Loneliness in urbanizing China

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Data Availability Statement

Data available on request from the authors.

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Abstract

Despite the growing literature on loneliness, little attention has been paid to the impact of broader changes in social structure and environment on individuals' experience of loneliness. Drawing on data from the 2018 Urbanization and Quality of Life Survey (N = 3,229) conducted in 40 localities undergoing rural–urban transition in China, this study investigates how measures of urbanization (including population density, duration of urban status, neighborhood transition, and housing type) are associated with residents' loneliness. We revised measures of the six-item De Jong Gierveld Loneliness Scale, differentiated between emotional and social loneliness, estimated multi-level mixed-effects regressions, and controlled for a number of individual-level covariates. The results show that emotional loneliness and social loneliness have different patterns of association with multi-level covariates: urbanization at county, township, and neighborhood levels is significantly associated with emotional loneliness, whereas residence in temporary housing is a clear risk factor for social loneliness. The analyses further demonstrate that the revised measures of loneliness address concerns about the original scale, offer a clearer sense of the degrees of loneliness, and are strongly associated with multi-level covariates and psychological distress. In addition to showing how urbanization leads to greater individual loneliness, our research also illustrates how to model locational parameters in analyses of individual well-being.

Keywords: Urbanization; Loneliness; De Jong Gierveld Loneliness Scale; Well-being; China

What is known about this topic:

- The established correlates of loneliness are wide-ranging, including demographic characteristics; cognitive, physical, and mental health status; biological and genetic inheritance; and environmental and social attributes.
- Specifically focused approaches cannot fully account for differences in loneliness; an integrative perspective is required.
- Global urbanization has had significant implications for public health.

What this paper adds:

- The revised measures of the six-item De Jong Gierveld Loneliness Scale were strongly associated with multi-level covariates and psychological distress.
- In the context of China's urbanization, emotional loneliness and social loneliness show different patterns of association with multi-level covariates.
- In demonstrating how urbanization leads to greater individual loneliness, our research illustrates how to model locational parameters.

1. Introduction

Loneliness is an important measure of an individual's well-being. It is defined as a situation experienced by the individual in which an unpleasant absence or lack of certain relationships exists (De Jong Gierveld, 1987). Weiss (1973) distinguishes between emotional loneliness and social loneliness. Emotional loneliness refers to the absence of an intimate figure/relationship or a close emotional attachment, whereas social loneliness refers to the lack of an engaging social network or a broader group of contacts. Loneliness is based on peoples' subjective evaluation of their social connection or isolation. It is an expression of negative feelings arising from a longing for intimate relationships and a perceived discrepancy between needed social connections and their availability in the environment (De Jong Gierveld and Von Tilburg, 2006; Hawkley and Cacioppo, 2010).

Loneliness is not a new phenomenon, although, in the past, it was often ignored, trivialized, or even stigmatized (Cacioppo and Cacioppo, 2018). Only in recent years has loneliness attracted the attention of academic researchers, health professionals, the media, and policy-makers. Loneliness has been increasingly recognized as a critical public health issue, and even a global health priority, that requires social and medical support (Cacioppo and Cacioppo, 2018; Lim et al., 2020). In 2018, the United Kingdom even made international news by appointing a Minister of Loneliness to tackle growing concerns about this "sad reality of modern life" (Klinenberg, 2018).

Loneliness is a consequence of multiple factors; its effects are also multi-layered and multi-dimensional (Beutel et al., 2017; Cacioppo et al., 2014; Hawkley and Cacioppo, 2010; Heinrich and Gullone, 2006; Mihalopoulos et al., 2020; Spithoven et al., 2019). Despite the growing literature on loneliness, little attention has been paid to the impact of broader changes in

the social structure and environment. Specifically focused loneliness studies cannot account for differences in the experience of loneliness; an integrative approach is required (De Jong Gierveld et al., 2018; Lim et al., 2020). There is a pressing need to view loneliness in the context of the current social and political environment, because ongoing changes, such as urbanization, are dramatically altering the ways we live, function, and communicate.

Global urbanization, and the accompanying population transitions, in the last half century has had a profound influence on individual well-being and public health (Hoare et al., 2019; Sampson et al., 2020). How does urbanization affect people's feelings of loneliness? Does it contribute equally to emotional and social loneliness? This article investigates how urbanization is associated with loneliness in the context of rapidly urbanizing China. Based on data from a national survey (N = 3,229) conducted in 40 localities undergoing rural-urban transition, we tested a series of measures related to the process of urbanization. We differentiated between emotional loneliness and social loneliness. We revised the existing measure of loneliness—the six-item De Jong Gierveld Loneliness Scale—to reflect the state of loneliness in more detail (De Jong Gierveld and Von Tilburg, 2006; Leung et al., 2008). While controlling for a number of individual-level covariates as identified in existing literature (Lim et al., 2020), we estimated multi-level mixed-effects models and allowed random effects at the neighborhood and township/county levels.

In the following sections, we first discuss the theoretical and empirical connections between urbanization and loneliness; we then describe the context of our study, before presenting the empirical data, analyses, and findings.

