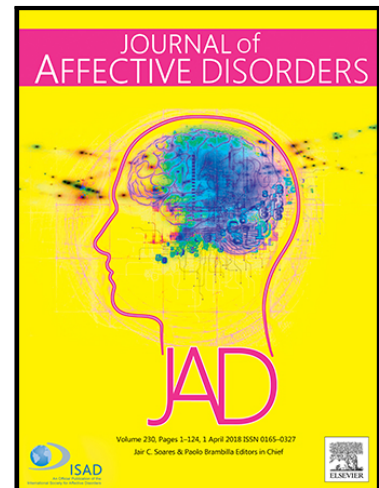


Journal Pre-proof

Urbanization level and neighborhood deprivation, not COVID-19 case numbers by residence area, are associated with severe psychological distress and new-onset suicidal ideation during the COVID-19 pandemic

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Highlights

- Higher urbanization was associated with poor mental health during the pandemic
- Higher neighborhood deprivation was associated with poor mental health
- COVID-19 case numbers by residence area were not associated with poor mental health

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Urbanization level and neighborhood deprivation, not COVID-19 case numbers by residence area, are associated with severe psychological distress and new-onset suicidal ideation during the COVID-19 pandemic

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Abstract

Background: Recent studies indicate an urgent need to take action against mental health issues during the COVID-19 pandemic. However, the association between larger-scale

environmental factors such as living conditions and mental health problems during the pandemic is currently unknown.

Methods: A nationwide, cross-sectional internet survey was conducted in Japan between August and September 2020 to examine the association between urbanization level and neighborhood deprivation as living conditions and COVID-19 case numbers by prefecture. Prevalence ratios (PRs) for severe psychological distress, suicidal ideation, and new-onset suicidal ideation during the pandemic were adjusted for potential confounders.

Results: Among 24,819 responses analyzed, the prevalence of mental health problems was 9.2% for severe psychological distress and 3.6% for new-onset suicidal ideation. PRs for severe psychological distress were significantly associated with higher urbanization level (highest PR = 1.30, 95% CI = 1.08-1.56). PRs for new-onset suicidal ideation were significantly associated with higher urbanization level (highest PR = 1.83, 95% CI = 1.37-2.45) and greater neighborhood deprivation (highest PR = 1.35, 95% CI = 1.06-1.72). Severe psychological distress and new-onset suicidal ideation were significantly more prevalent when there was higher urbanization plus lower neighborhood deprivation (PR = 1.34 [1.15-1.56], and 1.57 [1.22-2.03], respectively).

Conclusion: These findings suggest that it is not the number of COVID-19 cases by residence area but higher urbanization level and greater neighborhood deprivation (lower neighborhood-level socioeconomic status) that are associated with severe psychological distress and new-onset suicidal ideation during the pandemic. These findings differ in part from evidence obtained before the pandemic.

Key words:

Psychological distress, suicidal ideation, deprivation, urbanization level, COVID-19

1. INTRODUCTION

In extensive studies, infectious disease epidemics were reported to affect the mental health of both infected and non-infected individuals. The 1918 influenza pandemic, or “Spanish flu”, is widely considered one of history’s deadliest pandemics. This epidemic was not only directly responsible for approximately 30 million or more deaths worldwide, but it is also thought to have caused an increase in suicidal behavior (Wasserman, 1992). Similarly, a recent review reported that the 2003 SARS epidemic in China and Canada and the 2014 Ebola outbreak in West Africa had a negative impact on mental health (Brooks et al., 2018).

The coronavirus disease (COVID-19) has now spread worldwide. So far, more than 72 million people have been infected, 1.6 million of whom have died, and numbers continue to rise (<https://coronavirus.jhu.edu/>). The COVID-19 pandemic differs from recent epidemics such as SARS, Ebola, and swine flu in that it encompasses the entire world, with only a handful of countries not having reported cases. In most countries, the virus has spread to all regions. Many infected cases are asymptomatic, with more than half of the infected population not knowing how they contracted the virus. These features make COVID-19 extremely hard to defend against. Countless people have undergone some form of quarantine due to "close contact" with someone who has tested positive. Aside from mandatory quarantine, many voluntarily avoid contact with others and practice social distancing, based

on the widespread perception that essentially anyone can be unknowingly infected.

On April 7, 2020, the Japanese government declared a state of emergency in seven major prefectures, including Tokyo, after domestic cases surged to more than 3,000.

Following a further increase in untraceable cases, the declaration was expanded across the nation on April 16, with 13 prefectures designated "special alert zones." As the number of new cases began to fall, the declaration was lifted on May 25 in all regions and restrictions on inter-prefectural travel were lifted on June 19. Despite the easing of restrictions, a series of celebrity suicides since July have focused attention on the issue of suicide. Although the number of suicides temporarily decreased during the state of emergency, it gradually increased again and the number since July is now higher than in the entire previous year; this increasing trend is supported by recent research (Nomura et al., 2020). In addition, there has been a 1.2-fold increase in prevalence of severe psychological distress during the COVID-19 pandemic (Kikuchi et al., 2020). These studies indicate an urgent need to take action against this mental health issues.

Determining what action to take should be based on the findings of research conducted to identify populations vulnerable to mental health problems during the COVID-19 pandemic. Thus far, extensive research has indicated that mental health has worsened during the pandemic among women, young people, people with economic problems, comorbid disease, and past diagnosis of mental health issues (Every-Palmer et al.,

2020; Fountoulakis et al., 2021; Mamun et al., 2021; O'Connor et al., 2020). In line with this research, recent Japanese studies have shown that low income, comorbid respiratory disease (Kikuchi et al., 2020), and younger age are risk factors for negative mental health effects (Ueda et al., 2020). These risk factors include a variety of individual-level characteristics, but, to our knowledge, larger-scale environmental risk factors for mental health problems related to the pandemic have **not** yet to be examined.

