Exploring characteristics of increased suicide during the COVID-19 pandemic in Japan using provisional governmental data

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Summary

Background The Japanese age-standardised death rate of suicide (SDR) had decreased during 2009−2019, but increased in 2020−2021, during the COVID-19 pandemic.

Methods This study aimed to explain the trend change in the SDR during the pandemic, disaggregated by prefecture, gender, suicide method and household, as compared to predicted SDR derived from pre-pandemic data, using linear mixed-effect and hierarchical linear regression models with robust standard error analyses.

Findings The SDR was lower during March−June 2020 (during the first wave of the pandemic), but higher during July−December 2020 than the predicted SDR. In 2021, males' SDR was nearly equal to the predicted SDR, whereas females' SDR in the metropolitan-region (17.5%: 95% confidence interval: 13.9−21.2%) and non-metropolitan-region (24.7%: 95% confidence interval: 22.8−26.7%) continued to be higher than the predicted SDR. These gender- and region-dependent temporal fluctuations of SDR were synchronised with those of SDRs caused by hanging, at home and single-person-households. Additionally, the rising number of infected patients with the SARS-CoV-2 and polymerase chain reaction (PCR) diagnostic examinations were positively ($\beta = 0.024$) and negatively ($\beta = -0.002$) related to the SDR during the pandemic, respectively.

Interpretation Japanese suicide statistics have previously established that the predominant method and place of suicide were by hanging and at the individual's home, respectively. The present findings suggest that transformed lifestyles during the pandemic, increasing time spent at home, enhanced the suicide risk of Japanese people by hanging and at home.

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Keywords: Suicide mortality; COVID-19; Japan; Prefecture; Gender

Introduction

Globally, the coronavirus (SARS-CoV-2) disease 2019 (COVID-19) pandemic has deleteriously affected public health, impacting individuals' daily living, psychosocial well-being, and socioeconomic status. In some countries, the pandemic's predominant impact has been illustrated in the number of deaths caused by COVID-19.[1] In contrast, for other countries, including Japan, the number of patients who are infected by the SARS-CoV-2 and die from COVID-19 has been fewer, and the associated public health effects likely stem from the adverse psychosocial consequences from the various social restrictions implemented for COVID-19 prevention along with anxiety regarding SARS-CoV-2 infection and/or death.[2,3] During the initial stage of the pandemic, many reports speculated about the possibility of increased suicides, based on an increase in established risk factors of suicide, such as increased unemployment rates and mental health deterioration.[2,3] It has been concerning that social distance requirements, stay-at-home orders, lockdown (designed to prevent the spread of

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Abbreviations: SDR, age-standardised death rate of suicide

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Research in context

Evidence before this study

At the initial stage of the COVID-19 pandemic, the fields of psychiatry and psychology suggested that the accompanying COVID-19 pandemic itself, social restrictions for infection prevention and transformations in lifestyle adversely affect psychosocial functioning and socioeconomic status, contributing to increased suicides. However, suicide mortality in most countries/regions did not increase during the early pandemic or in 2020. In contrast, Japan experienced an increase in suicides during the pandemic, while it had decreasing suicide rates over the decade before the pandemic.

Added value of this study

This study reports the first national-level suicide mortality rates in Japan disaggregated by prefecture, gender, suicide method and household characteristics between 2020 and 2021 using the panel data analysis method and the Japanese government's suicide database: Basic Data on Suicide in the Region (BDSR). Suicide mortality was lower during April—May 2020, but was higher during July—December 2020 compared to predicted suicide mortality. In 2021, the increasing trend in female suicide mortality continued to be higher than predicted suicide mortality. In contrast, males' SDR in the metropolitan-region returned to being nearly equal to the predicted suicide mortality level, but the increasing trends continued for those in the non-metropolitan region. Notably, increases in suicide by hanging and suicide at home accounted for most of the increased suicide mortality in Japan between 2020 and 2021.

Implications of all the available evidence

The present findings suggest that, contrary to international evidence showing that suicide mortality did not increase during the pandemic, in Japan, suicide mortality did increase. This is possibly due to the transformed lifestyle of individuals, such as increasing time spent at home. Even if the rise in suicide mortality in Japan was an exception internationally, differences in the fluctuation of suicide mortality in Japan between 2020 and 2021 suggest that even in other countries, the continued impacts of the pandemic and associated transformations in lifestyle might have increased suicides through deteriorating psychosocial functioning and/or socioeconomic status.

COVID-19), or transformation of individuals' lifestyles at the individuals' discretion[4] led to isolation from the community, resulting in deterioration of mental health.[2,3] To illustrate, the increasing prevalence of major depressive and anxiety disorders in 2020 was positively related to the degree of pandemic seriousness in 204 countries[5]; however, contrary to expectations, most studies from numerous countries reported that suicide mortality in 2020 did not increase, with the exceptions of Japan, India, Puerto Rico and Vienna (in Austria).[6–13]

In Japan, the number of patients infected by SARS-CoV-2 and dying from COVID-19 has been relatively few, and social restriction policies were milder than in the UK (https://www.gov.uk/government/news/coronavirus-COVID-19-what-has-changed-9-september), since deviating from the stay-at-home order had no legal penalties.[14] However, although suicide numbers in Japan consistently decreased from 2009 to 2019 (from 32,845 to 20,169), the suicide numbers increased in 2020 (21,081)[13] compared to 2019. The increased suicides in Japan in 2020 comprised mainly suicides among females (from 6,091 to 7,026; Supplementary Table 1), while male suicides declined marginally compared to 2019 (from 14,078 to 14,055).[13] During the first wave of the pandemic (between March and June 2020), suicides decreased,[12,13] whereas, during the second half of 2020, they increased with the highest excess in October 2020 (in females more than males).[11–13] Copycat suicide[15] was considered to play important roles in the drastic/transient increasing female suicides in October 2020[11]; however, the drastic/transient increasing suicides observed in the second half of 2020, diminished thereafter but increasing trends persisted during the first half of 2021.[13] Considering these findings, the mechanisms of increased suicides in Japan during the pandemic may have involved complex factors, such as region, gender, age, and pandemic duration.[13]