2. Urbanization and loneliness

"Urbanization" generally refers to the process by which a growing number of people move from the countryside to cities. It involves changes in demographic, socio-economic, and environmental situations (McGranahan and Satterthwaite, 2014). More than four billion people (over half of the world population) now live in urban settings globally, and it is estimated that five billion will do so by 2030 and seven billion by 2050 (Ritchie and Roser, 2020). Loneliness is a common feature of modern societies, particularly urban ones (Klinenberg, 2018). It is the product of not only individual attributes but also historical and social influences. Loneliness is the psychological experience of an individual in a specific social and historical period: it reflects changes in social structure and environment (Tian, 2010).

When people move to the city, leaving behind their traditional agricultural community and lifestyle, they must deal with a complex, ever-changing urban society and rely on their own efforts to make a living and achieve self-development. Although the process of urbanization provides more freedom, it also isolates the individual and generates the social conditions for greater loneliness (Ng et al., 2011; Riesman et al., 2001; Tian, 2010). There is considerable popular interest in the relationship between urbanization and loneliness, as news outlets and statistics agencies report the increasing numbers of individuals living alone in cities (Klinenberg, 2018). Studies focusing on the associations between urbanization and loneliness, however, are limited, and the findings of existing empirical research are mixed.

Finlay and Kobayashi (2018), for instance, investigated the experience of loneliness and social isolation among older adults (N = 124) in the U.S. Their results suggest that loneliness increases when individuals live further from urban centres. In contrast, Karmakar and Raychaudhuri (2015) examined a clinical group and a matched non-clinical group (N = 160) in India and reported that individuals in urban areas were lonelier than those living in rural

locations. With a much larger sample of Dutch adults (N = 8,356), MacDonald et al. (2020) investigated the association of place of residence (degree of urbanization) and leisure activities with self-reported loneliness. Their results show that living in more urbanized areas and engaging in fewer social activities are significant predictors for loneliness. The range of findings in the existing literature could be due to the diverse target groups and sample selections, differences in social contexts, and various measures of loneliness employed in the analyses. In this study, we investigate how urbanization is associated with loneliness in the context of China's rapid urbanization, drawing on data from a national survey and using the revised De Jong Gierveld Loneliness Scale.

3. China's urbanization: the study context

Developed countries have already reached a high level of urbanization. Ninety-five percent of the projected urban expansion in the coming decades is likely to take place in the developing world (United Nations, 2015). China's ongoing urbanization is unprecedented in human history in terms of its speed and scale (Chen et al., 2014). From 1978 to 2018, the proportion of the country's urban population increased from 17.9% to 59.6% (National Bureau of Statistics of China, 2019). By 2018, the area designated "urban" was eight times larger than in 1981, and over 200 million formerly rural residents had become urbanites without even leaving their home villages or towns (Chen et al., 2015; Ministry of Housing and Urban–Rural Development of China, 2019). During the process of urbanization in China, counties (and county-level cities) are converted to urban districts, rural townships are upgraded to towns, and towns and rural townships are reclassified as street districts. Between 1999 and 2018, the number of counties decreased from 1,510 to 1,335 and the number of rural townships dropped from 24,745 to

10,253; meanwhile, the number of urban districts increased from 749 to 970, and the number of street districts rose from 5,904 to 8,393 (National Bureau of Statistics of China, 2020).

The current leadership in China continues to implement policies to promote urbanization. The National New-Type Urbanization Plan was launched in March 2014, which emphasizes people-centred urbanization (Wang et al., 2015). According to the Plan, the percentage of the population classified as urban will rise to 60% by 2020, an increase that requires the reclassification or relocation of 100 million villagers. Pilot programs have been implemented to promote the new-type urbanization in different localities (Chen et al., 2018; National Development and Reform Commission, 2014, 2015, 2016). Before the end of 2020, the goal set by the Plan was already achieved: more than 60% of Chinese citizens live in towns and cities. It is expected that the urbanization rate will reach 70% by 2030 and 80% by 2050 (Zheng, 2019).

Scholars argue that, as China undergoes rapid urbanization, traditional family ties and social connections will continue to weaken, and people will experience alienation in their new surroundings. Loneliness in Chinese urban society will parallel that in urban societies around the world (Tian, 2010). In particular, local governments have been criticized for seeking financial gains through land sales, resulting in "urbanization of place" rather than "urbanization of people" (Ong, 2014). Many former rural residents have been reclassified as urban residents without leaving their homes, but they have had to adapt to a new way of life within a very short period (Chen et al., 2015). This in-situ urbanization of place is viewed with cynicism: instead of a sign of economic development, it is a way for local governments to augment their revenues without improving the general well-being of affected residents (Guan et al., 2018; Ong, 2014). As people relocate from traditional rural villages to modern urban communities, a sense of loneliness is likely to emerge (Tian, 2010). The psychological distress associated with adapting to urban life

and disruptions in social networks will result in anxiety and loneliness (Chen et al., 2014). Given China's rapid urbanization, the problem of loneliness will grow quickly (Tian, 2010). It seems likely that emotional loneliness will be more intense than social loneliness, as people will probably retain social connections with their original community even after urbanization.