To this end, and based on growing evidence about the relationship between environmental factors and mental health (Chen et al., 2020; Choi et al., 2021; Gonzalez-Valderrama et al., 2020; Miura et al., 2020; O'Donoghue et al., 2016; Too et al., 2015), we designed this study to investigate the association between living conditions and mental health during the COVID-19 pandemic, using a large dataset covering all 47 prefectures in Japan.

2. METHODS

2.1. Study design and participants

This cross-sectional study sought to identify populations vulnerable to mental health problems related to the COVID-19 pandemic using data collected by a national representative survey, the JACSIS (Japan “*COVID-19 and Society*” Internet Survey) study. The JACSIS study is described in detail in a preprint article

(<https://www.medrxiv.org/content/10.1101/2020.12.03.20243352v3>). This web-based,

self-reported questionnaire survey was conducted in the summer of 2020 by a large internet survey agency (Rakuten Insight, Inc., Tokyo, Japan; <https://in.m.aipsurveys.com>). The agency had approximately 2.2 million registered panelists in 2019, and its datasets have been used in previous studies (Kiyohara and Tabuchi, 2018; Tabuchi et al., 2019). For the JACSIS study to obtain responses from 28,000 men and women aged 15-79 years across Japan, 224,389 panelists were invited to participate in the survey. They were selected using random sampling stratified by sex, age, and prefecture (covering all 47 prefectures). Web-based informed consent was obtained before the participants responded to the online questionnaire, and they were provided the option to stop the survey at any point. Questionnaire distribution began on August 25, 2020 and ended on September 30, 2020 once the pre-determined target number of respondents for each sex, age, and prefecture category was achieved. The target number was determined from the population distribution in 2019. The response rate was 12.5%.

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975 as revised in 2008. The study protocol was reviewed and approved by the Research Ethics Committee of the Osaka International Cancer Institute (approved June 19, 2020; Approval No. 20084). The internet survey agency respected the Act on the Protection of Personal Information in Japan. As incentive, participants received “Epoints,” which are credit points used for internet shopping

and cash conversion.

2.2. Mental health variable

Severe psychological distress was assessed using the Kessler Psychological Distress Scale (K6) (Kessler et al., 2002). This 6-item scale has been widely used in epidemiological studies to measure psychological distress in general populations. A score of 13 or higher is defined as severe psychological distress (Furukawa et al., 2008; Kessler et al., 2002). Suicidal ideation was assessed by distinguishing between new-onset suicidal ideation during the COVID-19 pandemic (since April 2020) and suicidal ideation at the time of the survey (including both pre-existing suicidal ideation before the pandemic and new-onset suicidal ideation).

2.3. Living condition variables

Urbanization level and neighborhood deprivation have been shown to be directly and interactively associated with mortality (Nakaya et al., 2014). In line with a previous study (Hanibuchi & Nakaya, 2020), we therefore used these two variables of neighborhood-level exposure as living condition variables in this study. Both were created at the zip code level. Japan has 113,107 zip codes, each with as an average population of approximately 1,100 people.

We used the census-based areal deprivation index (ADI) derived from the 2010 Population Census of Japan as an indicator of neighborhood deprivation. Details of this ADI are described elsewhere (Nakaya et al., 2014). This composite indicator comprises weighted sums of poverty-related census variables such as unemployment rate and proportion of elderly couple households, elderly single-occupier households, single mother households, rented houses, sales and service workers, agricultural workers, and blue-collar workers. The larger the ADI score (neighborhood deprivation), the more deprived the neighborhood conditions are.

As a proxy indicator of urbanization level, we also used Densely Inhabited District (DID) data, based on the 2015 Population Census of Japan (https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-A16-v2_3.html). DID is considered to have multiple influences on health, such as overcrowded housing and individualistic lifestyles (i.e., urban penalty) (Hanibuchi & Nakaya, 2020). Any DID without a zip code centroid was classified as non-DID (i.e., rural area) and placed in the lowest category of urbanization level. Any DID with a zip code centroid was classified as DID (i.e., urbanized area) and grouped into tertiles according to population density, corresponding to the second, third, and highest categories of urbanization level.

We also calculated the number of COVID-19 cases by prefecture from January 15, 2020 to September 30, 2020 (<https://gis.jag-japan.com/covid19jp/>) and divided them by the

population per prefecture as estimated on October 1, 2016. Although COVID-19 case numbers (per 100,000 population) were prefecture level, they were used as a proxy indicator of the number of people with COVID-19 in a residence area. In the following analyses, neighborhood deprivation and the number of COVID-19 cases by prefecture were divided by quartile (lowest, second, third, and highest).

2.3. Individual-level variables

Potential confounders were as follows: sex; age group (15-29, 30-44, 45-59, and 60-79 years); income; marital status (married, never married, or widowed/divorced); living alone (yes or no); caring for family member (yes or no); occupation (essential workers in the food industries, healthcare professionals, other workers, or unemployed); education (junior high school graduate, high school graduate, two-year college graduate, bachelor's degree, or master's/doctoral degree), smoking; drinking; major comorbidities; and worsening of employment situation due to COVID-19. Major comorbidities were categorized as any of the following: hypertension; diabetes mellitus; asthma or chronic obstructive pulmonary disease (COPD); cardiovascular disease, cerebrovascular disease; cancer; chronic pain; and psychiatric disorders (Tabuchi et al., 2013).