Notably, suicides by hanging for males and females during the second half of 2020 increased, whereas the annual suicide numbers induced by other methods, such as poisoning, charcoal-burning, throwing (e.g., in front of a moving car/train), and jumping (e.g., from a high-rise) did not increase.[13] Hanging has traditionally been the most frequent suicide method in Japan.[16,17] The most common location of suicide by hanging was at the individual's home.[16,17] Moreover, suicide by charcoal-burning is also more likely to occur in (single-person) households compared to other methods.[18] Additionally, pandemic duration was positively related to suicide mortality.[13] To illustrate, during the Spanish flu pandemic, suicide mortality in Taiwan, where people were advised to maintain a physical distance from individuals with influenza by the Japanese Colonial Government, was no higher than the predicted suicide mortality during the first wave (between October and December 1918) but significantly increased during the second wave (between January and March 1920).[19] However, whether the increasing suicide mortality of females by hanging was a specific feature of 2020 or persisted in 2021 remains to be clarified. Therefore, we had no hypotheses related the other analyses but sought to characterise suicide rates by gender, prefecture, suicide means and household condition. To this end, the present study, first, determined the age-standardised suicide death rate (SDR) disaggregated by region, gender, household, suicide method and place of death during the pandemic (between January 2020 and December 2021) compared to the predicted SDR and, second, determined the fixed-effects of factors associated with COVID-19 on SDRs.

Methods

Data sources

The annual and monthly prefectural numbers of suicides disaggregated by age (younger than 20, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and older than 80), gender, household (single- and multiple-person household residents), and suicide method (hanging; ICD-X70, throwing: ICD-X81, jumping: ICD-X80, poisoning: ICD-X60, and charcoal-burning) and place of death were obtained from the Basic Data on Suicide in the Region (BDSR) database in the Ministry of Health, Labour, and Welfare (MHLW).[20] The suicide method of 'throwing' is categorised by lying down or throwing oneself in the path of a fast-moving vehicle, either on the road or onto railway tracks.[20] The data of the monthly number of suicides in the BDSR until December 2020 was final accounting; however, as of March 2022, the records on the annual number of suicides in 2021 was final accounting, but the monthly suicide cases remain provisional accounting. In 2021, the final annual total number of suicides in the BDSR and the monthly numbers of suicides in the provisional data were 21,007 and 20,984, respectively (the difference was about 0.1%) (Supplementary Table 1). Although the final data of annual suicides is defined in the identification of death caused by suicide alone, the final data of monthly suicides in the BDSR requires several investigations to identify the date, method and motive for suicide. Therefore, the publication of the final data of monthly suicides in the BDSR may be delayed, since it is difficult to confirm monthly compared to annual suicides.

Prefectural populations disaggregated by gender (males and females) and age (younger than 20, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and older than 80) were obtained from the Regional Statistics Database (RSD) of the System of Social and Demographic Statistics of the Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC).[21] Standardised infection rates of SARS-CoV-2 (per 1,000,000; SR-AC), standardised mortality caused by COVID-19 (per 100,000; SM-C) and standardised numbers of COVID-19 polymerase chain reaction examination rates (per 1,000,000; PCR-N) were obtained from the Database of the National Institute of Infectious Diseases (NIID)[22] and Sapporo Medical University School of Medicine[23] (Supplementary Figure 1).

Age-standardised suicide death rates

The BDSR provides monthly suicide numbers; however, to correct the variation in the number of days per month (28–31 days), monthly suicide numbers were converted into annual values (per 365 days). Prefectural crude suicide rates disaggregated by gender and age were calculated by dividing the monthly suicide numbers by the prefecture population in the same year. Prefectural crude suicide rates disaggregated by gender and age were calculated using the empirical Bayes standardised mobile ratio method with the empirical Bayes estimator for the Poisson/gamma model (ver 2.1; National Institute of Public Health, Wako, Japan; https://www.niph.go.jp/soshiki/gijutsu/download/ebpoig/index_j.html; accessed 1 January 2022) to eliminate artefacts induced by small prefectural populations (Supplementary Table 1). The age-standardised suicide death rates for males, females, and the total population per 100,000 population (SDR) were calculated based on the 2019 Japanese age-dependent population composition for males and females. This was done in this way because the age distributions between the WHO standard population and Japan models differ.[24,25]

Traditionally, Japanese suicide mortality in urban regions has been lower than in rural regions.[13,24,25] However, there have been more COVID-19 cases in urban than in rural regions.[13] Indeed, the first government stay-at-home order (between April and May 2020) included the major metropolitan regions of Japan, such as the Capital area (Tokyo-to, Saitama-ken, Chiba-ken, and Kanagawa-ken), Kansai area (Osaka-fu, Kyoto-fu, and Hyogo-ken), Chukyo area (Aichi-ken), Fukuoka area (Fukuoka-ken), and Sapporo area (Hokkaido). Based on these regional characteristics of SDRs and COVID-19, to identify the regional features of SDRs, the rates were disaggregated by regions between the metropolitan-region (Hokkaido, Tokyo, Saitama, Chiba, Kanagawa, Aichi, Kyoto, Osaka, Hyogo, and Fukuoka) and non-metropolitan-region (Supplementary Table 1).

Data analysis

The predicted SDR values during 2020–2021 were calculated using time series models as control data, since there are no actual control data, as noted.[26] The method and process are described in the Supplementary Material and Supplementary Figs. 2 and 3.

Prefectural monthly SDRs between predicted and observed SDRs between January 2020 and December 2021 were compared via a linear mixed-effect model using SPSS for Windows version 27 (IBM, Armonk, NY, USA). When the data did not violate the assumption of sphericity ($p > 0{\cdot}05$), the *F*-value of the linear mixed-effect model was analysed using sphericity-assumed degrees of freedom, whereas if the assumption of sphericity was violated ($p < 0{\cdot}05$), the F-value was analysed using Greenhouse and Geisser's corrected degrees of freedom. When the F-value was significant ($p < 0.05$), data (monthly factor and annual factor) were analysed using Scheffé's post-hoc analysis.