Still, China's urbanization is not without benefits for its citizens. Because urbanization in China is almost entirely managed by the party-state (Cartier, 2015), the process has not created the urban slums that are common in other developing countries, such as India and Brazil (Ren, 2018). Although urbanization is a top-down process, involuntary relocation has, in fact, led to the replacement of substandard rural dwellings with more sound townhouses or apartments in newly created urban neighborhoods (Hou et al., 2019). Studies have documented that the residents are generally happy with the physical elements of their new residential environment (Jiang et al., 2018; Li et al., 2016; Yep and Forrest, 2016). Yep and Forrest (2016), for example, report that many former peasants who were moved to high-rise apartments consider their relocation to be a step closer to their "ideal" urban lifestyle, with more sanitary surroundings and easy and stable access to water, gas, and heating services. Government policy-makers have labelled this "human-centred" urbanization and have encouraged local governments to adopt this policy to ease villagers' transition to urban ways of living (Chen et al., 2017). In addition to improvements in the living environment, several studies have shown that urbanization in China had an independent and positive effect on health and well-being (Hou et al., 2019; Sampson et al., 2020; Wang et al., 2018). If this is the case, it is possible that the increased loneliness associated with adapting to urban life and disruptions in social networks may be offset by improvements in living environment during the process of urbanization.

Clearly the arguments and evidence outlined above are contradictory. Our analysis of the relationship between urbanization and loneliness should shed some light on this complicated issue. Our study draws on data from the 2018 Urbanization and Quality of Life Survey (N = 3,229) that we conducted in 40 townships undergoing rural-urban transition throughout China.

4. Data and methods

4.1 The 2018 Urbanization and Quality of Life Survey

We used data from the 2018 Urbanization and Quality of Life Survey (N = 3,229) that targeted residents in 40 primary sampling units (PSUs), including 32 townships (street districts or towns) in newly urbanized areas and eight townships (towns or rural townships) that were considered potential sites of urbanization (see Appendix 1 for details of the survey sampling design). The participants in the survey were adults aged 18 to 75 who had resided in the township for more than six months and in the household for at least 30 days. Fieldwork was conducted between April and June 2018 through face-to-face interviews using the computer-assisted personal interviewing (CAPI) system. We obtained ethical approval for research involving human subjects from our home institute. All respondents gave their consent to participate in the survey before the interviews were conducted. After data checking and cleaning, the final valid sample size was 3,229 with a response rate of 65.2%. Post-stratification weights were generated to ensure that, on key demographic variables, the survey respondents were representative of the general population as documented in the 2010 China Township Population Census Data (National Bureau of Statistics of China, 2012).

4.2 Measures

4.2.1 The six-item De Jong Gierveld Loneliness Scale

We used the Chinese version of the six-item De Jong Gierveld Loneliness Scale to measure emotional, social, and overall loneliness (Leung et al., 2008). To measure emotional loneliness, we asked the respondents whether the following statements described their current situation or feelings: "I experience a general sense of emptiness"; "I miss having people around"; and "I often feel rejected." Three statements were also used to measure social loneliness: "There are plenty of people I can rely on when I have problems"; "There are many people I can trust completely"; and "There are enough people feel close to." The scale has been proven to be a valid and reliable measurement instrument, suitable for a large survey and a broad age range, and applicable across locations and countries (De Jong Gierveld, 2006).

Participants could respond to the statements with the following answers: "Yes." "More or less," and "No." The scores were calculated as sums of dichotomously coded items. A score of 0 was used for the answer "No," and the answers "Yes" and "More or less" were both coded as 1. One concern about this scale is that feeling lonely some of the time, which a "More or less" response suggests, is quite common and, therefore, represents an extremely low bar (Klinenberg, 2018). Moreover, when the scores of the dichotomously coded items are added up, those for emotional and social loneliness (ranging from 0 to 3) do not correspond to the scale used for overall loneliness (ranging from 0 to 6). Scholars have therefore suggested that loneliness should be measured comprehensively, avoiding dichotomous measurement (Lim et al., 2020).

In adapting the scale to our purposes, we replaced the original three-answer choice with a seven-point Likert scale, where "1" indicates "completely untrue" and "7" indicates "completely true." The use of a continuous measure of loneliness allows for more nuanced responses. We reverse coded the scale scores on those positive statements and took the mean of the

respondents' answers on all six items as the measure of overall loneliness, ranging from 1 to 7, with a higher score indicating greater overall loneliness. Cronbach's α was 0.72 for the study sample.

Confirmatory factor analysis further established the specification of two latent factors: emotional loneliness and social loneliness. The likelihood-ratio test yielded χ^2 (15) = 8093.76 with p = 0.00. We calculated the means of respondents' answers on the items for emotional loneliness and social loneliness separately. Cronbach's α was 0.75 for the former and 0.90 for the latter.

4.2.2 Individual-level measures

Individual-level covariates included demographic characteristics, socio-economic status, and religion, family, and housing situations. We also controlled for respondents' chronic health conditions, experience of life events, and frequency of access to the Internet (Lim et al., 2020). Appendix Table A1 provides detailed descriptions of individual-level measures.

4.2.3 County/township- and neighborhood-level measures

In addition to drawing on individual-level data from the 2018 Urbanization and Quality of Life Survey, we also compiled a number of county/township- and neighborhood-level measures. The variable descriptions are presented in Appendix Table A2.

County population density. We used a conventional measure of population density—the average number of people per square kilometre in each county-level administrative unit—as the key indicator reflecting the level of urbanization. Because of

the skewed distribution of population density, the natural logarithm transformation was used in the subsequent regression analysis.

County GDP per capita and growth. We collected gross domestic product (GDP) data at the county level from 2014 to 2017. The year 2014 marked the implementation of the National New-Type Urbanization Plan, and 2017 is the year before the household survey was conducted. The natural logarithm of GDP per capita in 2014 and the percentage of GDP growth from 2014 to 2017 were used to control the variations of local economic development in the analysis.

