Surveys

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## ABSTRACT

**Objectives:** The rapid growth of urban areas in China in the past few decades has introduced profound changes in family structure and income distribution that could plausibly affect mental health. Although multi-level studies of the influence of area-level socioeconomic factors on mental health have become more common in other parts of the world**,** a study of this sort has not been carried out in Chinese cities. Our objectives were to examine the associations of two key neighborhood-level variables—relative income and percentage of married individuals living in a neighborhood—with individual-level mental disorders net of individual-level characteristics in three Chinese cities.

**Setting**: Household interviews in Beijing, Shanghai, and Shenzhen, PRC, as part of the cross-sectional World Mental Health Surveys.

**Participants**: 4,072 men and women aged 17 or older

**Primary and secondary outcome measures**: History of mental disorder and past-year mental disorder among both the full sample and those with a history of disorder.

**Results:** About 13% of respondents met criteria for lifetime history of any disorder and 8.2% met criteria for any disorder in the past year. Neighborhood-level proportion of married residents was associated with reduced odds of both lifetime (OR: 0.66, 95% CI: 0.45-0.96; P-value = 0.03) and past-year (OR: 0.59, 95% CI: 0.38-0.91; P-value = 0.014) individual-level disorder, net of individual-level marital status. Neighborhood-level household relative income, in comparison, was not statistically significantly associated with odds of disorder.

**Conclusions:** The proportion of married residents in a neighborhood was significantly inversely associated with prevalence of mental disorders in this sample of Chinese cities. While the relative importance of causation versus selection is unclear from cross-sectional data, causal mechanisms could include neighborhood processes that influence vulnerability to mental disorders in rapidly growing areas of China. Future work may examine these relationships longitudinally.

**Keywords**: Anxiety disorders, depression & mood disorders, impulse control disorders, substance misuse, public health, statistics & research methods

## STRENGTHS AND LIMITATIONS OF THIS STUDY

**Strengths of this study:**

- We are the first to our knowledge to investigate the association of neighborhood characteristics with mental disorders in large urban areas of China
- We completed sensitivity analyses of different types of regression models in order to account for both the complex survey design and the multilevel nature of the analysis, and found that our findings are robust
- We used statistical weights in order for ensure that our sample was representative of the demographics of the cities included

**Limitations of this study**:

- The cross-sectional design does not allow us to examine true temporality of our exposures and outcomes
- The data were collected from 2002-2007

## INTRODUCTION

China, the world's most populous country, has recently experienced the largest internal migration process in human history; the proportion of the population living in urban areas increased from 36.2% in 2000 to 50.0% in 2011.(1, 2) Mental disorders are an important concern in urban areas with rapid and unequal growth.(3) Despite important early gains in personal well-being, recent studies have suggested that the negative effects of rapid urbanization on the mental health of Chinese residents may have now caught up with the potential benefits of economic growth.(4, 5) Results from the Global Burden of Disease Study found that mental disorders accounted for seven of the top 20 causes of years living with a disability (YLD) in China, with all disorders increasing in absolute terms from 1990 to 2010.(4) It is estimated that around 173 million Chinese adults have a mental disorder, 158 million of whom have never received any professional treatment.(6)

Based on this literature, it is becoming increasingly important to characterize the risk and protective factors for mental disorders in urban China. Individual factors such as demographics and socioeconomic position have long been known to be associated with mental disorders in urban areas worldwide, but neighborhood characteristics are a growing area of concern, especially in rapidly developing countries.(7, 8) Neighborhoods are responsible for the conditions in which people are born, grow, live, and age; neighborhood-level characteristics may represent both an important driver of mental health and an opportunity for prevention.(9)

Extant work has shown that neighborhood characteristics such as violence, economic disadvantage, social interactions, and income inequality are associated with depression and other mental disorders in urban areas.(10, 11) While research has examined the association between neighborhood factors and physical health in Shanghai,(12) no previous analyses to our knowledge have assessed associations of neighborhood-level factors with mental disorders in Chinese cities.

To better understand the potential role of neighborhood factors in determining mental health, we analyzed community epidemiological survey data collected in three of the largest urban areas in China: Shanghai, Beijing, and Shenzhen. We focused on two neighborhood-level contextual variables that we hypothesized to be associated significantly with prevalence of mental disorders: neighborhood-level income and percent of neighborhood residents who are married.

The focus on income is based on abundant evidence that group-level income is associated with health indicators in the U.S., even when taking into account individual income.(13) Neighborhood-level income could be associated with availability of salutary resources that would otherwise not be present in particular neighborhoods.(14) Further, neighborhood-level income may be associated with strong pro-social forces such as social cohesion that are themselves linked to better health.(15) The focus on marriage is motivated by the finding of previous studies that in China, family disruption is associated with a higher risk of mental disorder, possibly a manifestation of the importance of family-oriented life in Chinese culture.(16, 17) In addition, reports of the importance of family arrangements in overall community life in China, such as social interactions and political participation, suggest that neighborhood-level family relations could plausibly have an effect on mental disorders after accounting for individual marital and relationship status.

## METHODS

### Sample

The sample was comprised of residents aged 17 or older in the cities of Shenzhen, Beijing, and Shanghai who participated in the World Mental Health (WMH) Survey Initiative (Table 1). The Beijing and Shanghai surveys were carried out in 2002-2003 and the Shenzhen survey in 2006-2007. The samples in all three cities were based on a multi-stage area clustered household survey design, described in detail elsewhere.(16, 18, 19)

**Table 1**. WMH Sample Characteristics by City

| City | Survey[a] | Sample characteristics | Field dates | Age range | Sample size | | Response rate[b] |
|---|---|---|---|---|---|---|---|
| | | | | | Part I | Part II | |
| Beijing / Shanghai | B-WMH / S-WMH | Beijing and Shanghai metropolitan areas | 2002-3 | 18-70 | 5,201 | 1,628 | 74.7 |
| Shenzhen | Shenzhen | Shenzhen metropolitan area. Included temporary residents as well as household residents | 2006-7 | 17-88 | 7,134 | 2,476 | 80.0 |
| **TOTAL** | | | | | (12,335) | (4,104) | 77.7 |

[a] B-WMH (The Beijing World Mental Health Survey); S-WMH (The Shanghai World Mental Health Survey)

[b] The response rate is calculated as the ratio of the number of households in which an interview was completed to the number of households originally sampled, excluding from the denominator households known not to be eligible either because of being vacant at the time of initial contact or because the residents were unable to speak the designated languages of the survey. The weighted average response rate is 77.7%.

Neighborhoods in this sample consisted of neighborhood committees (NCs), the official, local community organizations in urban China that consist of 100-700 households, and that were also used as the primary sampling unit in the WMH study in China.(16) In Shenzhen, work units (e.g., schools or companies) were also used as primary sampling units in addition to NCs, in order to capture temporary residents living in the city for at least one year. After combining Beijing, Shanghai and Shenzhen and including both NCs and work units under the definition of neighborhood for this study, our sample consisted of 143 total neighborhoods.

All participants completed Part I of the survey, which assessed core disorders and demographics, while a probability subsample consisting of all respondents who met lifetime criteria for any Part I disorder plus a probability subsample of 25% of other Part I respondents completed Part II (n = 2,476 in Shenzhen, n = 914 in Beijing, and n = 714 in Shanghai; Table 1). The sample was weighted to adjust for differential sampling of Part I respondents into Part II, for differential probability of selection within households (one respondent selected for interview in each household regardless of household size, creating an inverse association between number of household residents and probability of selection), and to match socio-demographic distributions in the respective cities.(19) The weighted Part II sample represents the distribution of mental disorders and marital status in the entire sample without bias and adjusts the sample for minor discrepancies from the population on the distributions of age, sex, and marital status; the analyses reported in this paper are based on this weighted Part II sample, with the exception of 32 respondents (0.2% of the weighted Part II sample) who refused to answer or answered “don’t know” on a key covariate, resulting in a final analytic sample of 4,072 respondents.

**Data collection**

WMH interviews were administered face-to-face in the homes of respondents by trained lay interviewers. The WMH interview schedule was translated using a standardized World Health Organization (WHO) translation, back-translation, and harmonization protocol.(20) Written, informed consent after a full description of the study was obtained from all participants before conducting the surveys. These consent procedures were approved by the Institutional Review Boards of the Shenzhen Institute of Mental Health and the Research Center for Contemporary China in Beijing.

**Measures**

*Primary outcome: Mental disorders*

Mental disorders were assessed with the WHO Composite International Diagnostic Interview (CIDI) Version 3.0.(21) The disorders assessed included anxiety (posttraumatic stress disorder, panic disorder, specific phobia, social phobia, agoraphobia, adult separation anxiety, generalized anxiety disorder), mood (major depressive disorder, dysthymic disorder, bipolar/sub-threshold bipolar disorders), behavioral (intermittent explosive disorder, oppositional defiant disorder, conduct disorder, attention-deficit/hyperactivity disorder), and substance use (alcohol and drug abuse with or without dependence) disorders. Diagnoses were based on the definitions and criteria of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM IV).(22) Both lifetime and past-year diagnoses were assessed. Clinical calibration studies carried out in a number of WMH countries confirmed good concordance of DSM-IV diagnoses based on the CIDI with diagnoses based on blinded clinical reappraisal interviews using the Structured Clinical Interview for DSM-IV (SCID).(23, 24) Due to concern about recall, disorders defined as beginning in childhood (attention-deficit/hyperactivity disorder, conduct disorder, and oppositional defiant disorder) were assessed only among respondents aged 18–44.

*Individual-level fixed effects*

Individual-level covariates chosen for this analysis included age (categorized into 35-49 and 50+ vs. 18-34), sex (female vs. not), marital status (married vs. not), employment status (unemployed vs. not employed vs. "don't know"/refused), migrant status (migrant to a large city vs. not, where migrant was defined as not "raised mostly in a large city"), income, and education. Individual income was defined as the combined income of all family members divided by number of family members. The ratio of individual income to the weighted median city-level income was then calculated and split into tertiles to represent categorical levels of relative individual income. Individual education was categorized as being above vs. below the median of country-level education.

*Individual-level random effects*

A random intercept at the neighborhood level was included in all models, in order to allow the predicted probabilities from each model to vary by neighborhood. Additionally, random coefficients for individual-level income were included in the main models predicting lifetime and past-year disorder, to assess whether the effects of individual-level income varied across neighborhoods and act as the error term for tests of associations of these variables with diagnostic outcomes.