To explore the impact of COVID-19, such as incidence (SR-AC), mortality (SM-C), and laboratory diagnosis (PCR-N), on monthly SDRs during the pandemic (between April 2020 and December 2021), the fixed-effects of SR-AC, SM-C and PCR-N on monthly SDRs disaggregated by region, and gender were analysed by fixed-effects of a hierarchical linear regression model with robust standard error using gretl v2021d (http://gretl.sourceforge.net/)(accessed on 28 December 2021). Fixed-effects models can control for unobserved time-invariant factors, such as culture, climate, economic and educational situation, etc., that may affect the regional incidence or mortality caused by COVID-19, resulting in an effect on regional suicide mortality each month. Following panel data applications,[27,28] the regression model was: SDR = $\gamma_{00} + \sum_{i=1}^{n}((\gamma_{10*n}$*(COVID-19)ij + γ_{10*n+1}* (centred_COVID-19)$_j$* (COVID-19) ij + u_{oj} + r_{ij} (residual), where (COVID-19)$_i$ was the value of SR-AC, SM-C, and PCR-N. Fixed effects were applied to the hierarchical linear regression analysis when the Hausman test indicated statistical significance ($p < 0.05$).

The missing data were limited in the suicide data disaggregated by method and represented less than 3% of all monthly suicide data. Therefore, the missing data were excluded in the analysis using the linear mixed-effects model.

Role of the funding source

The funding source of this study helped to define the research questions and assisted with interpretation, but had no role in model development, parameterisation or methodological aspects of the study.

Results

The joinpoint of SDR for males (slopes: -5.60 and -1.73 during 2010–2017 and 2017–2019, respectively) and females (slopes: -5.61 and -3.91 during 2010–2017 and 2017–2019, respectively) was detected in 2017 (Supplementary Figure 2). According to these results, predicted SDRs were calculated from observed SDRs between January 2017 and December 2019.

Suicide mortality disaggregated by gender and region

In 2020, during the first wave of COVID-19 (between March and June 2020) in Japan, all observed monthly SDRs, except the female SDRs, in metropolitan-region were lower than predicted SDRs (95% confidence interval (95%CI)) of SDRs of males+females in the metropolitan-region and non-metropolitan-region were: -0.1—-15.0% and -4.4—-16.8%, respectively. Male SDRs in the metropolitan-region and non-metropolitan -region were: -0.7—-14.6% and -0.1—-15.6%, respectively. Female SDR in the non-metropolitan-region was -5.4—-23.2%) (Figure 1). In contrast, during the second half of 2020, all monthly SDRs were higher than predicted SDRs (95% CI of males+females in the metropolitan-region and non-metropolitan -region were: 7.0—44.1% and 2.3—26.7%, respectively. Male SDRs in the metropolitan region and non-metropolitan regions were 2.9—19.7% and 0.5—13.2%, respectively. Female SDRs in the metropolitan and non-metropolitan regions were 12.2—108.1% and 3.3—86.2%, respectively) (Figure 1). In 2021, observed monthly female SDRs were continuously higher in the metropolitan-region (8.3—48.0%) and non-metropolitan-region (6.6—44.6%) (Figure 1). The observed monthly male SDRs was higher than the predicted SDRs in the non-metropolitan -region (7.7—12.6%). Comparatively, the monthly SDR in the metropolitan-region was nearly equal during the first half of 2021 but lower during the second half (-24.7—-0.1%) than the predicted SDRs (Figure 1).

In 2020, the observed annual SDRs of males +females and females in both regions were higher than the predicted SDRs (95%CI of SDRs of males+females in metropolitan-region and non-metropolitan-region were: 5.0—10.1% and 2.5—4.7%, respectively. Female SDR in the metropolitan-region and non-metropolitan-region were 13.1—24.1% and 13.9—21.2%, respectively) (Figure 1 and Supplementary Figure 4-4). The observed annual SDRs of males in the non-metropolitan-region was lower (-0.1—-2.1%), whereas that in the metropolitan-region was nearly equal to the predicted SDRs (Figure 1). In 2021, the observed annual SDRs of females in both regions were higher than the predicted SDRs (metropolitan-region: 14.5—19.8%, non-metropolitan-region: 22.8—26.7%) (Figure 1 and Supplementary Figure 4-4). The observed male SDRs in the non-metropolitan-region was slightly higher (0.2—2.7%) and lower in the metropolitan-region (-2.7—-8.6%) than the predicted SDRs (Figure 1 and Supplementary Figure 4-4).

See Supplementary Figure 4—1 for the differences among subgroups disaggregated by gender, region, and year of relative observed SDR rates per predicted SDR.

Suicide mortality disaggregated by suicide method and suicide at home

In 2020, during the first wave, the observed monthly SDRs by hanging of males and females in the metropolitan-region were nearly equal to the predicted SDRs, whereas the observed monthly SDRs by hanging of males (-0.4—-11.2%) and females (-7.9—-17.9%) in the non-metropolitan-region were lower than the predicted SDRs (Figures 2 and 3). In contrast, during the second half of 2020, all monthly SDRs by hanging were higher than the predicted SDRs (95%CI of males in the metropolitan-region and non-metropolitan-region were: 10.4