Length of the township's tenure as an urban administrative unit. We used the length of time since a township was established as a street district to measure the duration of a township classified as urban in the Chinese administrative division system.

Townships in the 2014 Pilot Program. To account for the survey sampling design effects, we controlled whether the townships were located in places participating in the 2014 National New Urbanization Comprehensive Pilot Program in the analysis.

Neighborhood type. At the neighborhood level, we coded the 159 SSUs into four types: urban neighborhoods with no administrative change (n = 9), newly established urban neighborhoods (a new urban residents' committee was established on the sampling site after 2000, n = 29), rural villages converted to urban neighborhoods (the urban residents' committee was converted from the former rural villagers' committee on the sampling site after 2000, n = 11), and rural villages with no administrative reclassification (n = 110).

4.3 Analysis

The dependent variables were overall loneliness, emotional loneliness, and social loneliness. We treated these variables as continuous variables and estimated generalized linear regressions. We

first included individual-level variables in the models; we then added county/township- and neighborhood-level measures. Given the data have a hierarchical structure, we estimated three-level mixed-effects models with random intercepts, allowing each PSU to have its own intercept and each SSU to have its own intercept relative to the PSU in which it is located.

The three-level data structure was defined as follows: $i = 1, ..., n_{jk}$ level-one units (individuals) were nested within $j = 1, ..., n_k$ level-two units (SSUs), which were further nested within $k = 1, ..., n$ level-three units (PSUs). The three-level mixed-effects model was expressed as

$$y_{ijk} = \beta x_{ijk}^T + \gamma_k + \mu_{jk} + \varepsilon_{ijk}.$$

In the equation, y_{ijk} represents the reported loneliness of individual i in SSU j and PSU k. The covariate vector $\boldsymbol{x}_{ijk}$ includes potential explanatory variables at all three levels, and $\boldsymbol{\beta}$ is the corresponding vector of regression coefficients. γ_k represents the random intercept of PSUs; μ_{jk} indicates the random intercept of SSUs; and ε_{ijk} denotes the first-level individual disturbance.

We estimated the three-level mixed-effects models using the "meglm" command in Stata 14.2. The Intraclass Correlation Coefficient (ICC) of each model was calculated. All coefficients were standardized to allow comparison across variables.

5. Results

5.1 Descriptive statistics

The descriptive statistics of survey respondents are reported in Table 1. It is notable that respondents reported a higher level of social loneliness (mean = 2.99) than emotional loneliness (mean = 2.60). Although rural–urban administrative reclassification had taken place at the township or county level, a large majority of respondents (about 84%) still held rural hukou.

Only about 7% held traditional urban hukou, and about 9% had converted to the newly created jumin hukou. More than three-quarters of the respondents resided in self-built housing; about 11% lived in commercial housing; another 11% were in public or resettlement housing; and 3% were staying in temporary housing (shelters or shacks).

According to Table 2 which reports the descriptive statistics of county/township- and neighborhood-level measures, the county population density ranges from 69.90 to 19249.90 per square kilometre and the average length of the township classification as an urban administrative unit was only 5.15 years. In addition, a large proportion (nearly 70%) of rural villages had not been administratively converted to urban neighborhoods; nonetheless, in-situ urbanization had been ongoing in these localities (Ong, 2014; Yep and Forrest, 2016).

5.2 Regression results

The regression results are reported in Table 3. The size of the ICCs in Model 1 was 0.08 and 0.13, suggesting that 8% and 13% of the variance in overall loneliness could be attributed to county/township and neighborhood differences, respectively. As for the measures, according to Model 2, both county population density (standardized coefficient = 0.12, $p < 0.05$) and tenure of the township as an urban unit (standardized coefficient = 0.14, $p < 0.01$) appear to be positively associated with overall loneliness. While respondents residing in counties with higher GDP per capita were less lonely, the association between county GDP growth and overall loneliness was positive. No significant differences were observed across the different neighborhood types. The standardized coefficients on individual-level variables were stable both with and without controls for county/township and neighborhood variables (as shown in Model 1 and Model 2). Membership in the CCP, married status, and greater household wealth were associated with

lower levels of overall loneliness. Holding a professional or managerial job, having more chronic health conditions, and experiencing more life events were associated with higher levels of overall loneliness. Respondents with occasional access to the Internet reported a higher level of overall loneliness than those with no access and those with access every day.

As we continued to compare the regression results on emotional and social loneliness, the ICCs in Model 3 and Model 5 indicate that county/township and neighborhood differences explained more variance in emotional loneliness than in social loneliness (24% vs. 15% in total). The coefficients also followed different patterns: the county/township and neighborhood measures are more prominent for emotional loneliness (Model 4) than for social loneliness (Model 6). In particular, as shown in Model 4, respondents residing in newly established urban neighborhoods (standardized coefficient = 0.68, $p < 0.01$) and rural villages with no reclassification (standardized coefficient = 0.68, $p < 0.001$) reported significantly higher levels of emotional loneliness than those in urban neighborhoods with no change. Respondents in rural villages converted to urban neighborhoods, however, did not show significantly higher levels of emotional loneliness than those in urban neighborhoods with no change. As shown in Model 6, the level of social loneliness did not vary significantly across different neighborhood types.