*Neighborhood-level fixed effects*

We divided the median income in each neighborhood by the city-level median to calculate relative neighborhood-level income. The neighborhood-level marital status variable was calculated as the weighted proportion of married individuals in each stratum. Each of these variables was then split into tertiles to classify each neighborhood as high, intermediate, or low on each of these two neighborhood-level measures, and used as categorical fixed effects.

**Data Analysis**

Data analysis was carried out using SAS version 9.4. We used SAS survey procedures to calculate valid design-based standard errors for frequencies and means. Weighted, multilevel, multivariate,

mixed logistic regression models were estimated using Proc Glimmix with neighborhood as a repeated subject and both fixed and random effects varying at the neighborhood level. One set of models predicted lifetime history and past-year disorders in the total sample, while another predicted persistence, defined as the probability of past-year disorders in the subsample of respondents with history of disorder that began prior to the past year.

For sensitivity analyses, we also ran multilevel models using a jackknife resampling method for estimation of variance and SAS Surveylogistic regressions without repeated measures correction, and found very similar results across all three methods, suggesting robust findings (see appendix tables).

## RESULTS

### Prevalence of mental disorders (outcome)

Thirteen percent of the weighted analytic sample met criteria for lifetime history of any DSM-IV/CIDI disorder, and 8.2% met criteria for past-year disorder (Table 2). Over half (62.7%) of those who experienced disorder that onset prior to the past year (n = 1,022) also met criteria for past-year diagnosis (persistence).

**Table 2**. Prevalence and Means of Independent and Dependent Variables Among 4,072 Urban China Residents

| | Unweighted n | Weighted % | Weighted mean | Weighted design-based SE [a] |
|---|---|---|---|---|
| *Cities* | | | | |
| Beijing | 914 | 22.31% | - | 1.38% |
| Shanghai | 713 | 17.43% | - | 0.90% |
| Shenzhen | 2445 | 60.26% | - | 1.34% |
| *Individual-level variables* | | | | |
| Age 35-49 | 1353 | 24.11% | - | 0.84% |
| Age 50+ | 673 | 13.93% | - | 0.73% |
| Female | 2014 | 49.26% | - | 1.19% |
| Bottom tertile of ratio of individual income to city income | 1278 | 33.16% | 0.39 | 0.01 |
| Middle tertile of ratio of individual income to city income | 1299 | 33.87% | 1.05 | 0.01 |
| Top tertile of ratio of individual income to city income | 1495 | 32.98% | 3.48 | 0.11 |
| In top 50% of country-level education | 2770 | 64.30% | - | 1.18% |
| Married | 2695 | 59.04% | - | 1.05% |
| Migrant to megacity | 2526 | 63.89% | - | 1.18% |
| Unemployed | 163 | 3.21% | - | 0.45% |
| *Mental disorders* | | | | |

| | | | | |
|---|---|---|---|---|
| Any lifetime disorder | 1091 | 12.96% | - | 0.71% |
| Any past-year disorder | 698 | 8.23% | - | 0.54% |
| Any past-year disorder among those with lifetime history prior to the past 12 months | 640 | 62.68% | - | 2.01% |
| *Neighborhood-level variables* | | | | |
| Bottom tertile of ratio of neighborhood income to city income | 1428 | 34.97% | 0.66 | 0.01 |
| Middle tertile of ratio of neighborhood income to city income | 1207 | 32.22% | 0.97 | 0.00 |
| Top tertile of ratio of neighborhood income to city income | 1437 | 32.81% | 1.56 | 0.02 |
| Bottom tertile of % married | 1163 | 33.98% | 40.92% | 0.38% |
| Middle tertile of % married | 1223 | 33.41% | 65.11% | 0.15% |
| Top tertile of % married | 1686 | 32.61% | 79.83% | 0.19% |

[a] SE = Standard error

**Distributions of independent variables**

About half (49.3%) of respondents were female; 24.1% were 35 to 49 years old; 13.9% were 50 years or older; 59.0% were married; 63.9% were migrants to a large city; and 3.2% were unemployed (Table 2). The mean ratio of individual income to city income was 0.39, 1.05, and 3.48 in the bottom, middle, and top tertile, respectively.

The mean of the relative neighborhood-level income was 0.66 for the bottom tertile, 0.97 for the middle tertile, and 1.56 for the top tertile. Neighborhood-level mean percentages of married individuals for tertile categories were 40.9%, 65.1%, and 79.8% respectively.

**Lifetime mental disorder models**

Table 3 reports the multivariate, logistic regressions for individual variables only (first column), neighborhood-level income as the main independent variable of interest (second column), and neighborhood-level percentage of married individuals as the main independent variable of interest (third column) with any lifetime disorder as the outcome. The associations between individual fixed effects and mental disorders were modest, with the exception of the significant associations of lower odds of disorder with being female (OR: 0.76 in all models) and with being in the middle age group compared to the youngest (OR's range from 0.69 to 0.74).

**Table 3**. Logistic Multilevel, Multivariate Mixed Regression Models Predicting Any Lifetime Disorder Among 4,072 Urban China Residents [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.69* | 0.49 | 0.98 | 0.70* | 0.50 | 0.98 | 0.74 | 0.52 | 1.04 |
| Age 50+ | 0.76 | 0.47 | 1.24 | 0.76 | 0.47 | 1.24 | 0.81 | 0.50 | 1.32 |
| Female | 0.76* | 0.59 | 0.99 | 0.76* | 0.59 | 0.98 | 0.76* | 0.59 | 0.98 |
| Middle tertile of ratio of individual income to city income | 0.86 | 0.65 | 1.14 | 0.86 | 0.64 | 1.14 | 0.85 | 0.65 | 1.12 |
| Top tertile of ratio of individual income to city income | 1.14 | 0.86 | 1.51 | 1.14 | 0.85 | 1.53 | 1.12 | 0.84 | 1.48 |
| In top 50% of country-level education | 1.26 | 0.95 | 1.67 | 1.26 | 0.95 | 1.68 | 1.25 | 0.95 | 1.65 |
| Married | 0.93 | 0.69 | 1.24 | 0.93 | 0.69 | 1.26 | 0.98 | 0.72 | 1.34 |
| Migrant to megacity | 1.10 | 0.77 | 1.56 | 1.09 | 0.77 | 1.56 | 1.06 | 0.74 | 1.52 |
| Unemployed | 1.76 | 0.85 | 3.63 | 1.78 | 0.86 | 3.66 | 1.87 | 0.90 | 3.90 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood income to | | | | 1.16 | 0.85 | 1.58 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.99 | 0.73 | 1.34 | | | |
| Middle tertile of % married | | | | 0.72 | 0.49 | 1.05 |
| Top tertile of % married | | | | 0.66* | 0.45 | 0.96 |

* = $P < 0.05$

[a] Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept and a random effect of relative individual income

Higher neighborhood-level income was not statistically significant in this model (second column), but neighborhood-level percentage of married individuals (third column) was statistically associated with lower odds of disorder (OR: 0.72, 95% CI: 0.49-1.05 for the middle tertile compared to the lowest, and OR: 0.66, 95% CI: 0.45-0.96 for the highest tertile compared to the lowest).

**Past-year mental disorder models**

Models for past-year mental disorders are presented on Table 4, with the same independent variables included as in Table 3. Being 35 to 49 years old was consistently significantly associated with lower odds of past-year mental disorder in comparison with younger individuals for each model (OR's ranged from 0.57 to 0.61). Having a high educational attainment (OR's: 1.46 to 1.49) and being unemployed (OR's: 2.66 to 2.87) were significantly associated with *higher* odds of mental disorder.

**Table 4.** Logistic Multilevel, Multivariate Mixed Regression Models Predicting Any Past-Year Disorder Among 4,072 Urban China Residents [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.57* | 0.38 | 0.84 | 0.57* | 0.38 | 0.83 | 0.61* | 0.41 | 0.90 |
| Age 50+ | 0.61 | 0.36 | 1.04 | 0.61 | 0.36 | 1.04 | 0.67 | 0.39 | 1.13 |
| Female | 0.86 | 0.64 | 1.15 | 0.86 | 0.64 | 1.15 | 0.85 | 0.63 | 1.14 |
| Middle tertile of ratio of individual income to city income | 0.91 | 0.65 | 1.27 | 0.91 | 0.64 | 1.30 | 0.89 | 0.64 | 1.23 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Top tertile of ratio of individual income to city income | 1.06 | 0.77 | 1.45 | 1.09 | 0.78 | 1.52 | 1.03 | 0.74 | 1.41 |
| In top 50% of country-level education | 1.47* | 1.02 | 2.11 | 1.49* | 1.02 | 2.17 | 1.46* | 1.02 | 2.10 |
| Married | 1.09 | 0.77 | 1.55 | 1.11 | 0.77 | 1.58 | 1.17 | 0.81 | 1.70 |
| Migrant to megacity | 1.09 | 0.72 | 1.64 | 1.07 | 0.71 | 1.62 | 1.04 | 0.69 | 1.58 |
| Unemployed | 2.66* | 1.33 | 5.32 | 2.69* | 1.36 | 5.32 | 2.87* | 1.43 | 5.75 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood income to city income | | | | 1.22 | 0.84 | 1.78 | | | |
| Top tertile of ratio of neighborhood income to city income | | | | 0.86 | 0.58 | 1.26 | | | |
| Middle tertile of % married | | | | | | | 0.78 | 0.50 | 1.24 |
| Top tertile of % married | | | | | | | 0.59* | 0.38 | 0.91 |

* = $P < 0.05$

[a] Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept and a random effect of relative individual income

The second model in Table 4 shows that again, there was not a statistically significant association between relative neighborhood-level income and odds of mental disorder. However, a higher neighborhood-level percentage of married individuals (third column) was again significantly associated with lower odds of disorder (OR: 0.78, 95% CI: 0.50-1.24 for the middle tertile compared to the lowest, and OR: 0.59, 95% CI: 0.38-0.91 for the highest tertile compared to the lowest).

**Persistence models**

Table 5 shows the same models as in Table 4, but only among individuals with a mental disorder that onset prior to the past year (n=1,022). Older age was significantly associated with lower odds of past-year mental disorder (OR's: 0.44 to 0.50 for ages 35-49 and OR's: 0.44 to 0.47 for ages 50+), while being married as an individual was consistently associated with higher odds (OR range: 1.61-1.72).