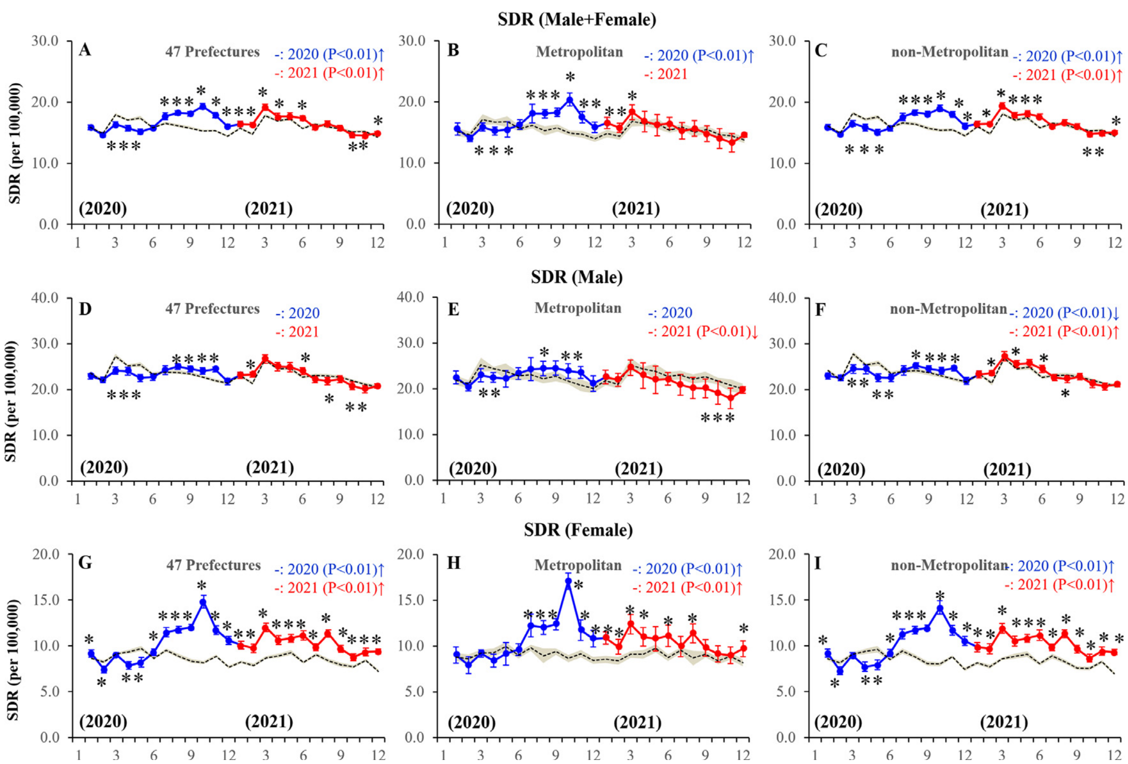

Figure 1. Fluctuations of monthly SDR during COVID-19 pandemic (2020−2021) of males+females (A,B,C), males (D,E,F) and females (G,H,I) compared to the predicted SDRs in the 47 prefectures (A,D,G), Metropolitan-region (B,E,H) and non-Metropolitan-region (C,F, I). Dotted, blue and red lines indicate the average of predicted SDR, observed SDR in 2020 and 2021, respectively. Brown areas, blue and red bars indicate the 95% confidence intervals (CI) of predicted SDR, observed SDR in 2020 and 2021, respectively. Ordinates indicate the SDR (per 100,000 people), and abscissas indicate the month. * $p < 0.05$, significant change of monthly SDR compared to predicted SDR using a linear mixed-effects model with Scheffe's post-hoc test. ↑and↓indicate increasing and decreasing annual SDRs compared to predicted SDRs, respectively.

−41.5% and 9.8−31.2%, respectively. Female SDRs in the metropolitan-region and non-metropolitan-region were: 30.7−181.3% and 28.0−142.0%, respectively) (Figures 2 and 3). In 2021, the observed monthly SDRs by hanging of males in the non-metropolitan region (10.5−13.3%) and females in both regions (metropolitan-region: 9.2−67.4%, non-metropolitan-region: 13.6 −60.4%) were higher than the predicted SDRs throughout 2021. Comparatively, the observed males' SDRs by hanging in the metropolitan-region was nearly equal to the predicted SDRs (Figures 2 and 3).

In 2020, the observed annual hanging SDRs of males were higher than the predicted SDRs in the metropolitan-region (3.6−9.6%) and non-metropolitan-region (7.3−10.4%); those of females were also higher in the metropolitan-region (30.4−48.2%) and non-metropolitan-region (29.8−37.5%) (Figures 2 and 3). In 2021, the observed annual SDRs by hanging for females were higher in the metropolitan-region (32.0−41.75%) and non-metropolitan-region (33.6−38.1%); that of males in the metropolitan region was higher (10.5 −13.3%), while that in the non-metropolitan-region was nearly equal to the predicted SDRs (Figures 2 and 3).

Unexpectedly, in 2020, the observed annual charcoal-burning SDRs of males were lower than the predicted SDRs in the metropolitan-region (-3.9−-17.6%) and non-metropolitan-region (-5.7−-12.4%), whereas, in 2021, those in the metropolitan region was nearly equal to, but higher, than the predicted SDRs in the non-metropolitan region (6.6−13.7%) (Figure 2). In contrast, in 2020, the observed female annual charcoal-burning SDRs were almost equal to the predicted SDRs in both regions (Figure 3). In 2021, the observed annual female charcoal-burning SDRs in the metropolitan-region and non-metropolitan-region were nearly equal to, but higher, than the predicted SDRs (9.4−21.5%), respectively (Figure 3).

In 2020, during the first wave, the observed monthly SDRs at home of males and females in the metropolitan region were nearly equal to the predicted SDRs, whereas the observed monthly SDRs at home of males (-1.0 −-17.4%) and females (-6.2−-29.5%) in the non-metropolitan-region were lower than the predicted SDRs (Figures 2 and 3). In contrast, during the second half of 2020, all monthly SDRs at home were higher than the predicted SDRs (95%CI of males in the metropolitan-region and non-metropolitan-region were: 10.1−52.4%