2.4. Statistical methods

To adjust for differences between respondents to the internet survey and the general population (e.g., younger people are more likely to participate in and respond to such surveys), we used an inverse probability weighting (IPW) method. Weights (propensity scores) were calculated by logistic regression analysis using sex, age, and socioeconomic factors to adjust for differences between respondents of the present internet survey and respondents in a widely used population-based sample that is representative of the Japanese population from the 2016 Comprehensive Survey of Living Conditions of People on Health and Welfare (see Supplementary methods for details).

Proportions of the above-mentioned variables were calculated using the above-mentioned IPW as stratified by three living conditions: urbanization level, neighborhood deprivation, and number of COVID-19 cases by prefecture (lower and higher). To clarify the association of living conditions with severe psychological distress and suicidal ideation, prevalence ratios (PRs) and 95% confidence intervals (CIs) were calculated for severe psychological distress and suicidal ideation using a log-Poisson regression model (Barros and Hirakata, 2003; Spiegelman and Hertzmark, 2005) with IPW based on propensity score. In these analyses, all of the above-mentioned variables except for severe psychological distress and suicidal ideation were entered into the models as independent variables. Statistical significance was set at $p < 0.05$ (two-tailed). All analysis was performed using SAS software version 9.4 (SAS Institute, Cary, NC).

3. RESULTS

Among the 28,000 participants, we used an algorithm that we developed (see Supplementary methods for details) to exclude 2,518 participants who provided unnatural or inconsistent responses as well as 643 participants who provided missing values or inappropriate zip codes. This left us with data from 24,819 (88.6%) survey participants for analysis. Prevalence of mental health problems was 9.2% for severe psychological distress, 12.0% for suicidal ideation, and 3.6% for new suicide ideation during the COVID-19 pandemic (**Table 1**). **Table S1** shows demographic data before weighting.

As shown in **Table 2**, for neighborhood deprivation, we found significantly higher prevalence of suicidal ideation and new-onset suicidal ideation ((PR = 1.20 [1.06-1.37]; 1.35 [1.06-1.72], respectively) at the highest level of neighborhood deprivation. We found an especially significant linear trend in the relationship between neighborhood deprivation and new-onset suicidal ideation ($p = 0.035$). There was no significant association between neighborhood deprivation and severe psychological distress. For urbanization level, we found significantly higher prevalence of severe psychological distress and new onset suicidal ideation (PR = 1.30 [1.08-1.56]; 1.83 [1.35-2.45], respectively) at the highest urbanization level, and a significant linear trend ($p = 0.012$ and $p < 0.001$, respectively). For number of COVID-19 cases by prefecture, we found significantly lower prevalence of severe psychological distress in the third quantile (PR = 0.83 [0.71-0.97]) but no other

significant relationship. **Table S4** shows results for independent variables other than living conditions. The results of sensitivity analyses showed no substantial difference between the trends in the aforementioned results, although we analyzed the three living conditions separately (**Table S5**) and with the number of COVID-19 cases by prefecture removed from the three living conditions (**Table S6**).

In the analysis that grouped regions into four categories by urbanization level and deprivation (lower urbanization level & lower neighborhood deprivation, lower urbanization level & higher neighborhood deprivation, higher urbanization level & lower neighborhood deprivation, and higher urbanization level & higher neighborhood deprivation; **Figure 1**), we found significantly higher prevalence of severe psychological distress and new-onset suicidal ideation in the higher urbanization level & lower neighborhood deprivation (PR = 1.34 [1.15-1.56] and 1.57 [1.22-2.03], respectively).

4. DISCUSSION

This is the first study to examine the association of living conditions with mental health during the COVID-19 pandemic. Even after adjusting for possible individual factors and number of COVID-19 cases by prefecture, we found significant associations of urbanization level with severe psychological distress and suicidal ideation and a significant association of neighborhood deprivation with new-onset suicidal ideation. The prevalence of

severe psychological distress in the aforementioned national representative survey (2016) was 6.7% (Okubo and Tabuchi, 2021), whereas that in the present study increased 1.4-fold to 9.2%. This result indicates a rapid deterioration of mental health due to the COVID-19 epidemic.

People living in an area with higher urbanization had significantly higher prevalence of new-onset suicidal ideation during the COVID-19 pandemic and severe psychological distress (highest category PRs = 1.83 and 1.30, respectively), with a dose-response relationship. Higher urbanization level could have a negative impact on mental health, especially during the COVID-19 pandemic. In contrast to our results for the pandemic, before the pandemic, increased risk of suicide was reported in [rural](#) areas in Italy (Vichi et al., 2020), Germany (Helbich et al., 2017), the United States (Ivey-Stephenson et al., 2017), China (Fei et al., 2019), and Austria (Kapusta et al., 2008). Our findings for before the pandemic showed no significant association between urbanization level and pre-existing suicidal ideation, [which is](#) in good agreement with these studies. Furthermore, we found a consistently negative association between urbanization level and severe psychological distress when neighborhood deprivation was considered simultaneously (Cohen-Cline et al., 2018; Fernandez-Nino et al., 2014; Generaal et al., 2019; Hanibuchi and Nakaya, 2020). Our previous study conducted on 5,000 Japanese in 2015 also showed no significance in the association between urbanization level and severe psychological distress (odds ratio = 0.95 [0.89-1.01]) (Hanibuchi and

Nakaya, 2020).