Table 5. Logistic Multilevel, Multivariate Mixed Regression Models Predicting Any Past-Year Disorder Among Those With Lifetime Disorder Prior to Past Year (n = 1,022) [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.45* | 0.25 | 0.82 | 0.44* | 0.24 | 0.80 | 0.50* | 0.27 | 0.90 |
| Age 50+ | 0.44* | 0.22 | 0.91 | 0.44* | 0.21 | 0.92 | 0.47* | 0.23 | 0.98 |
| Female | 1.26 | 0.84 | 1.88 | 1.32 | 0.89 | 1.95 | 1.27 | 0.85 | 1.88 |
| Middle tertile of ratio of | 0.98 | 0.57 | 1.68 | 1.01 | 0.59 | 1.73 | 0.94 | 0.55 | 1.61 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| individual income to city income | | | | | | | | | |
| Top tertile of ratio of individual income to city income | 0.68 | 0.36 | 1.28 | 0.76 | 0.42 | 1.38 | 0.66 | 0.36 | 1.22 |
| In top 50% of country-level education | 1.32 | 0.77 | 2.28 | 1.36 | 0.79 | 2.35 | 1.32 | 0.77 | 2.25 |
| Married | 1.64* | 1.01 | 2.67 | 1.61 | 0.99 | 2.61 | 1.72* | 1.07 | 2.78 |
| Migrant to megacity | 0.87 | 0.54 | 1.42 | 0.83 | 0.51 | 1.34 | 0.89 | 0.56 | 1.42 |
| Unemployed | 2.61 | 0.56 | 12.27 | 2.69 | 0.61 | 11.90 | 2.77 | 0.65 | 11.80 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood income to city income | | | | 1.15 | 0.65 | 2.04 | | | |
| Top tertile of ratio of neighborhood income to city income | | | | 0.60 | 0.33 | 1.10 | | | |
| Middle tertile of % married | | | | | | | 1.00 | 0.55 | 1.82 |
| Top tertile of % married | | | | | | | 0.67 | 0.38 | 1.17 |

* = $P < 0.05$

[a] Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept

Neither of the neighborhood-level fixed effects in this subsample were statistically significant at the alpha=0.05 level (columns 2 and 3). However, the top tertile of neighborhood-level income was borderline significant (OR: 0.60, 95% CI: 0.33-1.10), suggesting a potentially protective negative association of higher neighborhood-level income with persistence of mental disorder.

## DISCUSSION

Using data from three of the largest cities in China with multilevel mixed models, we found that residence in neighborhoods with a higher proportion of married individuals was associated with lower odds of both past-year and lifetime mental disorders, even after accounting for individual-level marital status. Contrary to our expectations, living in a neighborhood with a higher relative per-capita income was not significantly associated with lower odds of disorder, although it was borderline significant in the subsample of respondents with a previous history of mental disorders, suggesting that contextual income may have a more important association with persistence of mental disorders than with onset.

These results should be interpreted in the context of several limitations. First, due to the cross-sectional nature of this study, we cannot exclude the possibility of reverse causation that concentrates individuals with a mental disorder in neighborhoods with fewer married individuals and lower income. Second, the study relied on data from fully-structured lay interviews instead of semi-structured clinician-administered interviews, which could affect both estimates of disease prevalence and of age of onset, although the diagnostic assessments were validated with blinded clinical reappraisal interviews.(24)

Third, our sample is not necessarily representative of every large urban area of China. Even across the three cities we assessed, there are important differences, most notably the fact that Shanghai and

Beijing are two of the oldest large cities in China, while Shenzhen is a migrant industrial city that evolved based on its designation in 1980 as the first PRC Special Economic Zone. In our sample, Beijing had the highest prevalence of disorder, followed by Shenzhen and then Shanghai, and we included city as a control variable in our models. Further, socioeconomic characteristics likely have differential effects on the health of migrants depending on the culture and area of origin,(25) which could modify our results; some new neighborhoods in China, especially in Shenzhen, are composed of migrants coming from the same area of origin and age living in small areas such as dormitories,(26) where high social cohesion could influence mental health outcomes. Our analysis of migration was limited by the absence of detailed data on these subjects' area of origin and current housing. However, we did statistically control for whether the responded grew up mostly in a large city. Future studies should investigate the associations of these factors with mental disorders in a sample with more detailed information on true migration status.

Despite these limitations, our study is the first to investigate the associations of neighborhood characteristics with mental disorders in large urban areas of China, providing data that may be consistent with previous concerns about the mental health effects of community disruption created by rapid urbanization.(27, 28)

At the individual level, two mechanisms have been proposed to explain general associations between lower income or social capital with higher odds of mental disorders: social causation and social selection.(29, 30) The latter posits that individuals with mental disorders have a predisposition to drift into lower socioeconomic positions, while the former attributes the association to the stress and adversity that comes with having low socioeconomic status. We were not able to test these hypotheses directly due to the cross-sectional nature of our data, but our results suggest that, after controlling for individual income, the aggregate income of all individuals in the same area of residence may be associated with persistent mental disorders. The pathways through which

neighborhood characteristics may affect mental disorders are likely multifactorial and at least partially mediated by individual socioeconomic status, but neighborhood features and social cohesion could help to explain some of this association.(10) First, low-income neighborhoods or those with less social capital lack important resources protect against mental disorders, such as adequate housing, green spaces, and mental health facilities.(31, 32) Second, individuals living in poorer neighborhoods report lower neighborhood social cohesion,(33) which may increase vulnerability to stress and mental disorders.

Similarly, individual marital status has been previously associated with mental disorders.(34, 35) The inverse association of neighborhood-level percentage of married individuals and mental disorders found in our study suggests a protective community effect of marriage, possibly through its effect on social cohesion. Living in a neighborhood with more married individuals has been associated with higher neighborhood satisfaction,(36) and marital status is frequently associated with more political participation and social support.(17) We were not able to directly analyze neighborhood social cohesion with WMH data, but we welcome new studies that test this hypothesis.

Despite our focus on contextual variables in this analysis, we also found that being married was associated at the individual level with higher odds of persistence of mental disorder, and that being more highly educated was associated at the individual level with higher odds of past-year mental disorders, both of which may be unexpected in contrast to findings in other parts of the world.(37) However, we hypothesize that in the context of Chinese cities, these two characteristics may be proxies for added family or job-related stress resulting from marriage and higher education, especially when controlling for unemployment and for proxies of social cohesion at a neighborhood level. Being married was also found to be an individual risk factor for any disorder in an earlier analysis using WMH data in Beijing and Shanghai only (16) (being “never married” was

significantly protective against any past-year disorder). The relationship between marital status and mental disorder also depends on the timing of each condition (37) as well as severity and type of disorder,(16) which could be focuses for future papers using urban Chinese data, but were not our focus here.

Mental disorders are a growing public health problem in China and the government has recently taken steps to address the problem by creating hundreds of new psychiatric hospitals and integrating its resources with existing community health systems.(27) A few recent sociodemographic changes such as the increasing globalization of its economy and the end of the one-child policy may also significantly improve neighborhood characteristics. However, more progress will likely be needed to develop broad social measures for enhancing social cohesion, participation, and support to help manage the consequences of decades of under-diagnosed mental disorders.

The large and rapid urbanization process that China went through during the last few decades has been recently replicated, on a much smaller scale, in other countries. While there are important early benefits of urbanization, the frequently chaotic expansion of urban areas is associated with community disruption and the worsening of health outcomes. A growing number of low-income individuals now live in large urban areas that do not provide the social support and stability found in smaller communities. Understanding the effects of neighborhood characteristics on mental disorders in fast growing regions of the world can help to promote better neighborhood environments and control the burden of mental disorders in emerging countries.

One direction for future research would be to further investigate the role of migration. A high proportion of individuals in our sample and in urban China as a whole were born in rural areas. Migrating from rural to urban areas is not only prevalent in China, but also likely to be associated with both marital status and income in addition to mental health.(12) Investigators should continue

to study the relationships among important neighborhood-level indicators of health, including a more specific measure of migration status at both an individual and neighborhood level. Finally, another potentially fruitful direction for future research could be to investigate how the distribution of mental disorders at the neighborhood-level acts as a potential predictor for individual disorder outcomes, preferably in a longitudinal setting.

**Contributors:**

Chiavegatto Filho ADP designed statistical analyses; conducted the literature review; performed preliminary analyses; and wrote the introduction, results, and discussion sections. Sampson L aided in the literature review and analyses; wrote the methods section; created tables; and critically edited all versions of the manuscript. Martins SS helped to design statistical analyses; participated in interpretation of results; and critically edited all versions of the manuscript. Yu S performed statistical analyses; created tables; and critically edited all versions of the manuscript. Huang Y carried out the Beijing data acquisition; participated in interpretation of results; and critically edited all versions of the manuscript. He Y carried out the Shanghai data acquisition; participated in interpretation of results; and critically edited all versions of the manuscript. Lee S coordinated data acquisition and critically edited all versions of the manuscript. Hu C carried out the Shenzhen data acquisition and critically edited all versions of the manuscript. Zaslavsky AM designed data analyses; provided statistical support; participated in interpretation of results; and critically edited all versions of the manuscript. Kessler RC conceptualized and coordinated the study; participated in interpretation of results; and critically edited all versions of the manuscript. Galea S conceptualized the analyses; formulated hypotheses; led the analytic team; and critically edited all versions of the manuscript. All authors approved the final version and stand behind all aspects of the work.

**Competing interests**: In the past three years, Dr. Kessler received support for his epidemiological studies from Sanofi Aventis; was a consultant for Johnson & Johnson Wellness and Prevention, Shire, Takeda; and served on an advisory board for the Johnson & Johnson Services Inc. Lake Nona Life Project. Kessler is a co-owner of DataStat, Inc., a market research firm that carries out healthcare research. Other authors have no financial or personal conflicts of interest to disclose.

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**Data sharing statement**: Access to the cross-national World Mental Health (WMH) data is governed by the organizations funding and responsible for survey data collection in each country.

These organizations made data available to the WMH consortium through restricted data sharing agreements that do not allow us to release the data to third parties.