At the individual level, the positive standardized coefficient on age and the negative standardized coefficient on age-squared, taken together, indicate that the relationship between age and emotional loneliness follows an upward sloping curve (Models 3 and 4), which is consistent with the finding of the existing literature (Courtin and Knapp, 2017; Hawkley and Capitanio, 2015; Luhmann and Hawkley, 2016; Luo et al., 2012). Age, however, is not significantly associated with social loneliness (Model 5 and 6). Marital status had a stronger association with emotional loneliness, whereas household wealth was more strongly associated

with social loneliness. Moreover, respondents residing in temporary housing reported a significantly higher level of social loneliness (standardized coefficient = 0.47, $p < 0.01$). The relationship of loneliness with access to the Internet was also stronger in the case of social loneliness and showed a nonlinear association (standardized coefficient on access somedays = 0.53, $p < 0.001$). Compared to people who have full access or no access to the Internet, those who have limited access reported the highest level of social loneliness.

5.3 Robustness checks

To check the robustness of our results, we coded the three measures of overall, emotional, and social loneliness, following the scale's original coding methods. We recoded answer "1-completely untrue" into 0 and answers 2 to 7 into 1. We calculated the total count of the six items as the alternative measure for overall loneliness (ranging from 0 to 6, mean = 3.28). We used the total counts on the three items for emotional loneliness (ranging from 0 to 3, mean = 1.38) and the three items for social loneliness (ranging from 0 to 3, mean = 1.91) as the alternative measures for emotional and social loneliness, respectively. The alternative measures of loneliness were highly correlated with the continuous measures on the seven-point Likert scale used in our analysis. The Pearson's correction coefficients between the two sets of measures were 0.81, 0.84, and 0.76 for overall, emotional, and social loneliness, respectively.

We further estimated the models as specified in Table 3 on the three alternatively coded measures of loneliness. The patterns of coefficients were similar, but the relationships with the determinants were stronger for the continuous measures of loneliness on the seven-point Likert scale than for the alternatively coded measures. The regression results are available upon request.

6. Discussion

Based on the empirical analysis and results, several key findings and research implications can be highlighted. First, the revised measurements of the 6-item De Jong Gierveld Loneliness Scale appear to have strong relationships with multi-level covariates as well as psychological distress (for regression results on psychological distress, please see Appendix 3). The revised measurements address concerns about the original scale and more accurately reflect the intensity of loneliness. We, therefore, recommend that, where possible, future research should employ the seven-point Likert scale rather than the original three categories of response when measuring loneliness.

Secondly, although often used as a combined measure in the existing literature (De Jong Gierveld and Von Tilburg, 2006; Leung et al., 2008), emotional loneliness and social loneliness show different patterns of association with multi-level covariates. The literature on the relationship between urbanization and loneliness presents contradictory arguments and mixed evidence. Our analyses demonstrate that most measures of urbanization at county, township, and neighborhood levels were significantly associated with emotional loneliness, but not with social loneliness. Given that the context of the study is in-situ urbanization in China, these results may well indicate that the process of urbanization, which is still ongoing in many localities, has had more negative impacts on residents' emotional attachments than on perceived social support. Will the negative effects eventually extend to social loneliness as the process of urbanization continues to unfold? This question deserves further research and policy attention.

Among the measures we used to determine urbanization at the county, township, and neighborhood levels, neighborhood type appears to have the greatest effect on emotional loneliness. Respondents residing in newly established urban neighborhoods were more likely to

live in split and smaller households, far away from their original family and community (Yep and Wu, 2020), and therefore reported a higher level of emotional loneliness. For respondents residing in rural villages with no reclassification, the higher levels of emotional loneliness reported may be due to the fact that family members have left home to pursue work in the cities (Pan and Dong, 2020). These findings have important implications for policy and practice. As the process of rural–urban transition continues in China and residential patterns keep changing, people must maintain some form of continuity with their original community or establish neighborhood ties in their new setting (Yep and Wu, 2020). Although scholars argue that traditional family and village bonds will continue to weaken (Tian, 2010), close family and neighborhood cohesion remain important antidotes to loneliness, particularly emotional loneliness. In addition, as more people live longer and age alone (Klinenberg, 2018), it is essential to find effective approaches to strengthen family ties and neighborhood support during the process of rural–urban transition.

We controlled for variations in local economic development in our analysis. While higher county GDP per capita was associated with lower emotional loneliness, greater county GDP growth did not follow a similar pattern and led to higher emotional loneliness. It may be that, while a higher level of local economic development reduces residents' economic burden and improves emotional attachment, a fast-growing economy might add more pressure, require more adaptations, and create a sense of loneliness (Chen et al., 2015).

Among the effects of the individual and household variables, one noticeable finding is that residence in temporary housing is a significant risk factor for social loneliness. This may be explained by the unstable and often undesirable living conditions associated with temporary housing, as well as the lack of neighborhood cohesion and separation from former social

networks (De Jong Gierveld et al., 2018; Ling, 2020). Although the process of urbanization in China has been commended by scholars because it did not lead to the creation of large-scale slums like those in India and Brazil (Ren, 2018; Wang et al., 2015), there was still a small percentage of residents residing in temporary housing or transitory settlements, which has a detrimental effect on their well-being. This is a finding that should be brought to policy-makers' attention and one that requires practical interventions (Xie and Chen, 2018).