Urbanization level has been reported to influence health in multiple ways, for example, due to overcrowded housing and individualistic lifestyles (i.e., urban penalty) (Nakaya et al., 2014). Overcrowded housing is likely a major burden during the COVID-19 pandemic. During the pandemic, people have spent dramatically more time at home due to the switch to remote work and school and restrictions against seeing people other than family members. Also, multiple family members might have been forced to work at home in a shared, limited space. Another burden would be noise as more people spend more time at home. Previous studies have reported a link between noise and depression (Generaal et al., 2019). Individualistic urban lifestyles would be another potential burden during the COVID-19 pandemic. In a recent study, cognitive style in interpersonal situations was reported to be a significant mediator in the association between stress related to COVID-19 and suicidal ideation (Crasta et al., 2020). In urban areas, individualistic lifestyles might be maintained even during the pandemic, with possible variation in behaviors such as preventing the spread of infection. Exposure to interpersonal situations with others who think and act differently toward COVID-19 might also have contributed to poor mental health.

People living in an area with higher neighborhood deprivation had significantly higher prevalence of new-onset suicidal ideation during the COVID-19 pandemic (highest quantile PR = 1.35), with a dose-response relationship. The association between

neighborhood deprivation and prevalence of suicidal ideation could be strengthened by the pandemic. New-onset suicidal ideation was more strongly associated with neighborhood deprivation than pre-existing suicidal ideation before the pandemic. Neighborhood deprivation was used as an indicator of neighborhood socioeconomic status (SES). People living in a low SES area tend to have restricted access to all sorts of resources, such as nutritional diversity, an adequate physical environment, health care, and interpersonal relationships (Fernandez-Nino et al., 2014), and they have higher suicide risk even after adjusting for individual income (Helbich et al., 2017; Ngamini Ngui et al., 2015). Due to the COVID-19 pandemic, more people might have been consigned to an environment without access to the material and social necessities of living.

We failed to find a significant association between neighborhood deprivation and severe psychological distress during the COVID-19 pandemic. Before the pandemic, neighborhood deprivation was reported to be significantly related to severe psychological distress in the Netherlands (Generaal et al., 2019), the United States (Cohen-Cline et al., 2018), and Japan (Hanibuchi and Nakaya, 2020). Social participation and interaction have been reported to mediate the protective effect of higher neighborhood-level SES on severe psychological distress (Kim, 2008; Klijs et al., 2016). The pandemic could have drastically reduced these protective effects, with voluntary self-isolation drastically reducing social participation and interaction. Such changes in the social environment due to the COVID-19

pandemic might have influenced our results.

Interestingly, [the](#) prevalence of severe psychological distress and new-onset suicidal ideation was consistently highest among people living in areas with high urbanization plus low neighborhood deprivation (high neighborhood-level SES; PR = 1.57 for new-onset suicidal ideation; PR = 1.34 for severe psychological distress). These results contrast with those of a recent study reporting that COVID-19 infections occurred at particularly high rates in areas of high urbanization plus high neighborhood deprivation (Maroko et al., 2020). In urban and high neighborhood-level SES areas, in addition to overcrowded housing and individualistic lifestyles, the reduced protective effects of social participation and interaction due to the pandemic might have contributed to the deterioration in mental health.

We found no association between number of COVID-19 cases by prefecture or mental health outcomes, although we hypothesized that mental health would be worse in areas with many COVID-19 cases. In the sensitivity analysis, although we removed neighborhood deprivation and urbanization level from the analysis, the results remained almost the same. A recent study in Bangladesh reported that areas with high rates of COVID-19 infection also had higher rates of depression and suicidal ideation (Mamun et al., 2021). The Bangladesh study was conducted in April 2020 during the early phase of the pandemic, which might have contributed to the difference in results. In addition, we used a prefecture-level index. Using more detailed geographical information might show different

results. Although medical resources tend to be concentrated in areas of spreading infection, our results suggest that mental health was deteriorating even in areas without spreading infection. Therefore, mental health measures must be taken even in areas where infection has not spread.

Although the strengths of this study are its assessment of various individual-level factors and living conditions and a large-scale sample ($N = 28,000$) covering every prefecture in Japan, we recognize several limitations. First, the data was obtained from an internet survey and the response rate was relatively low (12.5%). We adjusted as much as possible to account for possible bias in the collected sample by using an external, nationally representative sample (see Supplementary methods). Second, a cross-sectional design cannot clarify the direction of causality. However, the aim of our study was not to clarify direction but to examine the association of living conditions with mental health during the COVID-19 pandemic in order to determine vulnerable populations under this circumstance. Therefore, we do not consider the cross-sectional design of this study to have adversely affected the relevance of our results. Third, the time span for living condition variables were inconsistent: the number of COVID-19 is as of the time of the survey, while DID is based on the 2015 census, and ADI is based on the 2010 census and individual surveys (Nakaya et al., 2014). However, these data were the most recent available at the time of the survey. Although the census is conducted every five years, most recently in 2020, the data will be available starting

in 2022, so the latest available census were 2015 census. For the ADI, its calculation requires detailed census responses across multiple areas to estimate the coefficients. Due to the increase in missing values in the 2015 census, the ADI calculated in the 2010 census was the most recent available. Our results could be undermined by inconsistencies in the time spans of these living condition variables, which will need to be verified with more recent data.