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Supplemental Table 1. Logistic Multilevel, Multivariate Regression Models using a Jackknife Resampling Method Predicting Any Lifetime Disorder Among 4,072 Urban China Residents [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.72* | 0.52 | 1.00 | 0.72* | 0.52 | 1.00 | 0.77 | 0.54 | 1.08 |
| Age 50+ | 0.79 | 0.54 | 1.15 | 0.79 | 0.54 | 1.15 | 0.84 | 0.57 | 1.24 |
| Female | 0.78* | 0.62 | 0.99 | 0.78* | 0.62 | 0.99 | 0.77* | 0.61 | 0.98 |
| Middle tertile of ratio of individual income to city income | 0.89 | 0.66 | 1.21 | 0.89 | 0.65 | 1.20 | 0.87 | 0.64 | 1.19 |
| Top tertile of ratio of individual income to city income | 1.15 | 0.87 | 1.53 | 1.15 | 0.86 | 1.54 | 1.13 | 0.85 | 1.49 |
| In top 50% of country-level education | 1.25* | 1.03 | 1.53 | 1.25* | 1.03 | 1.53 | 1.25* | 1.02 | 1.52 |
| Married | 0.95 | 0.70 | 1.29 | 0.96 | 0.71 | 1.30 | 1.01 | 0.74 | 1.39 |
| Migrant to megacity | 1.08 | 0.79 | 1.48 | 1.07 | 0.78 | 1.47 | 1.04 | 0.75 | 1.43 |
| Unemployed | 1.84 | 0.88 | 3.84 | 1.86 | 0.88 | 3.92 | 1.95 | 0.92 | 4.13 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of | | | | 1.16 | 0.86 | 1.56 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| neighborhood income to city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 1.00 | 0.77 | 1.31 | | | |
| Middle tertile of % married | | | | 0.70* | 0.51 | 0.94 |
| Top tertile of % married | | | | 0.63* | 0.47 | 0.85 |

* = $P < 0.05$

% Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept

Supplemental Table 2. Logistic Multilevel, Multivariate Regression Models using a Jackknife Resampling Method Predicting Any Past-Year Disorder Among 4,072 Urban China Residents [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.58* | 0.40 | 0.86 | 0.58* | 0.40 | 0.85 | 0.63* | 0.42 | 0.93 |
| Age 50+ | 0.63* | 0.40 | 0.99 | 0.63* | 0.40 | 0.99 | 0.68 | 0.43 | 1.09 |
| Female | 0.87 | 0.65 | 1.18 | 0.87 | 0.65 | 1.18 | 0.86 | 0.64 | 1.16 |
| Middle tertile of ratio of individual income to city income | 0.95 | 0.66 | 1.36 | 0.95 | 0.66 | 1.37 | 0.92 | 0.64 | 1.33 |
| Top tertile of ratio of individual income to city income | 1.07 | 0.76 | 1.51 | 1.10 | 0.77 | 1.58 | 1.04 | 0.73 | 1.47 |
| In top 50% of country-level education | 1.46* | 1.07 | 1.99 | 1.48* | 1.08 | 2.02 | 1.45* | 1.06 | 1.99 |
| Married | 1.11 | 0.78 | 1.57 | 1.12 | 0.79 | 1.59 | 1.19 | 0.82 | 1.71 |
| Migrant to megacity | 1.09 | 0.75 | 1.57 | 1.07 | 0.74 | 1.55 | 1.04 | 0.71 | 1.50 |
| Unemployed | 2.68* | 1.33 | 5.40 | 2.72* | 1.35 | 5.50 | 2.89* | 1.45 | 5.79 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood | | | | 1.21 | 0.85 | 1.73 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| income to city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.85 | 0.64 | 1.15 | | | |
| Middle tertile of % married | | | | 0.77 | 0.53 | 1.10 |
| Top tertile of % married | | | | 0.57* | 0.40 | 0.83 |

* = $P < 0.05$

% Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept

Supplemental Table 3. Logistic Multilevel, Multivariate Mixed Regression Models using a Jackknife Resampling Method Predicting Any Past-Year Disorder Among Those With Lifetime Disorder Prior to Past Year (n = 1,022) [a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.45* | 0.26 | 0.80 | 0.44* | 0.25 | 0.77 | 0.50* | 0.27 | 0.90 |
| Age 50+ | 0.44* | 0.23 | 0.87 | 0.44* | 0.22 | 0.88 | 0.47* | 0.23 | 0.95 |
| Female | 1.26 | 0.84 | 1.89 | 1.32 | 0.88 | 1.97 | 1.27 | 0.84 | 1.90 |
| Middle tertile of ratio of individual income to city income | 0.98 | 0.59 | 1.61 | 1.01 | 0.61 | 1.67 | 0.94 | 0.57 | 1.55 |
| Top tertile of ratio of individual income to city income | 0.68 | 0.40 | 1.16 | 0.76 | 0.45 | 1.31 | 0.66 | 0.39 | 1.12 |
| In top 50% of country-level education | 1.32 | 0.78 | 2.25 | 1.36 | 0.80 | 2.32 | 1.32 | 0.78 | 2.23 |
| Married | 1.64* | 1.04 | 2.58 | 1.61* | 1.02 | 2.55 | 1.72* | 1.08 | 2.74 |
| Migrant to megacity | 0.87 | 0.53 | 1.42 | 0.83 | 0.51 | 1.35 | 0.89 | 0.55 | 1.43 |
| Unemployed | 2.61 | 0.31 | 21.79 | 2.69 | 0.34 | 21.37 | 2.77 | 0.37 | 20.86 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of | | | | 1.15 | 0.78 | 1.69 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| neighborhood income to city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.60* | 0.38 | 0.94 | | | |
| Middle tertile of % married | | | | 1.00 | 0.65 | 1.53 |
| Top tertile of % married | | | | 0.67 | 0.40 | 1.11 |

* = $P < 0.05$

% Models include the above variables as well as fixed effects for city and for having a missing value on individual unemployment, as well as a random intercept

Supplemental Table 4. Multivariate Logistic Regression Models Predicting Any Lifetime Disorder Among 4,072 Urban China Residents, using Proc SurveyLogistic[a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.72 | 0.52 | 1.01 | 0.72* | 0.52 | 1.00 | 0.78 | 0.57 | 1.09 |
| Age 50+ | 0.81 | 0.54 | 1.21 | 0.81 | 0.53 | 1.21 | 0.88 | 0.58 | 1.32 |
| Female | 0.80 | 0.64 | 1.01 | 0.80 | 0.63 | 1.02 | 0.79* | 0.62 | 1.00 |
| Middle tertile of ratio of individual income to city income | 0.86 | 0.63 | 1.17 | 0.86 | 0.64 | 1.17 | 0.85 | 0.62 | 1.15 |
| Top tertile of ratio of individual income to city income | 1.14 | 0.86 | 1.50 | 1.15 | 0.86 | 1.55 | 1.11 | 0.84 | 1.47 |
| In top 50% of country-level education | 1.33* | 1.09 | 1.61 | 1.33* | 1.09 | 1.63 | 1.29* | 1.06 | 1.58 |
| Married | 0.96 | 0.71 | 1.28 | 0.97 | 0.72 | 1.31 | 1.04 | 0.76 | 1.43 |
| Migrant to megacity | 1.01 | 0.72 | 1.42 | 1.00 | 0.71 | 1.41 | 0.97 | 0.68 | 1.37 |
| Unemployed | 1.89 | 0.97 | 3.70 | 1.92 | 0.97 | 3.80 | 2.07* | 1.06 | 4.04 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood income to | | | | 1.14 | 0.80 | 1.63 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.95 | 0.70 | 1.30 | | | |
| Middle tertile of % married | | | | 0.70 | 0.48 | 1.02 |
| Top tertile of % married | | | | 0.61* | 0.43 | 0.87 |

* = $P < 0.05$

^Models include the above variables as well as controls for city and missing values on individual unemployment status

Supplemental Table 5. Multivariate Logistic Regression Models Predicting Any Past-Year Disorder Among 4,072 Urban China Residents, using Proc SurveyLogistic[a]

| | | 95% CI | 95% CI | | 95% CI | 95% CI | | 95% CI | 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit | Odds ratio | Lower limit | Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.57* | 0.39 | 0.85 | 0.57* | 0.39 | 0.85 | 0.64* | 0.44 | 0.93 |
| Age 50+ | 0.62 | 0.38 | 1.02 | 0.62 | 0.38 | 1.02 | 0.70 | 0.42 | 1.15 |
| Female | 0.91 | 0.69 | 1.19 | 0.90 | 0.68 | 1.20 | 0.88 | 0.67 | 1.17 |
| Middle tertile of ratio of individual income to city income | 0.90 | 0.62 | 1.29 | 0.92 | 0.64 | 1.34 | 0.87 | 0.60 | 1.26 |
| Top tertile of ratio of individual income to city income | 1.04 | 0.74 | 1.46 | 1.11 | 0.78 | 1.59 | 1.00 | 0.71 | 1.41 |
| In top 50% of country-level education | 1.51* | 1.13 | 2.02 | 1.56* | 1.16 | 2.09 | 1.48* | 1.10 | 1.98 |
| Married | 1.09 | 0.78 | 1.54 | 1.11 | 0.78 | 1.59 | 1.22 | 0.83 | 1.78 |
| Migrant to megacity | 1.03 | 0.70 | 1.51 | 1.00 | 0.68 | 1.48 | 0.98 | 0.66 | 1.45 |
| Unemployed | 2.67* | 1.27 | 5.60 | 2.72* | 1.30 | 5.70 | 3.02* | 1.48 | 6.14 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of neighborhood | | | | 1.13 | 0.75 | 1.71 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| income to city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.78 | 0.56 | 1.07 | | | |
| Middle tertile of % married | | | | 0.77 | 0.50 | 1.19 |
| Top tertile of % married | | | | 0.53* | 0.35 | 0.81 |

* = $P < 0.05$

% Models include the above variables as well as controls for city and missing values on individual unemployment status

Supplemental Table 6. Multivariate Logistic Regression Models Predicting Any Past-Year Disorder, Among Those With Lifetime Disorder Prior to Past Year (n = 1,022) using Proc SurveyLogistic [a]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.48* | 0.25 | 0.91 | 0.45* | 0.24 | 0.87 | 0.53 | 0.28 | 1.01 |
| Age 50+ | 0.44* | 0.20 | 0.95 | 0.45* | 0.20 | 0.98 | 0.48 | 0.22 | 1.07 |
| Female | 1.29 | 0.87 | 1.90 | 1.36 | 0.92 | 2.01 | 1.30 | 0.88 | 1.92 |
| Middle tertile of ratio of individual income to city income | 1.03 | 0.61 | 1.73 | 1.06 | 0.63 | 1.78 | 0.96 | 0.58 | 1.60 |
| Top tertile of ratio of individual income to city income | 0.66 | 0.36 | 1.20 | 0.76 | 0.44 | 1.33 | 0.64 | 0.36 | 1.12 |
| In top 50% of country-level education | 1.28 | 0.75 | 2.18 | 1.33 | 0.76 | 2.32 | 1.28 | 0.75 | 2.18 |
| Married | 1.60 | 0.96 | 2.68 | 1.59 | 0.95 | 2.64 | 1.73* | 1.06 | 2.82 |
| Migrant to megacity | 0.94 | 0.57 | 1.54 | 0.86 | 0.53 | 1.42 | 0.95 | 0.60 | 1.50 |
| Unemployed | 2.75 | 0.54 | 14.06 | 2.80 | 0.59 | 13.21 | 2.88 | 0.67 | 12.41 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Middle tertile of ratio of | | | | 1.12 | 0.72 | 1.75 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| neighborhood income to city income | | | | | | |
| Top tertile of ratio of neighborhood income to city income | 0.58* | 0.36 | 0.92 | | | |
| Middle tertile of % married | | | | 1.00 | 0.64 | 1.55 |
| Top tertile of % married | | | | 0.61 | 0.36 | 1.04 |