Finally, digital communication (as measured by access to the Internet in our analysis), which has been increasingly identified as a key variable in loneliness research (Lim et al., 2020), was only a significant factor for social loneliness following a nonlinear association. Although access to the Internet was only used as an individual-level control in this study, the results require further investigation. Good use of digital communication could promote social connections (Nowland et al., 2018).

7. Conclusion

Drawing on data from the 2018 Urbanization and Quality of Life Survey, we estimated separate models for emotional loneliness and social loneliness, tested measures related to China's urbanization on multiple levels, and controlled for a number of individual-level attributes. Our research contributes to the broader literature on urbanization and loneliness. Although situated in the specific context of urbanizing China, our findings draw attention to the need for more comparative analyses involving other developing countries and regions undergoing rapid urbanization. These analyses should consider, in particular, the negative impact of population density, tenure of urban status, and certain neighborhood types on emotional loneliness, and the higher level of social loneliness associated with temporary housing.

In addition to demonstrating how urbanization is associated with greater individual loneliness, our study also illustrates how to model locational parameters effectively in analyses of individual outcomes of well-being. We estimated multi-level mixed-effects models, so the endogeneity between individual-level outcome and locational measures is less of an issue in the context of in-situ urbanization in China. Nonetheless, a more comprehensive study would have longitudinal data compiled at multiple levels to confirm causal inferences between locational measures of urbanization and residents' reported loneliness.

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Table 1. Descriptive statistics of survey respondents

Variables	Means or percentages
Overall loneliness (mean, 1-7)	2.79 (0.03)
Emotional loneliness (mean, 1-7)	2.60 (0.04)
Social loneliness (mean, 1-7)	2.99 (0.04)
Age (mean, 18-75)	51.09 (0.45)
Gender (female, %)	48.65
Migration status (cross-town migrant, %)	16.85
Hukou (%)	
Rural hukou	84.40
Urban hukou	6.63
Jumin hukou	8.97
Education (mean, 0-20)	7.12 (0.09)
Occupation (professional/managerial, %)	8.90
CCP membership (%)	6.85
Religion (having a religion, %)	8.20
Marital status (married, %)	79.23
Household size (mean, 1-9)	2.52 (0.03)
Household wealth (mean, 0-7)	2.39 (0.05)
Home ownership (%)	85.66
Housing type (%)	
Self-built housing	75.67
Commercial housing	10.53
Public housing	6.30
Resettlement housing	4.42
Temporary housing	3.08
Chronic health conditions (mean, 0-6)	0.60 (0.02)
Life events (mean, 0-10)	0.64 (0.02)
Access to the Internet (%)	
No access	59.85
Some days	9.72
Everyday	30.43

Notes: N = 3,076. 153 cases with missing data were excluded.
Data were weighted. Means or percentages are reported. Standard errors are in parentheses.

Table 2. Descriptive statistics of county/township and neighborhood level measures

Variables	Means or percentages
Counties/townships (N = 40):	
County population density per km^2 (mean, 69.90-19249.90)	1480.26 (3237.63)
County population density per km^2 (ln, mean, 4.25-9.87)	6.45 (1.15)
County GDP per capita in 2014 (RMB, mean, 8997.79-181370.30)	60047.90 (36946.12)
County GDP per capita in 2014 (ln, mean, 9.10-12.11)	10.81 (0.66)
County GDP growth 2014-2017 (mean, 8.93-46.25)	28.27 (9.32)
Tenure of the township as an urban administrative unit (mean, 0-26)	5.15 (7.48)
Townships in the 2014 Pilot Program (%)	50.00
Neighborhoods (N = 159):	
Neighborhood type (%)	
Urban neighborhoods with no change	5.66
Newly established urban neighborhoods	18.24
Rural villages converted to urban neighborhoods	6.92
Rural villages with no reclassification	69.18

Notes: Means or percentages are reported. Standard deviations are in parentheses.

Table 3. Three-level mixed-effects models on overall, emotional, and social loneliness