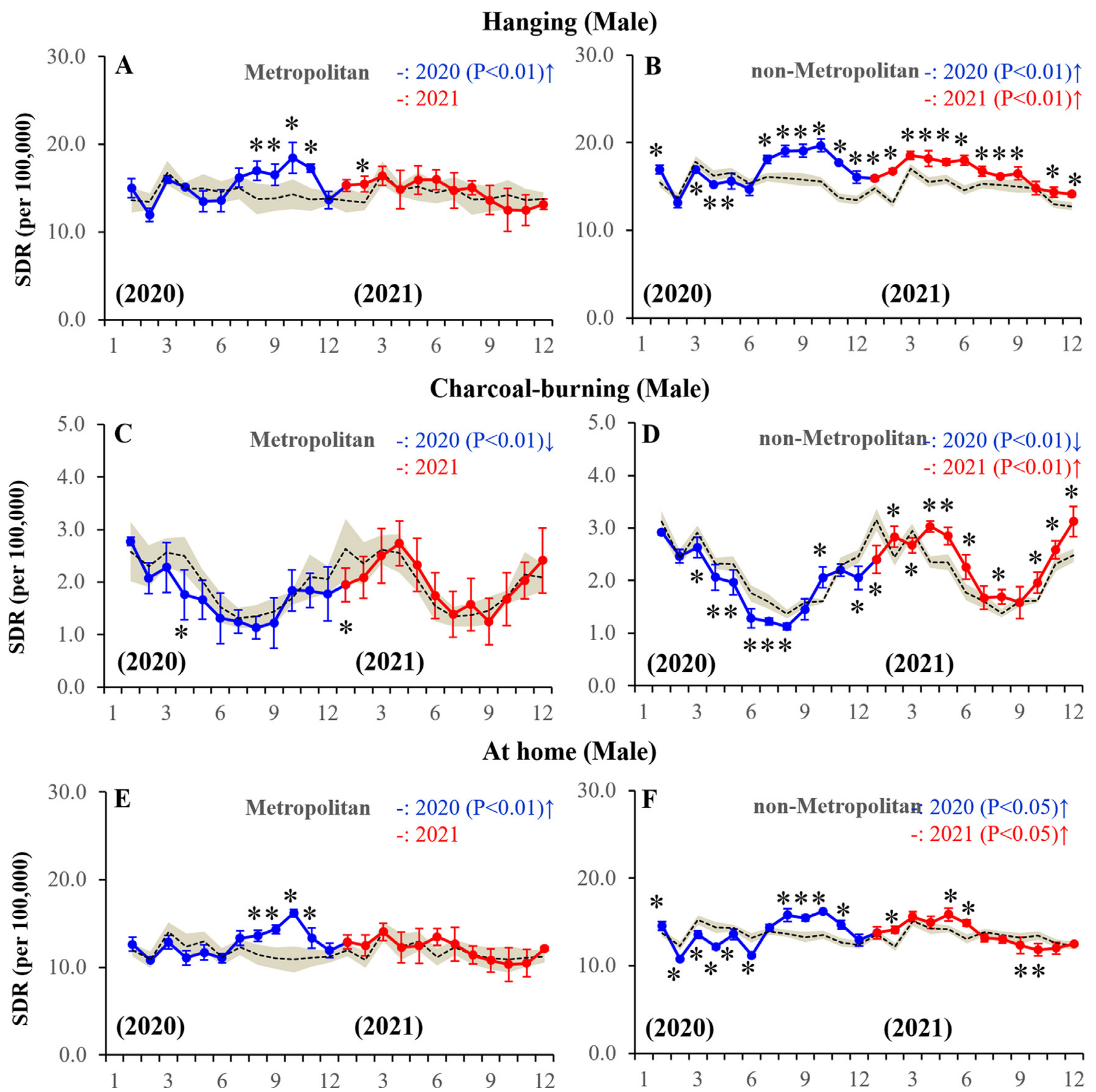

Figure 2. Fluctuations of monthly hanging-SDR (A,B), charcoal-burning SDR (C,D) and SDR at home (E,F) of males during COVID-19 pandemic compared to the predicted SDRs in Metropolitan- (A,C,E) and non-Metropolitan- (B,D,F) regions. Dotted, blue and red lines indicate the average of predicted SDR, observed SDR in 2020 and 2021, respectively. Brown areas, blue and red bats indicate the 95% confidence intervals of predicted SDR, observed SDR in 2020 and 2021, respectively. Ordinates indicate the SDR (per 100,000 people), and abscissas indicate the month. * $p < 0.05$, significant change of monthly SDR compared to predicted SDR using a linear mixed-effects model with Scheffe's post-hoc test. ↑and↓indicate increasing and decreasing annual SDRs compared to predicted SDRs, respectively.

and 10.3–20.6%, respectively. Female SDRs in the metropolitan-region and non-metropolitan-region were: 18.6–146.0% and 7.5–97.6%, respectively) (Figures 2 and 3). In 2021, the observed monthly female SDRs at home in both regions (metropolitan region: 7.2–61.2%, non-metropolitan region: 5.3–39.1%) were higher than the predicted SDRs throughout 2021 (Figure 3). The observed male SDRs at home in the metropolitan-region was nearly equal to the predicted SDRs throughout 2021, whereas that in the non-metropolitan region was higher (6.6–19.2%) and lower (-0.7–17.1%) during the first and second halves of 2021, respectively (Figure 2).

In 2020, all observed annual SDRs at home of males and females were higher than the predicted SDRs (males in metropolitan regions: 5.2–10.9% and in non-metropolitan regions: 0.2–3.2%, females in metropolitan regions: 18.2–32.8% and in non-metropolitan regions: 10.4–16.7%). In 2021, the observed annual female SDRs at home were higher than the predicted SDRs in metropolitan-region (18.1–27.0%) and non-