* = $P < 0.05$

% Models include the above variables as well as controls for city and missing values on individual unemployment status

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 3 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5-6 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 6 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6-8 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6-9 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 9-10 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 9-10 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8-9 |
| Study size | 10 | Explain how the study size was arrived at | 8 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 9-10 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9-11 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 10-11 |
| | | (*c*) Explain how missing data were addressed | 8 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | 8, 10-11 |
| | | (*e*) Describe any sensitivity analyses | 11 |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 8 |
| | | (b) Give reasons for non-participation at each stage | 8 |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 14 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 8 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 11 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9-10, 14-21 |
| | | (*b*) Report category boundaries when continuous variables were categorized | |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 19-21 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 21 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 21-22 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 22-24 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 21-22 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 27 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Neighborhood characteristics and mental disorders in three Chinese cities: Multilevel models from the World Mental Health Surveys

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| | |

# Neighborhood characteristics and mental disorders in three Chinese cities: Multilevel models from the World Mental Health Surveys

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## ABSTRACT

**Objectives:** The rapid growth of urban areas in China in the past few decades has introduced profound changes in family structure and income distribution that could plausibly affect mental health. Although multilevel studies of the influence of area-level socioeconomic factors on mental health have become more common in other parts of the world**,** a study of this sort has not been carried out in Chinese cities. Our objectives were to examine the associations of two key neighborhood-level variables—median income and percentage of married individuals living in the neighborhood—with mental disorders net of individual-level income and marital status in three Chinese cities.

**Setting**: Household interviews in Beijing, Shanghai, and Shenzhen, PRC, as part of the cross-sectional World Mental Health Surveys.

**Participants**: 4,072 men and women aged 18-88.

**Primary and secondary outcome measures**: Lifetime and past-year internalizing and externalizing mental disorders.

**Results:**. Each one-point increase in neighborhood-level percent of married residents was associated with a 1% lower odds of lifetime (p = .024) and 2% lower odds of past-year (p = .008) individual-level externalizing disorder, net of individual-level marital status. When split into tertiles, individuals living in neighborhoods in the top tertile of percent of married residents had 54% lower odds of a past-year externalizing disorder (OR=0.46, 95% CI: 0.24-0.87) compared to those in the bottom tertile. Neighborhood-level marital status was not statistically associated with either lifetime or past-year internalizing disorders. Neighborhood-level income was not statistically associated with odds of either internalizing or externalizing disorders.

**Conclusions:** The proportion of married residents in respondents' neighborhoods was significantly inversely associated with having externalizing mental disorders in this sample of Chinese cities. Possible mechanisms for this finding are discussed and related to social causation, social selection, and social control theories. Future work should examine these relationships longitudinally.

**Keywords**: Anxiety disorders, depression & mood disorders, substance misuse, impulse control disorders, epidemiology, statistics & research methods

## STRENGTHS AND LIMITATIONS OF THIS STUDY

**Strengths of this study:**

- We are the first to our knowledge to investigate the association of neighborhood characteristics with mental disorders in large urban areas of China
- We completed various sensitivity analyses including different types of regression models in order to account for both the complex survey design and the multilevel nature of the our data, as well as different ways of operationalizing the exposure variables, and found that our results were robust across different methods and models
- We applied statistical weights to our analyses in order to ensure that our sample was representative of the demographics in the included cities

**Limitations of this study**:

- The cross-sectional design does not allow us to examine temporality of our exposures and outcomes
- The data were collected from 2002-2007; these cities are likely to have changed demographically in the decade since data collection and therefore our results may not be as generalizable to today's population

## INTRODUCTION

China, the world's most populous country, has recently experienced one of the largest internal migration processes in human history; the proportion of the population living in urban areas increased from about 36% in 2000 to 50% in 2011.(1, 2) Mental disorders are an important concern in urban areas with rapid and unequal growth.(3) Despite important early gains in personal well being, recent studies have suggested that the negative effects of rapid urbanization on the mental health of Chinese residents may have now caught up with the potential benefits of economic growth.(4, 5) Results from the Global Burden of Disease Study found that mental disorders accounted for seven of the top 20 causes of years living with a disability (YLD) in China, with all disorders increasing in absolute terms from 1990 to 2010.(4) It is estimated that around 173 million Chinese adults have a mental disorder, 158 million of who have never received any professional treatment.(6)

Based on this literature, it is becoming increasingly important to characterize the risk and protective factors for mental disorders in urban China. Individual factors such as demographics and socioeconomic position have long been known to be associated with mental disorders in urban areas worldwide, but neighborhood characteristics are a growing area of concern, especially in rapidly developing countries.(7, 8) Neighborhoods are responsible for the conditions in which people are born, grow, live, and age; neighborhood-level characteristics may represent both an important driver of mental health and an opportunity for prevention.(9)

Extant work has shown that neighborhood characteristics such as economic disadvantage, social interactions, and income inequality are associated with depression and other mental disorders in urban areas.(10-12)

While research has examined the association between neighborhood factors and physical health in Shanghai,(13) no previous analyses to our knowledge have assessed associations of neighborhood-level factors with mental health in Chinese cities. Further, we expect there to be differences in the neighborhood-level explanatory factors for different types of mental disorders, as there are at the individual level in this population.(14) As a way of categorizing different outcomes, internalizing disorders are defined as those whose symptoms are typically expressed inwardly, such as anxiety and depression, whereas externalizing disorders are those that present outwardly with behavior, such as intermittent explosive disorder or alcohol abuse.(15)

The association of internalizing and internalizing disorders with neighborhood factors has been previously described in other contexts. A study of African American adolescents in the United States, for example, found that higher neighborhood poverty and unemployment levels predicted the presence of internalizing symptoms via lower social support.(16) On the other hand, a study of Mexican American youth found that while the interaction of neighborhood disadvantage with child generation predicted the presence of stressful life events, neighborhood disadvantage as a main effect was not associated with internalizing or externalizing symptoms.(17) However, this type of study has not been conducted, to our knowledge, in the adult population of urban China.

To better understand the potential role of neighborhood factors in determining mental health in this context, we analyzed epidemiological survey data collected in three of the largest urban areas in China: Beijing, Shanghai, and Shenzhen. We focused on two neighborhood-level contextual variables that we hypothesized to be associated with prevalence of mental disorders: neighborhood-level income and percent of neighborhood residents who are married.

The focus on income is based on abundant evidence that group-level income is associated with health indicators in other countries, even when taking into account individual income.(18, 19)

Neighborhood-level income could be associated with availability of salutary resources that would otherwise not be present in particular neighborhoods.(20, 21) Further, neighborhood-level income may be associated with strong pro-social forces such as social cohesion that are themselves linked to better health.(22, 23)

The focus on marriage was motivated by a previous study in China which found that being unmarried was associated with higher odds of having a mood disorder as well as with the severity of such disorders,(14) possibly a manifestation of the importance of family-oriented life in Chinese culture. In addition, reports of the importance of family arrangements in overall community life in China, such as in social interactions and political participation,(24) suggest that neighborhood-level family relations could plausibly have an effect on mental disorders after accounting for individual marital and relationship status.

## METHODS

### Sample

Our sample was comprised of residents aged 18-88 in the cities of Beijing, Shanghai, and Shenzhen who participated in the World Mental Health (WMH) Survey Initiative (Table 1). The Beijing and Shanghai surveys were carried out in 2002-2003 and the Shenzhen survey in 2006-2007. The samples in all three cities were based on a multi-stage area clustered household survey design, described in detail elsewhere.(14, 25, 26)

**Table 1**. WMH Sample Characteristics by City

| City | Survey [a] | Sample characteristics | Field dates | Age range | Sample size | | Response rate [b] |
|---|---|---|---|---|---|---|---|
| | | | | | Part I | Part II | |
| Beijing / Shanghai | B-WMH / S-WMH | Beijing and Shanghai metropolitan areas | 2002-3 | 18-70 | 5,201 | 1,628 | 74.7 |
| Shenzhen | Shenzhen | Shenzhen metropolitan area; included temporary residents as well as household residents | 2006-7 | 18-88 | 7,134 | 2,476 | 80.0 |
| **TOTAL** | | | | | (12,335) | (4,104) | 77.7 |

[a] B-WMH (The Beijing World Mental Health Survey); S-WMH (The Shanghai World Mental Health Survey)

[b] The response rate is calculated as the ratio of the number of households in which an interview was completed to the number of households originally sampled, excluding from the denominator households known not to be eligible either because of being vacant at the time of initial contact or because the residents were unable to speak the designated languages of the survey. The weighted average response rate is 77.7%.

Neighborhoods in this sample consisted of neighborhood committees (NCs), the official, local community organizations in urban China that consist of 100-700 households, and that were also used as the primary sampling unit in the WMH study in China.(14) These neighborhoods represent the areas of China in which respondents currently lived at the time of the survey. In Shenzhen, work units (e.g., schools or companies) were also used as primary sampling units in addition to NCs, in order to capture temporary residents living in the city for at least one year. After combining Beijing,

Shanghai, and Shenzhen and including both NCs and work units under the definition of neighborhood for this study, our sample consisted of 143 total neighborhoods.

All participants completed Part I of the survey, which assessed core disorders and demographics, while a probability subsample consisting of all respondents who met lifetime criteria for any Part I disorder plus a probability subsample of 25% of other Part I respondents completed Part II (n = 914 in Beijing; n = 714 in Shanghai; and n = 2,476 in Shenzhen; Table 1). The sample was weighted to adjust for differential sampling of Part I respondents into Part II; for differential probability of selection within households (one respondent selected for interview in each household regardless of household size, creating an inverse association between number of household residents and probability of selection); and to match socio-demographic distributions in the respective cities.(26) The weighted Part II sample represents the distribution of mental disorders and marital status in the entire sample without bias, and adjusts the sample for minor discrepancies from the population on the distributions of age, sex, and marital status.