	Overall loneliness		Emotional loneliness		Social loneliness	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
County/township-level variables						
County population density per km^2 (ln)		0.12*		0.18*		0.05
		(0.05)		(0.08)		(0.07)
County GDP per capita in 2014 (ln)		-0.20**		-0.42***		0.02
		(0.06)		(0.09)		(0.08)
County GDP growth 2014-2017		0.13*		0.23**		0.03
		(0.05)		(0.07)		(0.06)
Tenure of the township as an urban unit		0.14**		0.12*		0.15*
		(0.05)		(0.05)		(0.06)
Townships in the 2014 Pilot Program		-0.09		-0.17		-0.02
		(0.13)		(0.17)		(0.14)
Neighborhood-level variables						
Urban neighborhoods with no change (ref.)						
Newly established urban neighborhoods		0.29		0.68**		-0.13
		(0.22)		(0.24)		(0.30)
Rural villages converted to urban		0.00		0.34		-0.44
neighborhoods		(0.21)		(0.27)		(0.33)
Rural villages with no reclassification		0.19		0.68***		-0.38
		(0.18)		(0.20)		(0.30)
Individual-level variables						
Age	0.38	0.41	0.75**	0.80**	0.04	0.04
	(0.25)	(0.25)	(0.27)	(0.28)	(0.28)	(0.28)
Age^2	-0.37	-0.39	-0.74**	-0.78**	-0.03	-0.03
	(0.23)	(0.23)	(0.27)	(0.27)	(0.26)	(0.26)
Female	0.00	0.00	0.06	0.06	-0.05	-0.06
	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)
Cross-town migrants	-0.01	-0.03	0.05	0.04	-0.06	-0.12
	(0.13)	(0.13)	(0.17)	(0.17)	(0.23)	(0.23)
Hukou						
Rural hukou (ref.)						
Urban hukou	0.08	0.06	0.08	0.06	0.09	0.05
	(0.10)	(0.10)	(0.15)	(0.16)	(0.20)	(0.20)
Jumin hukou	-0.10	-0.13	-0.08	-0.10	-0.08	-0.16
	(0.11)	(0.11)	(0.15)	(0.16)	(0.15)	(0.17)
Years of schooling	-0.05	-0.05	-0.01	-0.00	-0.08*	-0.09*
	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)
Professional/managerial occupation	0.21*	0.21*	0.20	0.21	0.25	0.24
	(0.09)	(0.09)	(0.15)	(0.15)	(0.15)	(0.15)
CCP member	-0.28**	-0.28**	-0.24	-0.24	-0.31*	-0.30*
	(0.11)	(0.11)	(0.13)	(0.13)	(0.14)	(0.14)
Having a religion	-0.19	-0.20	-0.07	-0.07	-0.31*	-0.33*
	(0.12)	(0.13)	(0.16)	(0.16)	(0.15)	(0.16)
Married	-0.32***	-0.32***	-0.38***	-0.38***	-0.27*	-0.26
	(0.09)	(0.09)	(0.11)	(0.10)	(0.13)	(0.13)
Household size	-0.03	-0.04	-0.06*	-0.06*	-0.01	-0.01
	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)
Household wealth	-0.21***	-0.22***	-0.12*	-0.12**	-0.32***	-0.32***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.06)	(0.06)
Homeowner	-0.29	-0.27	-0.40	-0.39	-0.19	-0.15
	(0.17)	(0.16)	(0.24)	(0.24)	(0.24)	(0.23)
Housing type						
Self-built housing (ref.)						
Commercial housing	-0.25	-0.22	-0.06	0.02	-0.38	-0.46*
	(0.14)	(0.15)	(0.22)	(0.22)	(0.22)	(0.22)
Public housing	-0.16	-0.16	-0.38	-0.35	0.08	0.02
	(0.19)	(0.20)	(0.26)	(0.25)	(0.24)	(0.25)

Resettlement housing	-0.20	-0.21	-0.30	-0.28	-0.06	-0.13
	(0.14)	(0.12)	(0.22)	(0.19)	(0.21)	(0.19)
Temporary housing	0.20	0.21	-0.12	-0.10	0.47**	0.47**
	(0.13)	(0.13)	(0.16)	(0.15)	(0.17)	(0.17)
Chronic health conditions	0.11**	0.11**	0.17***	0.18***	0.03	0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
Life events	0.15***	0.15***	0.17***	0.17***	0.13**	0.13**
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.04)
Access to the Internet						
No access (ref.)						
Some days	0.30**	0.31**	0.10	0.11	0.53***	0.53***
	(0.10)	(0.10)	(0.15)	(0.15)	(0.15)	(0.16)
Everyday	0.03	0.03	-0.06	-0.05	0.10	0.10
	(0.09)	(0.09)	(0.12)	(0.12)	(0.11)	(0.11)
Constants	3.42***	3.29***	3.45***	2.91***	3.41***	3.74***
	(0.21)	(0.30)	(0.28)	(0.37)	(0.28)	(0.50)
Random-effects parameters						
Variance (county/township)	0.12**	0.07*	0.31**	0.17**	0.12	0.07
	(0.04)	(0.03)	(0.10)	(0.06)	(0.07)	(0.06)
Variance (neighborhood | county/township)	0.09***	0.09***	0.07	0.06	0.25***	0.26***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.06)	(0.06)
Intraclass Correlation Coefficient (ICC)						
County/township	0.08	0.05	0.11	0.06	0.04	0.02
Neighborhood | county/township	0.13	0.10	0.14	0.09	0.11	0.10
Observations						
Number of county/townships	40	40	40	40	40	40
Number of neighborhoods	159	159	159	159	159	159
Number of respondents	3,067	3,067	3,067	3,067	3,067	3,067
Log pseudolikelihood	-4948.32	-4940.13	-5759.99	-5747.90	-6052.16	-6046.09

Note: Data were weighted. Standardized coefficients are reported. Robust standard errors are in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Appendix

1. Survey sampling design

The 2018 Urbanization and Quality of Life Survey (N=3,229) targeted residents in 40 primary sampling units (PSUs) including 32 townships (street districts or towns) in newly urbanized areas (they were classified as rural before 2000 and were incorporated into urban districts in prefectural-level or centrally administered municipalities or urban centres of county or county-level cities after 2000) and eight townships (towns or rural townships) that are considered potential sites of urbanization (within a short distance to a prefectural centre). Half of the PSU samples were drawn from the group of townships that took part in the 2014 National New Urbanization Comprehensive Pilot Program (National Development and Reform Commission, 2014). The other half consisted of 20 localities selected from non-pilot areas using the Coarsened Exact Matching (CEM) technique (Iacus et. al., 2011). Because each PSU was located in a different county, county-level city, or urban district, the 40 PSUs were linked to 40 county-level administrative units.