In conclusion, this is the first study to have investigated the association between living conditions and mental health during the COVID-19 pandemic. Even after adjusting for possible individual factors and number of COVID-19 cases by prefecture, we found a significant association between neighborhood deprivation and urbanization level with mental health during the pandemic. Regardless of living in an area with a high number of COVID-19 cases, our results indicate that overcrowded housing, urban individualistic lifestyles, and limited access to material and social necessities in areas of low neighborhood-level SES can increase the risk of mental health problems such as onset of depression and suicide. Furthermore, reduced social participation and interaction in areas with high neighborhood-level SES can also be a risk factor for onset of depression. Our results suggest that public health experts should consider these living conditions as risk factors for mental health issues during the COVID-19 pandemic.

Conflicts of Interest

The authors report no conflicts of interest.

Author Statement

Contributors

Dr. Okubo and Tabuchi significantly contributed to making the protocol of this study. Dr. Okubo and Tabuchi significantly contributed to the data collection. All authors significantly contributed to the interpretation of our data and writing the manuscript.

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REFERENCES

- Barros, A.J., Hirakata, V.N., 2003. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 3, 21.
- Brooks, S.K., Dunn, R., Amlot, R., Rubin, G.J., Greenberg, N., 2018. A Systematic, Thematic Review of Social and Occupational Factors Associated With Psychological Outcomes in Healthcare Employees During an Infectious Disease Outbreak. *J Occup Environ Med* 60, 248–257.
- Chen, H., Xiong, P., Chen, L., Hao, G., 2020. Childhood neighborhood quality, friendship, and risk of depressive symptoms in adults: The China health and retirement longitudinal study. *Journal of affective disorders* 276, 732–737.
- Choi, J.K., Teshome, T., Smith, J., 2021. Neighborhood disadvantage, childhood adversity, bullying victimization, and adolescent depression: A multiple mediational analysis. *Journal of affective disorders* 279, 554–562.
- Cohen-Cline, H., Beresford, S.A.A., Barrington, W.E., Matsueda, R.L., Wakefield, J., Duncan, G.E., 2018. Associations between neighbourhood characteristics and depression: a twin study. *Journal of epidemiology and community health* 72, 202–207.
- Crasta, D., Daks, J.S., Rogge, R.D., 2020. Modeling suicide risk among parents during the COVID-19 pandemic: Psychological inflexibility exacerbates the impact of COVID-19 stressors on interpersonal risk factors for suicide. *J Contextual Behav Sci* 18, 117–127.
- Every-Palmer, S., Jenkins, M., Gerdall, P., Hoek, J., Beaglehole, B., Bell, C., Williman, J., Rapsey, C., Stanley, J., 2020. Psychological distress, anxiety, family violence, suicidality, and wellbeing in New Zealand during the COVID-19 lockdown: A cross-sectional study. *PloS one* 15, e0241658.
- Fei, F., Liu, H., S, I.L., Li, Y., Hu, R., Yu, M., Pan, J., Zhong, J., 2019. Suicide rates in Zhejiang Province, China, from 2006 to 2016: a population-based study. *Journal of epidemiology and community health* 73, 745–749.
- Fernandez-Nino, J.A., Manrique-Espinoza, B.S., Bojorquez-Chapela, I., Salinas-Rodriguez, A., 2014. Income inequality, socioeconomic deprivation and depressive symptoms among older adults in Mexico. *PloS one* 9, e108127.
- Fountoulakis, K.N., Apostolidou, M.K., Atsiova, M.B., Filippidou, A.K., Florou, A.K., Gousiou, D.S., Katsara, A.R., Mantzari, S.N., Padouva-Markoulaki, M., Papatriantafyllou, E.I., Sacharidi, P.I., Tonia, A.I., Tsagalidou, E.G., Zymara, V.P., Prezerakos, P.E., Koupidis, S.A., Fountoulakis, N.K., Chrousos, G.P., 2021. Self-reported changes in anxiety, depression and suicidality during the COVID-19 lockdown in Greece. *Journal of affective disorders* 279, 624–629.
- Furukawa, T.A., Kawakami, N., Saitoh, M., Ono, Y., Nakane, Y., Nakamura, Y., Tachimori, H.,