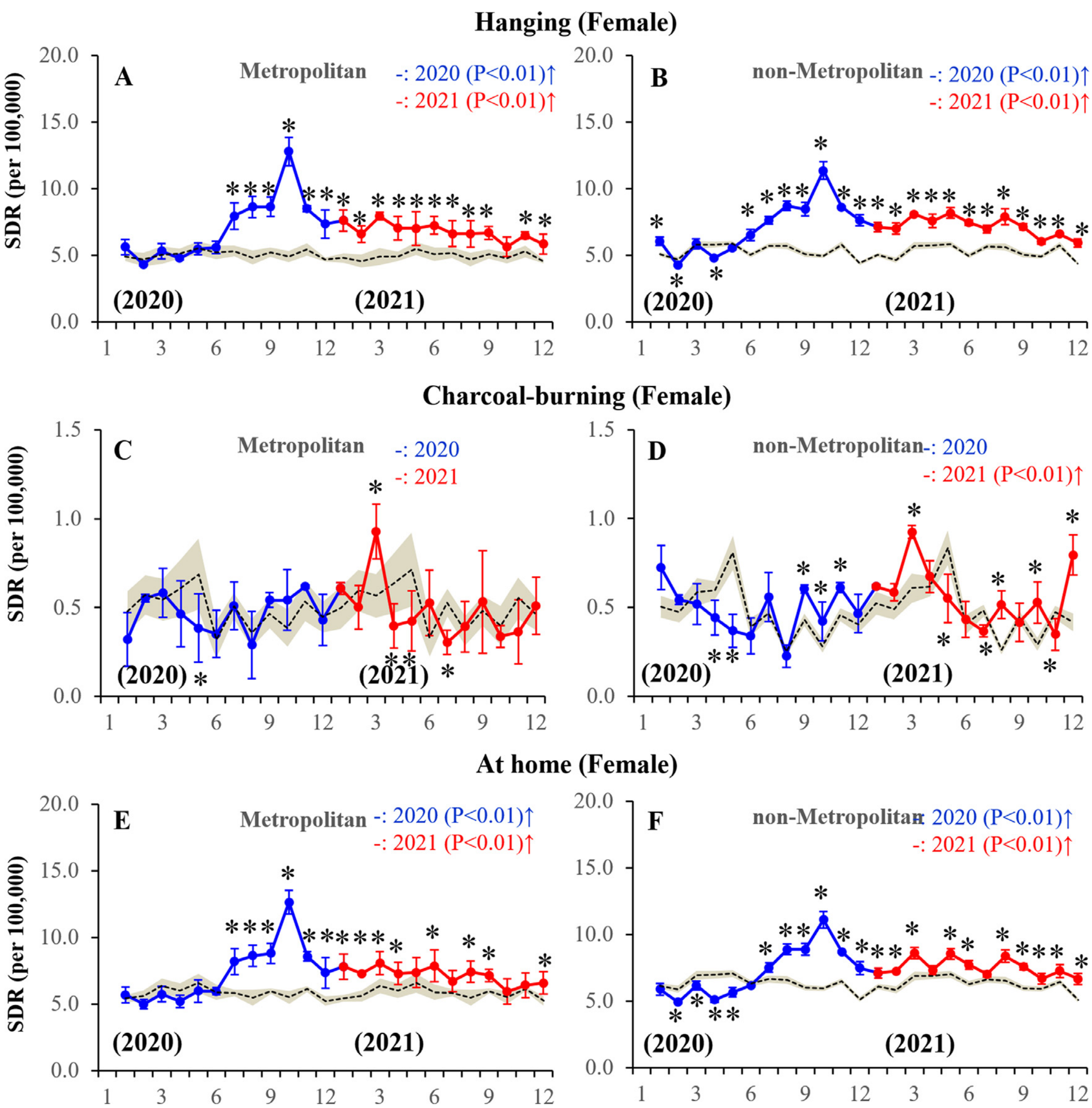

Figure 3. Fluctuations of monthly hanging-SDR (A,B), charcoal-burning SDR (C,D) and SDR at home (E,F) of females during COVID-19 pandemic compared to the predicted SDRs in Metropolitan- (A,C,E) and non-Metropolitan- (B,D,F) regions. Dotted, blue and red lines indicate the average of predicted SDR, observed SDR in 2020 and 2021, respectively. Brown areas, blue and red bats indicate the 95% confidence intervals of predicted SDR, observed SDR in 2020 and 2021, respectively. Ordinates indicate the SDR (per 100,000 people), and abscissas indicate the month. * $p < 0.05$, significant change of monthly SDR compared to predicted SDR using a linear mixed-effects model with Scheffe's post-hoc test. ↑and↓indicate increasing and decreasing annual SDRs compared to predicted SDRs, respectively.

metropolitan-region (17.3–21.1%) (Figures 2 and 3). The observed annual male SDRs at home were higher than the predicted SDRs in 2020 (metropolitan-region: 5.2 –10.9% and non-metropolitan-region: 0.2–3.2%). The observed annual male SDRs at home in the non-metropolitan-region were also higher (0.1–3.3%) than the predicted SDRs, whereas those in metropolitan regions were nearly equal to the predicted SDRs (Figures 2 and 3).

See Supplementary Figures 4–2 and 4–3 for the differences in SDRs by hanging and SDRs at home among subgroups disaggregated by gender, region, and year of relative observed SDR rates per predicted SDR. See Supplementary Figures 5 and 6 for the SDRs caused by throwing, poisoning and jumping.

Suicide mortality disaggregated by household

In 2020, during the first wave, the observed monthly SDRs of males (-8.1–-19.1%) and females (-10.8 –-23.1%) living in multiple-person households in the non-metropolitan-region were lower than the predicted SDRs. In the metropolitan-region, the observed monthly SDRs of males for living in multiple-person households was also lower than the predicted SDRs (-6.4–-23.0%) but that of females was nearly equal (Figure 4). In contrast, during the second half of 2020, all monthly SDRs for living in multiple-person households were higher than the predicted SDRs (males in the metropolitan-region and non-metropolitan-regions were: 10.9–29.4% and 2.3–23.6%, respectively. Female SDRs in the metropolitan-region and non-metropolitan-region were: 15.6–101.2% and 4.7–78.9%, respectively) (Figure 4). In 2021, the observed monthly female SDRs for living in multiple-person households in both regions were higher than the predicted SDRs (metropolitan-region: 7.6–41.0%, non-metropolitan-region: 5.2–40.9%) throughout 2021 (Figure 4). The observed male SDRs for living in multiple-person households in both regions were nearly equal to the predicted SDRs during the first half of 2021, whereas during the second half of 2021, those in the metropolitan-region (-13.7–-23.6) and non-metropolitan-region (-5.9–-14.1%) were lower than the predicted SDRs (Figure 4).

In 2020, the observed annual SDRs of males living in multiple-person households in both regions were nearly equal to the predicted SDRs, whereas those of females in both regions were higher (metropolitan-region and non-metropolitan-region were: 18.2–29.1% and 15.4–20.5%, respectively) (Figure 4). In 2021, the observed annual SDRs of males living in multiple-person households in the non-metropolitan region was nearly equal to the predicted SDRs, whereas that in the metropolitan region was lower than the predicted SDRs (-3.3–-10.2%) (Figure 4). The observed annual SDRs of females in both regions were higher than the predicted SDRs (metropolitan-region and non-metropolitan-region were: 16.4–25.5% and 18.9–22.7%, respectively) (Figure 4).

In 2020, during the first wave, observed monthly SDRs of males living in single-person households living in non-metropolitan-region (-2.8–-20.6%) and females in metropolitan-region (-25.1–-38.8%) and non-metropolitan-region (-13.0–-32.6%) were lower than predicted SDRs, whereas that of males in metropolitan-region was nearly equal to predicted SDR (Figure 4). In contrast, during the second half of 2020, all monthly SDRs for living in single-person households were higher than predicted SDRs (males in metropolitan-region and non-metropolitan-region were: 5.9–52.6% and 5.5–37.1%, respectively. Female SDRs in metropolitan-region and non-metropolitan-region were: 13.2–99.6% and 13.5–90.8%, respectively) (Figure 4). In 2021, observed monthly female SDRs for living in single-person households in both regions were higher than predicted SDRs (metropolitan -region: 7.1–19.9% and non-metropolitan -region: 8.6–74.1%) throughout 2021 (Figure 4). observed male SDR for living in single-person households in metropolitan-region was nearly equal to predicted SDR throughout 2021, whereas those in non-metropolitan-region during the first and second halves of 2021 were higher (12.6–27.8%) and lower (-4.0–-18.8%) than predicted SDRs, respectively (Figure 4).