The analyses reported in this paper are based on the weighted Part II sample, with the exception of 32 respondents (0.2% of the weighted Part II sample) who refused to answer or answered "don't know" on a key covariate, resulting in a final analytic sample of 4,072 respondents.

**Data collection**

WMH interviews were administered face-to-face in the homes of respondents by trained lay interviewers. The WMH interview schedule was translated using a standardized World Health Organization (WHO) translation, back-translation, and harmonization protocol.(27) Written, informed consent after a full description of the study was obtained from all participants before conducting the surveys. These consent procedures were approved by the Institutional Review

Boards of the Shenzhen Institute of Mental Health and the Research Center for Contemporary China in Beijing.

**Measures**

*Primary outcome: Mental disorders*

Mental disorders were assessed with the WHO Composite International Diagnostic Interview (CIDI) Version 3.0.(28) The disorders assessed included internalizing disorders (posttraumatic stress disorder, panic disorder, specific phobia, social phobia, agoraphobia, adult separation anxiety, generalized anxiety disorder, major depressive disorder, dysthymic disorder and bipolar/sub-threshold bipolar disorders), and externalizing disorders (intermittent explosive disorder and alcohol and drug abuse with or without dependence). Diagnoses were based on the definitions and criteria of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM IV).(29) Both lifetime and past-year diagnoses were assessed. Clinical calibration studies carried out in a number of WMH countries confirmed good concordance of DSM-IV diagnoses based on the CIDI with diagnoses based on blinded clinical reappraisal interviews using the Structured Clinical Interview for DSM-IV (SCID).(30, 31)

*Individual-level fixed effects*

Individual-level covariates chosen for this analysis included age (categorized into 35-49, 50-64 and 65+ vs. 18-34), sex (female vs. not), marital status (currently married vs. not), employment status (currently unemployed vs. not unemployed vs. “don’t know” or refused to answer), migrant status (migrant to the current city vs. not, where migrant was defined as not “raised mostly in a large city”), income, and education. For income, individual per-capita income was first calculated as the combined income of all family members divided by the number of family members. The ratio of each respondent’s individual per-capita income to the median city-level income was then calculated using each city’s full sample (including both Parts I and II). Finally, this variable was centered so

that the mean was equal to 0, and used as the continuous individual income exposure variable. Individual education was categorized as being above vs. below the median of country-level education.

*Neighborhood-level fixed effects*

We divided the median income in each neighborhood (using each city's full sample, both Parts I and II) by the city-level median to calculate relative neighborhood-level income. The neighborhood-level marital status variable was calculated as the weighted proportion of married individuals in each neighborhood, again using the full sample in all cities. Both of these continuous variables were then centered so that the means were equal to 0, and used as the main neighborhood-level fixed effects. Each of these variables was also split into tertiles to classify each neighborhood as high, intermediate, or low on these measures and used as categorical fixed effects for an additional sensitivity analysis.

**Data Analysis**

Data analyses were carried out using SAS version 9.4. We used SAS survey procedures to calculate valid design-based standard errors for frequencies and means. Regression models were first run with a random intercept varying at the neighborhood level as the only independent variable in order to calculate the intraclass correlation coefficient, which estimates the proportion of variation in the disorder outcomes that can be attributed to the neighborhood.(32)

Weighted, multilevel, multivariate logistic regression models were then run using Proc Glimmix with neighborhood as the repeated subject and both lifetime and past-year internalizing and externalizing disorders as the outcomes. Zero G tests were run in order to test for the random effect of the intercept in each model.(32)

As a sensitivity analyses, we also ran multilevel models using a jackknife resampling method for estimation of variance and SAS Surveylogistic regressions, and found very similar results across all three methods, suggesting robust findings (tables available on request).

## RESULTS

### Prevalence of mental disorders (outcome)

Ten percent of the weighted analytic sample met criteria for lifetime history of any internalizing disorder, while 4.7% met criteria for lifetime history of any externalizing disorder (Table 2). Six percent had past-year internalizing disorder, and 2.7% had past-year externalizing disorder.

**Table 2**. Prevalence and Means of Independent and Dependent Variables Among 4,072 Urban China Residents

| | Unweighted n | Weighted % | Weighted mean | Weighted design-based SE [a] |
|---|---|---|---|---|
| *Cities* | | | | |
| Beijing | 914 | 22.31% | - | 1.38% |
| Shanghai | 713 | 17.43% | - | 0.90% |
| Shenzhen | 2445 | 60.26% | - | 1.34% |
| *Individual-level variables* | | | | |
| Age 18-34 | 2046 | 61.96% | | 0.95% |
| Age 35-49 | 1353 | 24.11% | - | 0.84% |
| Age 50-64 | 473 | 8.97% | - | 0.60% |
| Age 65+ | 200 | 4.96% | - | 0.50% |
| Female | 2014 | 49.26% | - | 1.19% |
| Male | 2058 | 50.74% | | 1.19% |
| Ratio of individual income to city income | - | - | 1.63 | 0.05 |
| In bottom 50% of country-level education | 1302 | 35.70% | - | 1.18% |
| In top 50% of country-level education | 2770 | 64.30% | - | 1.18% |
| Currently married | 2695 | 59.04% | - | 1.05% |
| Not currently married | 1377 | 40.96% | - | 1.05% |
| Migrant to megacity | 2526 | 63.89% | - | 1.18% |

| | | | | |
|---|---|---|---|---|
| Not a migrant to megacity | 1546 | 36.11% | - | 1.18% |
| Unemployed | 163 | 3.21% | - | 0.45% |
| Not unemployed | 3909 | 96.79% | - | 0.45% |
| *Mental disorders* | | | | |
| Any lifetime internalizing disorder [b] | 885 | 9.82% | - | 0.57% |
| Any past-year internalizing disorder | 559 | 6.31% | - | 0.47% |
| Any lifetime externalizing disorder [c] | 368 | 4.67% | - | 0.46% |
| Any past-year externalizing disorder | 230 | 2.66% | - | 0.27% |
| *Neighborhood-level variables* | | | | |
| Ratio of neighborhood income to city income | - | - | 1.05 | 0.01 |
| Percent married in neighborhood | - | - | 61.69% | 0.36 |

[a] SE = Standard error

[b] Internalizing disorders include anxiety (posttraumatic stress disorder, panic disorder, specific phobia, social phobia, agoraphobia, adult separation anxiety, generalized anxiety disorder) and mood (major depressive disorder, dysthymic disorder and bipolar/sub-threshold bipolar) disorders

[c] Externalizing disorders include behavioral (intermittent explosive disorder) and substance use (alcohol and drug abuse with or without dependence) disorders

**Distributions of independent variables**

About half (49.3%) of respondents were female; the majority was younger than 35 years old (62.0%); 59.0% were married; 63.9% were migrants to a large city; and 3.2% were unemployed. The mean ratio of individual income to median city income was 1.63.

The mean ratio of neighborhood median income to city median income was 1.05. The mean percentage of married individuals in each neighborhood was 61.7%.

**Random-intercept only models**

The intraclass correlation coefficients for variation at the neighborhood level were calculated from random-intercept-only models (not shown in tables) to be 0.04 and 0.16 for any lifetime internalizing and externalizing disorder respectively, and 0.07 and 0.09 for any past-year internalizing and externalizing disorder respectively. In other words, neighborhoods explained the greatest proportion of variation of the outcome (16%) in the model for history of lifetime externalizing disorder.

**Lifetime mental disorder models**

Table 3 reports multivariate logistic regressions with individual-level variables only (first column), neighborhood-level income as the main independent variable of interest (second column), and neighborhood-level percentage of married individuals as the main independent variable of interest (third column) with any lifetime internalizing disorder as the outcome. The associations between the individual-level variables and this outcome were modest; the only statistically significant association was found was between higher individual income (OR: 1.05, 95% CI: 1.02-1.09 for all three models) and lifetime internalizing disorder.

Table 3. Logistic Multilevel, Multivariate Regression Models with Lifetime Internalizing Disorder [a] as the Outcome Among 4,072 Urban China Residents [b]

| | Individual-level exposures only | | | Individual-level exposures and neighborhood-level income | | | Individual-level exposures and neighborhood-level marital status | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.75 | 0.55 | 1.01 | 0.75 | 0.56 | 1.02 | 0.77 | 0.57 | 1.05 |
| Age 50-64 | 1.35 | 0.87 | 2.09 | 1.36 | 0.88 | 2.10 | 1.40 | 0.91 | 2.17 |
| Age 65+ | 0.90 | 0.53 | 1.53 | 0.90 | 0.53 | 1.53 | 0.93 | 0.55 | 1.58 |
| Female | 1.19 | 0.92 | 1.53 | 1.19 | 0.92 | 1.53 | 1.18 | 0.92 | 1.53 |
| Ratio of individual income to city income | 1.05* | 1.02 | 1.09 | 1.05* | 1.02 | 1.09 | 1.05* | 1.02 | 1.09 |
| In top 50% of country-level education | 1.28 | 0.97 | 1.69 | 1.26 | 0.95 | 1.69 | 1.27 | 0.96 | 1.68 |
| Married | 0.75 | 0.56 | 1.02 | 0.75 | 0.56 | 1.02 | 0.79 | 0.57 | 1.09 |
| Migrant to megacity | 1.11 | 0.77 | 1.60 | 1.11 | 0.77 | 1.61 | 1.09 | 0.75 | 1.57 |
| Unemployed | 1.49 | 0.77 | 2.89 | 1.50 | 0.78 | 2.91 | 1.57 | 0.80 | 3.06 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Ratio of neighborhood income to city income | | | | 1.07 | 0.82 | 1.40 | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Percent married in neighborhood | | | | | | | 0.99 | 0.99 | 1.00 |
| *Random effects* | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value |
| Intercept | 0.07 | 2.35 | .063 | 0.07 | 2.28 | .065 | 0.06 | 1.60 | .103 |

* = $P < 0.05$

[a] Internalizing disorders include anxiety (posttraumatic stress disorder, panic disorder, specific phobia, social phobia, agoraphobia, adult separation anxiety, generalized anxiety disorder) and mood (major depressive disorder, dysthymic disorder and bipolar/sub-threshold bipolar) disorders

[b] Models include the above variables as well as fixed effects for city and for having a missing ("don't know" or refused) value on individual unemployment

Neither neighborhood-level income nor neighborhood-level marital status was statistically significantly associated with lifetime internalizing disorder. Additionally, the random effect of the intercept was not statistically significant in the fully adjusted models (p-values ranged from .063-.103).