- Iwata, N., Uda, H., Nakane, H., Watanabe, M., Naganuma, Y., Hata, Y., Kobayashi, M., Miyake, Y., Takeshima, T., Kikkawa, T., 2008. The performance of the Japanese version of the K6 and K10 in the World Mental Health Survey Japan. *Int J Methods Psychiatr Res* 17, 152–158.
- Generaal, E., Timmermans, E. J., Dekkers, J. E. C., Smit, J. H., Penninx, B., 2019. Not urbanization level but socioeconomic, physical and social neighbourhood characteristics are associated with presence and severity of depressive and anxiety disorders. *Psychological medicine* 49, 149–161.
- Gonzalez-Valderrama, A., Jongasma, H. E., Mena, C., Castaneda, C. P., Nachar, R., Undurraga, J., Crossley, N., Aceituno, D., Iruretagoyena, B., Gallardo, C., Mondaca, P., Monje, M., Irarrazaval, M., Zavala, C., Valmaggia, L., Kirkbride, J. B., 2020. The incidence of non-affective psychotic disorders in Chile between 2005 and 2018: results from a national register of over 30 000 cases. *Psychological medicine*, 1–10.
- Hanibuchi, T., Nakaya, T., 2020. Associations of neighborhood socioeconomic conditions with self-rated health, mental distress, and health behaviors: A nationwide cross-sectional study in Japan. *Prev Med Rep* 18, 101075.
- Helbich, M., Plener, P. L., Hartung, S., Bluml, V., 2017. Spatiotemporal Suicide Risk in Germany: A Longitudinal Study 2007–11. *Scientific reports* 7, 7673.
- Ivey-Stephenson, A. Z., Crosby, A. E., Jack, S. P. D., Haileyesus, T., Kresnow-Sedacca, M. J., 2017. Suicide Trends Among and Within Urbanization Levels by Sex, Race/Ethnicity, Age Group, and Mechanism of Death – United States, 2001–2015. *MMWR Surveill Summ* 66, 1–16.
- Kapusta, N. D., Zorman, A., Etzersdorfer, E., Ponocny-Seliger, E., Jandl-Jäger, E., Sonneck, G., 2008. Rural-urban differences in Austrian suicides. *Social psychiatry and psychiatric epidemiology* 43, 311–318.
- Kessler, R. C., Andrews, G., Colpe, L. J., Hiripi, E., Mroczek, D. K., Normand, S. L., Walters, E. E., Zaslavsky, A. M., 2002. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychological medicine* 32, 959–976.
- Kikuchi, H., Machida, M., Nakamura, I., Saito, R., Odagiri, Y., Kojima, T., Watanabe, H., Fukui, K., Inoue, S., 2020. Changes in Psychological Distress During the COVID-19 Pandemic in Japan: A Longitudinal Study. *Journal of epidemiology* 30, 522–528.
- Kim, D., 2008. Blues from the neighborhood? Neighborhood characteristics and depression. *Epidemiol Rev* 30, 101–117.
- Kiyohara, K., Tabuchi, T., 2018. Electronic cigarette use in restaurants and workplaces where combustible tobacco smoking is not allowed: an Internet survey in Japan. *Tob Control* 27, 254–257.
- Klijs, B., Kibele, E. U., Ellwardt, L., Zuidersma, M., Stolk, R. P., Wittek, R. P., Mendes de Leon, C. M., Smidt, N., 2016. Neighborhood income and major depressive disorder in a large Dutch population: results from the LifeLines Cohort study. *BMC public health* 16, 773.
- Mamun, M. A., Sakib, N., Gozal, D., Bhuiyan, A. I., Hossain, S., Bodrud-Doza, M., Al Mamun, F., Hosen, I., Safiq, M. B., Abdullah, A. H., Sarker, M. A., Rayhan, I., Sikder, M. T., Muhit, M., Lin, C. Y., Griffiths, M. D., Pakpour, A. H., 2021. The COVID-19 pandemic and serious psychological

consequences in Bangladesh: A population-based nationwide study. *Journal of affective disorders* 279, 462–472.

Maroko, A.R., Nash, D., Pavilonis, B.T., 2020. COVID-19 and Inequity: a Comparative Spatial Analysis of New York City and Chicago Hot Spots. *J Urban Health* 97, 461–470.

Miura, R., Tani, Y., Fujiwara, T., Kawachi, I., Hanazato, M., Kim, Y., 2020. Multilevel analysis of the impact of neighborhood environment on postpartum depressive symptoms. *Journal of affective disorders* 263, 593–597.

Nakaya, T., Honjo, K., Hanibuchi, T., Ikeda, A., Iso, H., Inoue, M., Sawada, N., Tsugane, S., Japan Public Health Center-based Prospective Study, G., 2014. Associations of all-cause mortality with census-based neighbourhood deprivation and population density in Japan: a multilevel survival analysis. *PloS one* 9, e97802.

Ngamini Ngui, A., Vasiliadis, H.M., Preville, M., 2015. Individual and area-level factors correlated with death by suicide in older adults. *Prev Med* 75, 44–48.

Nomura, S., Kawashima, T., Yoneoka, D., Tanoue, Y., Eguchi, A., Gilmour, S., Kawamura, Y., Harada, N., Hashizume, M., 2020. Trends in suicide in Japan by gender during the COVID-19 pandemic, up to September 2020. *Psychiatry research* 295, 113622.

O'Connor, R.C., Wetherall, K., Cleare, S., McClelland, H., Melson, A.J., Niedzwiedz, C.L., O'Carroll, R.E., O'Connor, D.B., Platt, S., Scowcroft, E., Watson, B., Zortea, T., Ferguson, E., Robb, K.A., 2020. Mental health and well-being during the COVID-19 pandemic: longitudinal analyses of adults in the UK COVID-19 Mental Health & Wellbeing study. *The British journal of psychiatry : the journal of mental science*, 1–8.

O'Donoghue, B., Lyne, J.P., Renwick, L., Lane, A., Madigan, K., Staines, A., O'Callaghan, E., Clarke, M., 2016. Neighbourhood characteristics and the incidence of first-episode psychosis and duration of untreated psychosis. *Psychological medicine* 46, 1367–1378.

Okubo, R., Tabuchi, T., 2021. Smoking and drinking among patients with mental disorders: Evidence from a nationally representative Japanese survey. *Journal of affective disorders* 279, 443–450.

Spiegelman, D., Hertzmark, E., 2005. Easy SAS calculations for risk or prevalence ratios and differences. *American journal of epidemiology* 162, 199–200.

Tabuchi, T., Hoshino, T., Nakayama, T., Ito, Y., Ioka, A., Miyashiro, I., Tsukuma, H., 2013. Does removal of out-of-pocket costs for cervical and breast cancer screening work? A quasi-experimental study to evaluate the impact on attendance, attendance inequality and average cost per uptake of a Japanese government intervention. *International journal of cancer* 133, 972–983.