In 2020, all the observed annual SDRs for living in single-person households were higher than the predicted SDRs (males in the metropolitan-region: 2.0–9.6% and non-metropolitan-region: 4.5–8.6%, females in the metropolitan-region: 7.3–21.6% and non-metropolitan region: 9.7–17.1%) (Figure 4). In 2021, the observed annual SDRs were also higher than the predicted SDRs in the metropolitan-region (7.1–19.9%) and non-metropolitan-region (18.0–26.5%), whereas those of males were nearly equal to the predicted SDRs (Figure 4).

Impacts of incidence, mortality of COVID-19, and PCR examination numbers on SDR

In all 47 prefectures, between April 2020 and September 2021, monthly SDRs for males+females, males and females were negatively related to the number of PCR examinations (PCR-N), whereas neither SDRs of males+females, males, nor females were related to mortality by COVID-19 (SM-R). Incidence of COVID-19 (SR-AC) was positively related to SDRs of males +females and females, but did not relate to male SDRs (Table 1). In the metropolitan-region, between April 2020 and September 2021, monthly SDRs for males +females, males, and females were negatively related to numbers of PCR-N, whereas neither SDRs of males +females, males, nor females were related to SM-R. SR-AC was positively related to SDRs of males+females and females but did not relate to male SDRs (Table 1). In the non-metropolitan-region, between April 2020 and September 2021, monthly SDRs for males+females, males, and females were negatively related to numbers of PCR-N. SM-C was positively related to male SDRs, but neither SDRs of males+females nor females related to SM-C. SR-AC was positively related to SDRs of males +females and females, but did not relate to male SDRs (Table 1).

Discussion

This study revealed that the temporal fluctuations in the SDRs during the COVID-19 pandemic differed from those observed before the pandemic. Before the pandemic (during 2017–2019), monthly SDRs (males +females and males) were highest in March and then gradually decreased; however, during the first wave of the pandemic (March to June 2020), the increasing SDRs in March were not observed, and conversely, observed SDRs during the second half of 2020 were not lower than the observed SDRs in March 2020. During the first wave, the observed SDRs of males in both regions and females in the non-metropolitan-region were lower than the predicted SDRs, whereas the

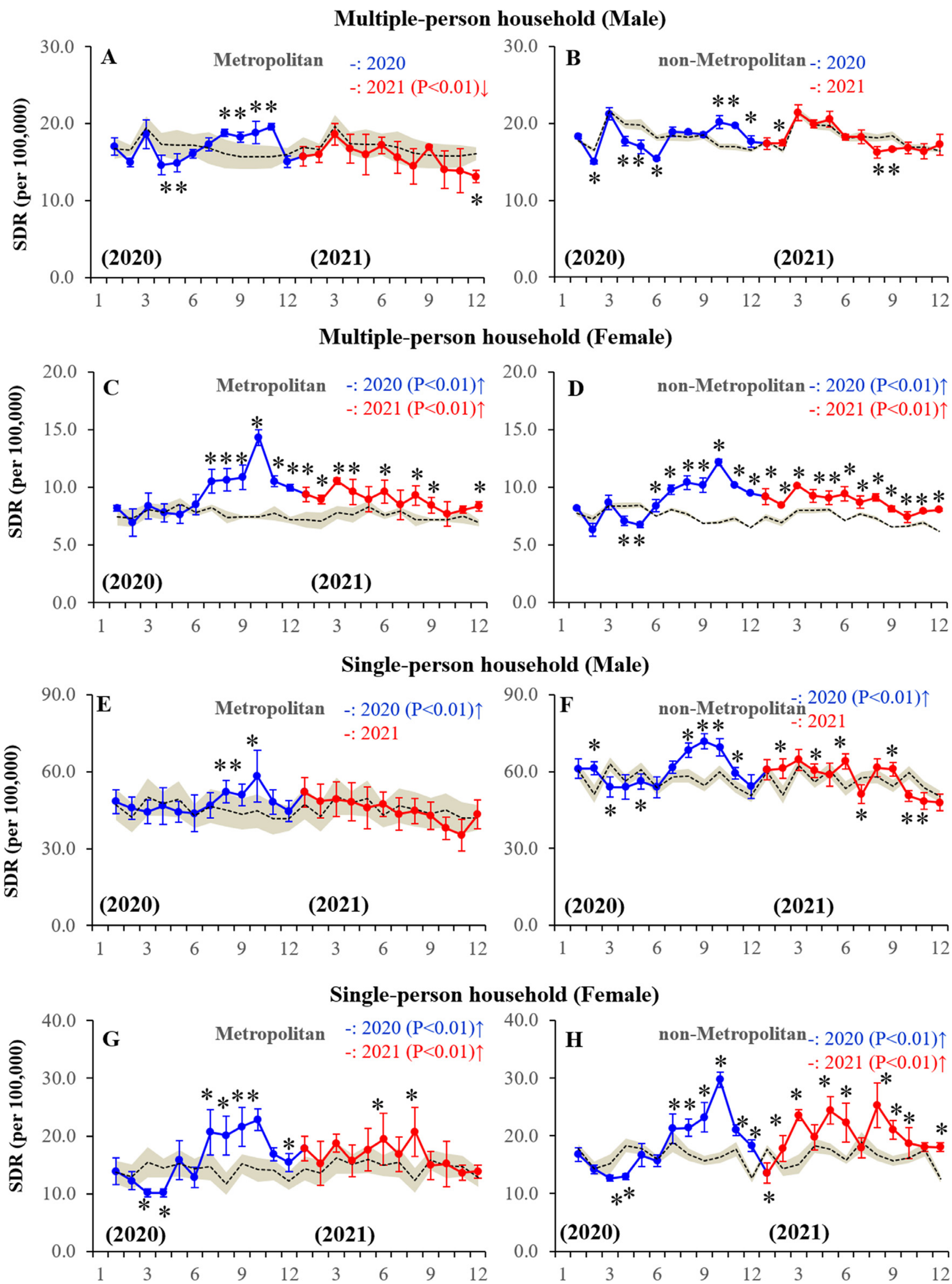

Figure 4. Fluctuations of males (A,B,E,F) and females (C,D,G,H) monthly SDR of multiple- (A-D) and single-person household residents (E-H) during COVID-19 pandemic compared to the predicted SDRs in Metropolitan- (A,C) and non-Metropolitan- (B,D) regions. Dotted, blue and red lines indicate the average of predicted SDR, observed SDR in 2020 and 2021, respectively. Brown areas, blue and red bats indicate the 95% confidence intervals of predicted SDR, observed SDR in 2020 and 2021, respectively. Ordinates indicate the SDR (per 100,000 people), and abscissas indicate the month. * $p < 0.05$, significant change of monthly SDR compared to predicted SDR using a linear mixed-effects model with Scheffe's post-hoc test. ↑and↓indicate increasing and decreasing annual SDRs compared to predicted SDRs, respectively.