Table 4 presents the same three models as in Table 3, but with lifetime externalizing disorder as the outcome. In these models, being of older age (OR's ranged from 0.41-0.43 for age 50-64 compared to age 18-34) and being female (OR's: 0.24-0.25) were both significantly protective against externalizing disorder, while being married (OR's: 1.75-1.96) was significantly positively associated with externalizing disorder.

Table 4. Logistic Multilevel, Multivariate Regression Models with Lifetime Externalizing Disorder [a] as the Outcome Among 4,072 Urban China Residents [b]

| | Individual-level exposures only | | | Individual-level exposures and neighborhood-level income | | | Individual-level exposures and neighborhood-level marital status | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.74 | 0.46 | 1.19 | 0.74 | 0.46 | 1.20 | 0.78 | 0.48 | 1.27 |
| Age 50-64 | 0.41* | 0.18 | 0.93 | 0.41* | 0.18 | 0.93 | 0.43* | 0.18 | 0.98 |
| Age 65+ | 0.24 | 0.05 | 1.22 | 0.24 | 0.05 | 1.22 | 0.24 | 0.05 | 1.30 |
| Female | 0.25* | 0.17 | 0.36 | 0.25* | 0.17 | 0.36 | 0.24* | 0.17 | 0.35 |
| Ratio of individual income to city income | 1.03 | 0.99 | 1.08 | 1.03 | 0.99 | 1.07 | 1.03 | 0.98 | 1.07 |
| In top 50% of country-level education | 1.41 | 0.91 | 2.20 | 1.39 | 0.89 | 2.19 | 1.39 | 0.90 | 2.15 |
| Married | 1.76* | 1.04 | 2.96 | 1.75* | 1.03 | 3.97 | 1.96* | 1.13 | 3.40 |
| Migrant to megacity | 1.10 | 0.76 | 1.60 | 1.10 | 0.76 | 1.59 | 1.07 | 0.73 | 1.57 |
| Unemployed | 2.30 | 0.92 | 5.77 | 2.31 | 0.92 | 5.82 | 2.49 | 0.98 | 6.33 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Ratio of neighborhood income to city income | | | | 1.10 | 0.77 | 1.56 | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Percent married in neighborhood | | | | | | | 0.99* | 0.97 | 1.00 |
| *Random effects* | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value |
| Intercept | 0.31 | 15.86* | <.0001 | 0.32 | 16.02* | <.0001 | 0.27 | 13.34* | <.0001 |

* = $P < 0.05$

[a] Externalizing disorders include behavioral (intermittent explosive disorder) and substance use (alcohol and drug abuse with or without dependence) disorders

[b] Models include the above variables as well as fixed effects for city and for having a missing ("don't know" or refused) value on individual unemployment

For the neighborhood-level exposures, higher neighborhood-level income was not statistically significant in its association (second column), but neighborhood-level percentage of married individuals (third column) was statistically associated with lower odds of lifetime externalizing disorder (OR: 0.99, 95% CI: 0.97-1.00). In other words, each one-point increase in neighborhood-level percent of married residents was associated with a 1% decreased odds of lifetime externalizing disorder.

As an alternative interpretation, when the sample was split into tertiles in order to use a categorical variable for percent married (not shown in tables), we found that living in a neighborhood in the top tertile of the percent married residents in each neighborhood was associated with a 51% decreased odds of lifetime externalizing disorder (OR: 0.49, 95% CI: 0.27-0.89), and being in the middle tertile was associated with a 50% decreased odds of lifetime externalizing disorder (OR: 0.50, 95% CI: 0.28-0.89), both compared to the bottom tertile.

Finally, the bottom row of Table 4 shows that the random effect of an intercept varying at the neighborhood level was statistically significant in all three models ($p < .0001$), further illustrating that the probability of having history of externalizing disorder varied by neighborhood.

**Past-year mental disorder models**

Models for past-year internalizing disorders are presented on Table 5, with the same independent variables included as in Tables 3 and 4. There were no statistically significant associations among individual-level variables with past-year internalizing disorders in the fully adjusted models, with the exception of being 35 to 49 years old, which was associated with lower odds of past-year internalizing disorder in comparison with younger individuals for each model (OR's: 0.66-0.69).

Table 5. Logistic Multilevel, Regression Multivariate Models with Past-Year Internalizing Disorder [a] as the Outcome Among 4,072 Urban China Residents [b]

| | Individual-level exposures only | | | Individual-level exposures and neighborhood-level income | | | Individual-level exposures and neighborhood-level marital status | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.66* | 0.44 | 0.98 | 0.66* | 0.44 | 0.98 | 0.69 | 0.47 | 1.03 |
| Age 50-64 | 1.27 | 0.73 | 2.19 | 1.27 | 0.73 | 2.19 | 1.34 | 0.77 | 2.32 |
| Age 65+ | 0.59 | 0.28 | 1.23 | 0.59 | 0.28 | 1.23 | 0.61 | 0.29 | 1.29 |
| Female | 1.17 | 0.83 | 1.65 | 1.17 | 0.83 | 1.65 | 1.16 | 0.82 | 1.63 |
| Ratio of individual income to city income | 1.04 | 0.99 | 1.08 | 1.04 | 1.00 | 1.08 | 1.03 | 0.99 | 1.08 |
| In top 50% of country-level education | 1.44 | 0.97 | 2.13 | 1.44 | 0.96 | 2.17 | 1.42 | 0.96 | 2.10 |
| Married | 0.83 | 0.56 | 1.23 | 0.83 | 0.56 | 1.23 | 0.88 | 0.58 | 1.35 |
| Migrant to megacity | 1.33 | 0.81 | 2.16 | 1.32 | 0.81 | 2.15 | 1.29 | 0.78 | 2.11 |
| Unemployed | 1.44 | 0.87 | 2.37 | 1.43 | 0.87 | 2.36 | 1.54 | 0.92 | 2.59 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Ratio of neighborhood income to city income | | | | 0.97 | 0.70 | 1.35 | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Percent married in neighborhood | | | | | | | 0.99 | 0.99 | 1.00 |
| *Random effects* | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value |
| Intercept | 0.15 | 5.99* | .007 | 0.15 | 5.88* | .008 | 0.13 | 4.18* | .021 |

* = $P < 0.05$

[a] Internalizing disorders include anxiety (posttraumatic stress disorder, panic disorder, specific phobia, social phobia, agoraphobia, adult separation anxiety, generalized anxiety disorder) and mood (major depressive disorder, dysthymic disorder and bipolar/sub-threshold bipolar) disorders

[b] Models include the above variables as well as fixed effects for city and for having a missing ("don't know" or refused) value on individual unemployment

The second two columns in Table 5 show that again, there were no significant associations between neighborhood-level income or proportion of married residents with odds of internalizing disorder. However, the proportion of married residents per neighborhood neared statistical significance (p = .09), and the random effect of the intercept varying at the neighborhood level was statistically significant in all three models (p values ranged from .021 to .007).

Table 6 presents the results for past-year externalizing disorder as the outcome. In these models, being of older age (OR's: 0.05-0.53 for all age groups compared to being 18-34 years old) and being female (OR's: 0.38-0.40) were again significantly protective against externalizing disorder, and being married (OR's: 1.92-2.23) was again significantly positively associated with externalizing disorder. Additionally, being unemployed, having a higher educational attainment, and having a higher relative individual income were all statistically associated with higher odds of disorder (OR's: 5.71-1.04).

Table 6. Logistic Multilevel, Multivariate Regression Models with Past-Year Externalizing Disorder [a] as the Outcome Among 4,072 Urban China Residents [b]

| | Individual-level exposures only | | | Individual-level exposures and neighborhood-level income | | | Individual-level exposures and neighborhood-level marital status | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit | Odds ratio | 95% CI Lower limit | 95% CI Upper limit |
| *Individual-level fixed effects* | | | | | | | | | |
| Age 35-49 | 0.49* | 0.26 | 0.91 | 0.49* | 0.26 | 0.92 | 0.53* | 0.28 | 0.99 |
| Age 50-64 | 0.17* | 0.07 | 041 | 0.17* | 0.07 | 041 | 0.19* | 0.08 | 0.45 |
| Age 65+ | 0.05* | 0.01 | 0.24 | 0.05* | 0.01 | 0.24 | 0.06* | 0.01 | 0.27 |
| Female | 0.40* | 0.27 | 0.59 | 0.40* | 0.27 | 0.59 | 0.38* | 0.26 | 0.57 |
| Ratio of individual income to city income | 1.05* | 1.00 | 1.09 | 1.04* | 1.00 | 1.09 | 1.04 | 0.99 | 1.09 |
| In top 50% of country-level education | 1.78* | 1.15 | 2.75 | 1.77* | 1.13 | 2.77 | 1.72* | 1.13 | 2.62 |
| Married | 1.92* | 1.09 | 3.40 | 1.92* | 1.08 | 3.42 | 2.23* | 1.19 | 4.16 |
| Migrant to megacity | 0.83 | 0.54 | 1.29 | 0.83 | 0.54 | 1.29 | 0.78 | 0.49 | 1.24 |
| Unemployed | 5.01* | 2.23 | 11.24 | 5.01* | 2.24 | 11.23 | 5.71* | 2.50 | 13.05 |
| *Neighborhood-level fixed effects* | | | | | | | | | |
| Ratio of neighborhood income to city income | | | | 1.01 | 0.73 | 1.42 | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Percent married in neighborhood | | | | | | | 0.98* | 0.97 | 0.99 |
| *Random effects* | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value | Variance estimate | Zero G test chi square | p-value |
| Intercept | 0.12 | 1.80 | .090 | 0.12 | 1.80 | .090 | 0.08 | 1.01 | .157 |

* = $P < 0.05$

[a] Externalizing disorders include behavioral (intermittent explosive disorder) and substance use (alcohol and drug abuse with or without dependence) disorders

[b] Models include the above variables as well as fixed effects for city and for having a missing ("don't know" or refused) value on individual unemployment

For the neighborhood-level exposures, results were very similar to those with lifetime externalizing disorder as the outcome. Higher neighborhood-level income was not statistically significant (second column), but neighborhood-level percentage of married individuals (third column) was again statistically associated with lower odds of externalizing disorder (OR: 0.98, 95% CI: 0.97-0.99). As an alternative interpretation, when split into tertiles for a categorical exposure variable, living in a neighborhood in the top tertile of perfent of married residents was associated with a 54% decreased odds of past-year externalizing disorder (OR: 0.46, 95% CI: 0.24-0.87).