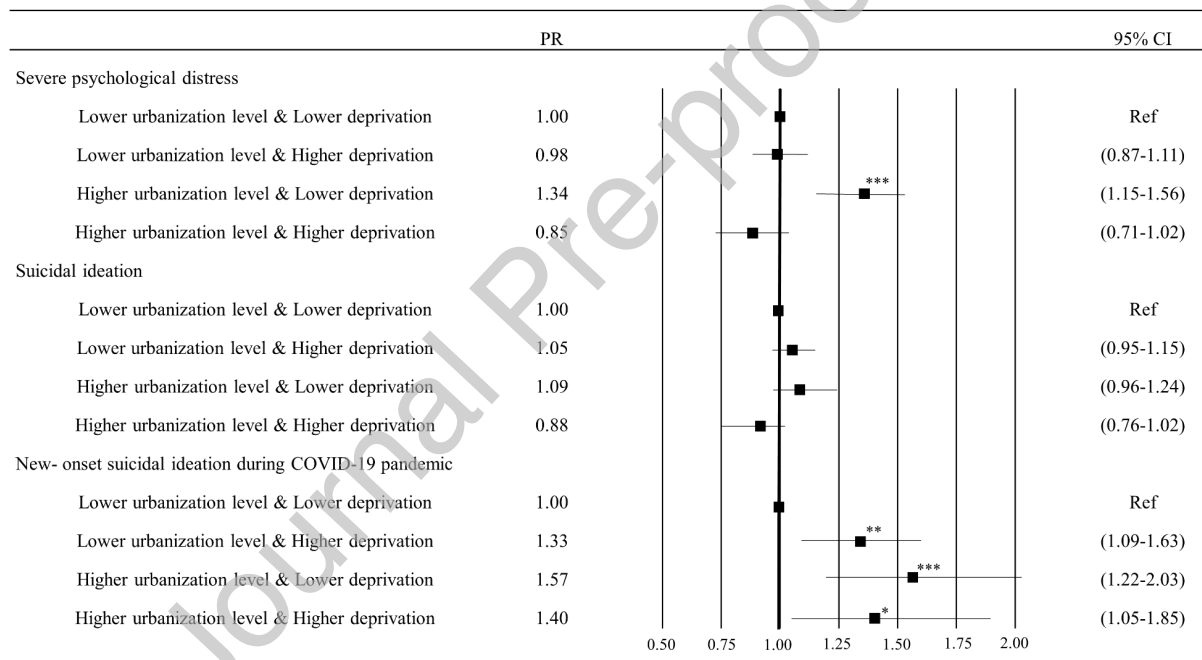
Tabuchi, T., Shinozaki, T., Kunugita, N., Nakamura, M., Tsuji, I., 2019. Study Profile: The Japan "Society and New Tobacco" Internet Survey (JASTIS): A Longitudinal Internet Cohort Study of Heat-Not-Burn Tobacco Products, Electronic Cigarettes, and Conventional Tobacco Products in Japan. *Journal of epidemiology* 29, 444–450.

- Too, L.S., Spittal, M.J., Bugeja, L., Milner, A., Stevenson, M., McClure, R., 2015. An investigation of neighborhood-level social, economic and physical factors for railway suicide in Victoria, Australia. *Journal of affective disorders* 183, 142–148.
- Ueda, M., Stickley, A., Sueki, H., Matsubayashi, T., 2020. Mental health status of the general population in Japan during the COVID-19 pandemic. *Psychiatry and clinical neurosciences*.
- Vichi, M., Vitiello, B., Ghirini, S., Pompili, M., 2020. Does population density moderate suicide risk? An Italian population study over the last 30 years. *European psychiatry : the journal of the Association of European Psychiatrists* 63, e70.
- Wasserman, I.M., 1992. The impact of epidemic, war, prohibition and media on suicide: United States, 1910–1920. *Suicide Life Threat Behav* 22, 240–254.

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FIGURE LEGEND

Figure 1. Prevalence ratios for severe psychological distress and suicidal ideation by living condition using multivariate regression analysis



Lower neighborhood deprivation included Lowest and Second neighborhood deprivation levels. Lower urbanization level included Lowest and Second urbanization levels. PR = Prevalence ratio. aPRs were calculated using all variables in Table 1 other than severe psychological distress and suicidal ideation as independent variables. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ for each PR.

Table 1. Participants' baseline characteristics for analyses (after propensity score weighting)

	Total (<i>N</i> = 24,819)		Urbanization level		Neighborhood deprivation		Number of COVID-19 cases by prefecture	
	<i>N</i>	%	Lower	Higher	Lower	Higher	Lower	Higher
Sex								
Female	12,425	51.1	50.5	52.3	51.6	50.6	51.3	50.6
Age (years)								
15-29	3,845	15.8	13.3	20.9	17.4	14.5	12.4	21.9
30-44	5,815	23.9	25.4	20.8	23.2	24.5	25.8	20.5
45-59	6,732	27.7	29.5	24.0	26.1	28.9	30.1	23.4
60-79	7,941	32.6	31.8	34.4	33.2	32.2	31.8	34.2
Income (million JPY/year)								
less than 1	841	3.5	3.6	3.2	3.2	3.7	3.7	3.1
1 to less than 6	11,160	45.9	46.9	43.7	43.2	48.0	46.9	44.0
6 to less than 120	6,016	24.7	23.6	27.1	26.5	23.3	22.8	28.2
120 or more	1,029	4.2	3.9	4.9	5.9	2.9	3.3	5.9
No response/unknown	5,288	21.7	22.0	21.2	21.3	22.1	23.4	18.8
Marital status								
Never married	5,798	23.8	23.2	25.1	23.6	24.0	23.9	23.7
Married	15,617	64.2	67.0	58.4	63.4	64.8	67.7	57.8
Widowed/divorced	2,917	12.0	9.8	16.5	12.9	11.3	8.4	18.4
Living alone, yes	4,026	16.6	13.1	23.6	18.0	15.4	12.7	23.5