After the 40 PSUs were carefully sampled, we created a detailed geographical information system (GIS) within each PSU that aggregated information at the arc-minute level and generated spatial frames of physical areas for further sample selection. Within each PSU, we randomly selected four secondary sampling units (SSUs) that were half-square minutes (HSMs) of latitude and longitude and approximately the size of a rural village or urban neighborhood. Within each SSU, we selected households to interview. To achieve a confidence level of 95% and an absolute sampling error of no greater than 5%, we sampled a total of 4,949 household addresses. Within each household, one eligible respondent was randomly selected using the Kish grid (Landry and Shen, 2005).

2. Descriptions of variables used in the analysis

Table A1. Descriptions of individual-level measures

Variables	Variable descriptions
Overall loneliness	De Jong Gierveld Loneliness Scale: min=1, max=7
Emotional loneliness	De Jong Gierveld Loneliness Scale: min=1, max=7
Social loneliness	De Jong Gierveld Loneliness Scale: min=1, max=7
Age	Years of age: min=18, max=75
Gender	Dichotomous: 1=female, 0=male
Migration status	Dichotomous: 1=cross-town migrant, 0=non-migrant
Hukou	Categorical: 0=rural hukou, 1=urban hukou, 2=jumin hukou
Education	Years of schooling: min=0, max=20
Occupation	Dichotomous: 1=professional/managerial, 0=other
CCP membership	Dichotomous: 1=Chinese Communist Party (CCP) member, 0=not a CCP member
Religion	Dichotomous: 1=having a religion, 0=no religion
Marital status	Dichotomous: 1=married, 0=other
Household size	Number of people: min=1, max=9
Household wealth	An index based on ownership of a number of consumer items, such as an LCD TV and a car: min=0, max=7
Home ownership	Dichotomous: 1=homeowner, 0=not a homeowner
Housing type	Categorical: 0=self-built housing, 1=commercial housing, 2=public housing, 3=resettlement housing, 4=temporary housing
Chronic health conditions	Number of pain-related, cardiovascular, respiratory, and other chronic disorders: min=0, max=6
Life events	Number of life events experienced by respondent or family members in the past three years: min=0, max=10
Access to the Internet	Categorical: 0=no access, 1=somedays, 2=everyday

Table A2. Descriptions of county/township and neighborhood level measures

Variables	Variable descriptions
County population density per km^2	County population density per square kilometre: min=69.90, max=19249.90
County population density per km^2 (ln)	Natural logarithm of county population density per square kilometer: min=4.25, max=9.87
County GDP per capita in 2014 (RMB)	County GDP per capital in RMB: min=8997.79; max=181370.30
County GDP per capita in 2014 (ln)	Natural logarithm of county GDP per capital in RMB: min=9.10, max=12.11
County GDP growth 2014-2017	Percentage of county GDP growth from 2014 to 2017: min=8.93, max=46.25
Tenure of the township as an urban administrative unit	Years since the township was established as an urban administrative unit: min=0, max=26
Townships in the 2014 Pilot Program	Dichotomous: 1=townships in the 2014 Pilot Program, 0=townships not in the Pilot Program
Neighborhood type	Categorical: 0=urban neighborhoods with no change, 1=newly established urban neighborhoods, 2=rural villages converted to urban neighborhoods, 3=rural villages with no change

3. Regression results on psychological distress

Because loneliness and poorer mental health often coexist, we also estimated the associations of the various measures of loneliness with a mental health outcome (Beutel et al., 2017; Lim et al., 2020). We used the Kessler Psychological Distress Scale (K10) administered in the survey as the dependent variable. The K10 scale is a self-reported questionnaire of ten items that measure the respondents' psychological distress in the previous month. We calculated the sum of the scores on the ten items, ranging from 10 to 50, with higher scores indicating higher levels of psychological distress. The Cronbach's alpha was 0.93 for the study sample. The validity of this measure has been tested in the Chinese context (Chen, 2011; Shen et al., 2005). We estimated three-level mixed-effects generalized linear regression models and controlled for the same set of county/township-, neighborhood-, and individual-level factors specified in Table 3. The standardized coefficients on the six measures of loneliness were reported in Table A. The results indicate that the measures we used by calculating the means of answers on the seven-point Likert scale showed stronger relationships with psychological distress than the alternative measures following the original coding methods.

Table A3. Three-level mixed-effects models on psychological distress: Coefficients on different measures of loneliness

	Kessler Psychological Distress Scale (K10)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Continuous measures of loneliness on the seven-point Likert scale used in the analysis						
Overall loneliness – mean of 6 items	2.25***					
	(0.17)					
Emotional loneliness – mean of 3 items		1.95***				
		(0.21)				
Social loneliness – mean of 3 items			1.25***			
			(0.17)			
Alternative measures of loneliness						
Overall loneliness – count of 6 items				1.75***		
				(0.19)		
Emotional loneliness – count of 3 items					1.84***	
					(0.21)	
Social loneliness – count of 3 items						0.92***
						(0.14)

Notes: Number of survey respondents = 3,061. 168 cases with missing data were excluded.
Three-level mixed-effects generalized linear regression models. The same set of county/township-, neighborhood-, and individual-level variables as specified in Table 3 was controlled in the model estimations.
Data were weighted. Standardized coefficients are reported. Robust standard errors are in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.