## DISCUSSION

Using multilevel models with data from three of the largest cities in China, we found that after accounting for individual-level marital status, residence in neighborhoods with a higher proportion of married individuals was associated with lower odds of both past-year and lifetime externalizing, but not internalizing, mental disorders. Contrary to our expectations, living in a neighborhood with a

higher median income compared to the city median income was not significantly associated with lower odds either internalizing or externalizing of disorder.

Despite the differences in samples, this finding is similar that of Roosa and colleagues who found that neighborhood disadvantage was not associated as a main effect with internalizing or externalizing symptoms in a sample of Mexican American youth.(17) However, it is at odds with the finding by Hurd et al that African American adolescents in the United States who lived in areas of higher neighborhood poverty were more likely to have internalizing symptoms as mediated by lower social support.(16)

Two mechanisms have been proposed to explain general associations between lower income or social capital with higher odds of mental disorders: social causation and social selection.(33, 34) The latter posits that individuals with mental disorders have a predisposition to drift into lower socioeconomic positions, while the former attributes the association to the stress and adversity that comes with having low socioeconomic status. The pathways through which neighborhood income may affect mental disorders are likely multifactorial and at least partially mediated by individual socioeconomic status, but neighborhood features and social cohesion are likely to explain some of this association,(10) as was the case in Hurd et al's study.(16) We were not able to test these hypotheses directly due to the cross-sectional nature of our data, but our results suggest that, in the context of adults living in urban China, neighborhood income does not in fact appear to be an important driver of mental health outcomes.

To our knowledge, the proportion of married individuals in a neighborhood has not been studied in relation to internalizing and externalizing mental disorders. At the individual level, marital status is very often shown to be associated with mental disorders.(35, 36) The inverse association of neighborhood-level percentage of married individuals and externalizing disorders found in our study

suggests a protective community effect of marriage, possibly through its effect on social cohesion. The social control (or social bond) theory primarily used in criminology, which states that traditional social relationships may buffer against externalizing behavior in the form of crime,(37) may potentially be extended to our results in terms of communities of married families acting as a buffer against its residents developing externalizing disorders such as substance abuse.

Additionally, living in a neighborhood with more married individuals has been associated with higher neighborhood satisfaction,(38) and marital status is frequently associated with more political participation and social support.(24) We were not able to directly analyze neighborhood social cohesion with our data, but we welcome new studies that test this hypothesis. Another possible explanation is that the neighborhood marriage distribution is an indicator of other neighborhood characteristics not measured. For example, previous studies in other contexts have found that areas with higher marriage rates also have more upward mobility,(39, 40) which could plausibly affect local mental health.

Despite our focus on contextual (neighborhood-level) exposures in this analysis, we also unexpectedly found that being married as an individual and being more highly educated were both associated a with higher odds of externalizing disorders, and having higher individual income relative to the city median was associated at the individual level with higher odds of both internalizing and externalizing disorders. These results were unexpected in contrast to findings in other parts of the world.(41) However, we propose that in the context of Chinese cities, these characteristics may be indicators of added family or job-related stress resulting from marriage and higher education, especially when controlling for unemployment and for proxies of social cohesion at the neighborhood level. Being married was also found to be an individual risk factor for any disorder in an earlier analysis using WMH data in Beijing and Shanghai only; never having been married was significantly protective against any past-year disorder.(14) The relationship between

marital status and mental disorder also depends on the timing of each condition (41) as well as severity and type of disorder,(14) which could be focuses for future papers using urban Chinese data, but were not our focus here.

These results should be interpreted in the context of a few limitations. First, due to the cross-sectional nature of this study, we cannot exclude the possibility of reverse causation that concentrates individuals with externalizing mental disorders in neighborhoods with fewer married individuals, as posited by the social selection theory.(33) Although this potential for reverse causation cannot be discarded, recent systematic reviews have suggested that there is a consistent association of neighborhood characteristics with mental health.(42) Further, Dohrenwent and colleagues found that social causation was a more likely theory than social selection for substance use disorders in men.(33) Men with substance use disorders are a primary group of those characterized as having externalizing disorder in our study, the outcome for which we found the significant relationship with neighborhood marital status, suggesting that there may in fact be a causal link.

As a second limitation, our study relied on data from lay interviews instead of clinician-administered interviews, which could affect estimates of disease prevalence and predictors. However, our diagnostic assessments have been validated with blinded clinical reappraisal interviews.(31)

Third, our sample is not necessarily representative of today's urban China, given that the data were collected in the early 2000's, or of other large urban areas of China not sampled. Even across the three cities we assessed, there are important differences, most notably the fact that Beijing and Shanghai are two of the oldest large cities in China, while Shenzhen is a migrant industrial city that evolved based on its designation in 1980 as the first PRC Special Economic Zone. In order to control for city-level differences in costs of living, we measured individual income as the ratio of

individual income to median city-level income, but other differences may remain. In our sample, Beijing had the highest prevalence of disorder, followed by Shenzhen and then Shanghai, and we included city as a control variable in our models.

Further, socioeconomic characteristics likely have differential effects on the health of migrants depending on the culture and area of origin,(43) which could modify our results. Some new neighborhoods in China, especially in Shenzhen, are composed of groups of migrants of similar ages, originating from the same areas, and living in small areas such as dormitories(44) where high social cohesion could influence mental health outcomes. Our analysis of migration was limited by the absence of detailed data on the respondents' area of origin and current housing. However, we did statistically control for whether the responded grew up mostly in a large city. Future studies should investigate the associations of these factors with mental disorders in a sample with more detailed information on migration status.

Despite these limitations, our study is the first to investigate the associations of neighborhood characteristics with mental disorders in large urban areas of China, providing data that may be consistent with previous concerns about the mental health effects of community disruption created by rapid urbanization.(45, 46)

Mental disorders are a growing public health problem in China. The government has recently taken steps to address the problem by creating hundreds of new psychiatric hospitals and integrating its resources with existing community health systems.(45) A few recent sociodemographic changes such as the increasing globalization of its economy and the end of the one-child policy may also significantly improve neighborhood characteristics. However, more progress will likely be needed to develop broad social measures for enhancing social cohesion, participation, and support to help manage the consequences of decades of under-diagnosed mental disorders.

The large and rapid urbanization process that China went through during the past few decades has been recently replicated, on a much smaller scale, in other countries. While there are important early benefits of urbanization, the frequently chaotic expansion of urban areas can be associated with community disruption and the worsening of health outcomes. A growing number of low-income individuals now live in large urban areas that do not provide the social support and stability found in smaller communities. Understanding the effects of neighborhood characteristics on mental disorders in fast growing regions of the world can help to promote better neighborhood environments and control the burden of mental disorders in emerging countries.

One direction for future research would be to further investigate the role of migration. A high proportion of individuals in our sample and in urban China as a whole were born in rural areas. Migrating from rural to urban areas is not only prevalent in China, but also likely to be associated with both marital status and income in addition to mental health.(13) Investigators should continue to study the relationships among important neighborhood-level indicators of health, including a more specific measure of migration status at both an individual and neighborhood level. Finally, another potentially fruitful direction for future research could be to investigate how the distribution of mental disorders at the neighborhood-level might act as a potential predictor for individual disorder outcomes, preferably in a longitudinal setting.

**Contributors:**

Chiavegatto Filho ADP designed initial statistical analyses; conducted the literature review; performed preliminary analyses; wrote the introduction and discussion sections; and critically edited all versions of the manuscript. Sampson L aided in the literature review and writing of introduction and discussion sections; wrote the methods and results sections; designed the revised analyses; created tables; and critically edited all versions of the manuscript. Martins SS helped to design statistical analyses; participated in interpretation of results; and critically edited all versions of the manuscript. Yu S performed statistical analyses; created tables; and critically edited all versions of the manuscript. Huang Y carried out the Beijing data acquisition; participated in interpretation of results; and critically edited all versions of the manuscript. He Y carried out the Shanghai data acquisition; participated in interpretation of results; and critically edited all versions of the manuscript. Lee S coordinated data acquisition and critically edited all versions of the manuscript. Hu C carried out the Shenzhen data acquisition and critically edited all versions of the manuscript. Zaslavsky AM designed data analyses; provided statistical support; participated in interpretation of results; and critically edited all versions of the manuscript. Kessler RC conceptualized and coordinated the study; participated in interpretation of results; and critically edited all versions of the manuscript. Galea S conceptualized the analyses; formulated hypotheses; led the analytic team; and critically edited all versions of the manuscript. All authors approved the final version and stand behind all aspects of the work.

**Competing interests**: In the past three years, Dr. Kessler received support for his epidemiological studies from Sanofi Aventis; was a consultant for Johnson & Johnson Wellness and Prevention, Shire, Takeda; and served on an advisory board for the Johnson & Johnson Services Inc. Lake Nona Life Project. Kessler is a co-owner of DataStat, Inc., a market research firm that carries out healthcare research. Other authors have no financial or personal conflicts of interest to disclose.

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**Patient consent**: Written, informed consent after a full description of the study was obtained from all participants before conducting the surveys in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. These consent procedures were approved by the Institutional Review Boards of the Shenzhen Institute of Mental Health and the Research Center for Contemporary China in Beijing.

**Data sharing statement**: Access to the cross-national World Mental Health (WMH) data is governed by the organizations funding and responsible for survey data collection in each country.

These organizations made data available to the WMH consortium through restricted data sharing agreements that do not allow us to release the data to third parties.

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**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 3 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 3 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5-7 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 6 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 7-9 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 8 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 7-9 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 10-11 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 10-11 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9 |
| Study size | 10 | Explain how the study size was arrived at | 9 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 10-11 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 11-12 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | N/A |
| | | (*c*) Explain how missing data were addressed | 9 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | 9, 11-13 |
| | | (*e*) Describe any sensitivity analyses | 12 |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 9 |
| | | (b) Give reasons for non-participation at each stage | 9 |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 13-14 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 9 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 14 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 10-11, 15-24 |
| | | (*b*) Report category boundaries when continuous variables were categorized | N/A |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | N/A |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 12,19,24 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 24-25 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 27-28 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 25-28 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 27 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 31 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.