Table 1. Continued

Caring for family members, yes	2,302	9.5	8.0	12.5	10.5	8.7	8.1	11.9
Occupation								
Healthcare professionals	1,155	4.8	4.2	5.8	5.3	4.3	4.4	5.3
Essential workers in the food industries	705	2.9	3.4	1.9	2.4	3.3	3.4	2.0
Other workers	13,215	54.3	54.9	53.0	54.8	53.9	53.4	55.9
Unemployed	9,258	38.1	37.5	39.2	37.6	38.4	38.7	36.8
Educational level								
Junior high school graduate	5,775	23.7	19.1	33.4	26.9	21.3	19.8	30.7
High school graduate	9,439	38.8	44.5	27.1	33.7	42.9	44.1	29.3
Two-year college graduate	4,486	18.4	19.5	16.3	18.0	18.8	20.0	15.7
Bachelor's degree	2,452	10.1	11.0	8.2	8.0	11.7	11.0	8.4
Master's or doctoral degree	2,180	9.0	6.0	15.1	13.4	5.4	5.1	15.9
Use of combustible cigarettes or HTPs								
Neither	19,714	81.0	80.6	82.0	83.0	79.4	80.6	81.8
Only HTPs	2,449	10.1	10.8	8.6	9.2	10.7	10.7	8.9
Only combustible cigarettes	1,172	4.8	4.6	5.2	4.0	5.5	4.5	5.5
Dual use	998	4.1	4.1	4.2	3.8	4.4	4.2	3.9
Alcohol use								
Never	5,303	21.8	21.7	22.0	21.6	22.0	22.0	21.4
Ever	7,838	32.2	32.6	31.3	32.0	32.4	30.9	34.5
Current	11,192	46.0	45.6	46.7	46.4	45.7	47.1	44.1
Comorbidity (present)								
Hypertension	4,933	20.3	20.5	19.7	17.2	22.7	21.7	17.8

Table 1. Continued

Diabetes mellitus	1,852	7.6	7.1	8.7	6.4	8.6	7.2	8.4
Asthma or COPD	1,531	6.3	4.1	10.8	6.9	5.8	4.1	10.3
Cardiovascular disease	896	3.7	2.1	7.0	2.8	4.4	2.1	6.6
Cerebrovascular disease	445	1.8	0.9	3.7	2.0	1.7	0.9	3.5
Cancer	751	3.1	1.8	5.8	3.7	2.6	1.7	5.5
Chronic pain	3,055	12.6	11.9	13.9	12.5	12.6	11.9	13.7
Psychiatric disorders	1,818	7.5	5.4	11.7	7.5	7.5	5.5	10.9
Worsening of employment situation due to COVID-19, yes	4,674	19.2	17.5	22.8	20.7	18.0	17.4	22.5
Severe psychological distress	2,237	9.2	7.3	13.2	10.7	8.0	7.5	12.3
Suicidal ideation	2,925	12.0	11.1	14.0	12.4	11.8	11.2	13.6
New-onset suicidal ideation during the COVID-19 pandemic	867	3.6	2.9	4.9	4.0	3.2	3.1	4.4

Analyses were weighted to adjust the difference between participants in this internet survey and national representative samples. Due to weighting, the sum of participants does not necessarily equal the number of total participants. Numbers except those for *N* are percentages (%).

Table 2. Prevalence ratios for severe psychological distress and suicidal ideation by living condition using multivariate regression analysis

	Severe psychological distress			Suicidal ideation			New- onset suicidal ideation during COVID-19 pandemic		
	PR ^a	95% CI	trend <i>p</i>	PR ^a	95% CI	trend <i>p</i>	PR ^a	95% CI	trend <i>p</i>
Neighborhood deprivation									
Lowest	1.00	Ref	0.003	1.00	Ref	0.230	1.00	Ref	0.027
Second	1.13	(0.98-1.30)		1.33 ***	(1.18-1.51)		1.30 *	(1.03-1.65)	
Third	0.93	(0.80-1.07)		1.10	(0.97-1.25)		1.34 *	(1.05-1.69)	
Highest	0.87	(0.75-1.00)		1.20 **	(1.06-1.37)		1.35 *	(1.06-1.72)	
Urbanization level									
Lowest	1.00	Ref	0.012	1.00	Ref	0.796	1.00	Ref	<0.001
Second	1.00	(0.89-1.13)		0.96	(0.87-1.05)		1.13	(0.94-1.37)	
Third	1.04	(0.90-1.20)		0.92	(0.81-1.04)		1.21	(0.95-1.53)	
Highest	1.30 **	(1.08-1.56)		1.04	(0.89-1.22)		1.83 ***	(1.37-2.45)	
Number of COVID-19 cases by prefecture									
Lowest	1.00	Ref	0.236	1.00	Ref	0.259	1.00	Ref	0.162
Second	0.92	(0.82-1.05)		0.96	(0.86-1.06)		1.05	(0.87-1.28)	
Third	0.83 *	(0.71-0.97)		0.93	(0.81-1.06)		0.79	(0.60-1.03)	
Highest	0.91	(0.77-1.08)		0.92	(0.80-1.05)		0.82	(0.63-1.08)	

PR = prevalence ratio. ^aPRs were calculated using all variables in Table 1 other than severe psychological distress and suicidal ideation as independent variables. These three living condition variables were simultaneously included in this model.

****p* < 0.001, ***p* < 0.01, **p* < 0.05 for each PR.