Factor	males+females				males				Females			
	β	SE	T	p	β	SE	T	P	β	SE	T	p
47 Prefectures												
SR_AC	0.024	0.005	4.803	<0.001**	0.013	0.010	1.355	0.182	0.034	0.007	4.773	<0.001**
SM_C	1.154	0.730	1.581	0.121	2.319	1.385	1.674	0.101	0.046	0.583	0.078	0.938
PCR_N	-0.002	0.000	-6.906	<0.001**	-0.003	0.000	-6.445	<0.001**	-0.001	0.000	-5.978	<0.001**
	Hausman X^2= 7.97 ($P < 0.05$)				Hausman X^2 = 13.05 ($P < 0.01$)				Hausman X^2= 8.03 ($P < 0.01$)			
Metropolitan												
SR_AC	0.020	0.007	2.733	0.023*	0.001	0.015	0.095	0.926	0.038	0.011	3.507	0.007**
SM_C	0.618	1.017	0.608	0.558	1.004	1.920	0.523	0.614	0.251	0.670	0.374	0.717
PCR_N	-0.002	0.000	-4.693	0.001**	-0.002	0.001	-3.626	0.006**	-0.001	0.000	-4.746	0.001**
	Hausman X^2= 72.15 ($P < 0.01$)				Hausman X^2= 23.22 ($P < 0.01$)				Hausman X^2=8.09 ($P < 0.01$)			
non-Metropolitan												
SR_AC	0.026	0.006	4.161	<0.001**	0.020	0.011	1.905	0.065	0.031	0.009	3.416	0.002**
SM_C	2.178	1.118	1.949	0.059	4.845	1.774	2.732	0.010*	-0.362	1.048	-0.345	0.732
PCR_N	-0.002	0.000	-5.499	<0.001**	-0.003	0.001	-5.738	<0.001**	-0.001	0.000	-4.184	<0.001**
	Hausman X^2= 9.84 ($P < 0.05$)				Hausman X^2= 14.12 ($P < 0.01$)				Hausman X^2= 8.44 ($P < 0.05$)			

***Table 1*: Impacts of parameters associated with COVID-19 pandemic on SDR between April 2020 and December 2021 in Japan.**
β: coefficient value, SE: standard error, X^2: Chi-square value by likelihood ratio test.
SR-AC: standardised infection rate with COVID-19 (per 1,000,000), SM-C: standardised mortality caused by COVID-19 (per 100,000) and PCR-N: standardised numbers of COVID-19 PCR examination rate (per 1,000,000). *$P < 0.05$ and **$P < 0.01$ by hierarchical linear regression model analysis with robust standard error.

observed female SDRs in the metropolitan region was not lower than the predicted value. During the second half of 2020, the observed female SDRs was higher than the predicted SDRs and was highest (73.5−90.2%) in October 2020. In 2020, the increasing annual observed SDRs compared to the predicted value for females was higher than that for males in the metropolitan-region (females: 9.0−30.4% vs males: -1.5−7.6%) and non-metropolitan-region (females: 13.4−24.5% vs males: -2.6−1.5%) (Supplementary Figure 4). In 2021, the observed female SDRs in both regions continued to be higher than the predicted SDRs throughout 2021. The observed male SDRs in the metropolitan-region was lower than the predicted SDRs during the second half of 2021, whereas in the non-metropolitan regions, the observed monthly male SDRs seemed to be almost equal to the predicted SDRs; the observed annual SDRs were also slightly higher than the predicted value.

First, during the second half of 2020, the observed SDRs for both genders by hanging and suicide at home were higher than the predicted values. The peak of elevation of female SDRs in both regions by hanging and suicide at home was detected in October 2020 (metropolitan: 137.9−181.3% and non-metropolitan: 115.4−142.0%). When comparing the number of suicides, the increased SDRs for females by hanging in 2020 and 2021 accounted for most of the increased SDRs at the national-level (Supplementary Table 2 and Figure 7). Additionally, the increased rate of suicides at home in 2020 and 2021 accounted for approximately 50% of the increase in SDRs (Supplementary Table 2 and Figure 7). Hanging has been established as the predominant method of suicide in Japan,[16,17] and the most common location and tools used for suicide by hanging were the individual's home and everyday items.[16,17] It has been reported that, respectively. Individuals experienced a change in their lifestyles in the form of increasing stay-at-home measures during the pandemic.[4] Therefore, this may contribute to an increased risk for suicide by hanging and at home. As noted above, increasing SDRs in 2020 were only observed in Japan, India, Puerto Rico, and Vienna[8,10,12,13]; other countries and regions showed decreased or unchanged SDRs.[6−9] Overall, the increasing SDRs by hanging and at home during the COVID-19 pandemic may be a specific characteristic of suicide in Japan; however, in the future, examining patterns of increased SDRs by categorising suicides due to the extension of pandemic duration in other countries might give an additional perspective. Suicide by hanging is also the most common method in countries other than Japan[29]; therefore, further studies are needed to clarify if there is an increased suicide risk for those remaining at home due to lifestyle change during the pandemic. Furthermore, previous studies have highlighted age differences in rates (suicide rates in young people were more affected compared to those in older individuals during the second half of 2020).[12,13] Taken together with these previous findings, the present results suggest that younger people living in single-person households are the most affected by the pandemic.

Second, during the third quarter of 2021, Japan experienced a sizeable increase in COVID-19 cases due to the spread of the Delta variant of SARS-CoV-2[22] (Supplementary Figure 1), which could have increased fear and hopelessness surrounding the pandemic. Increasing numbers of PCR diagnostic examinations were negatively related to SDRs in both genders and all regions. Conversely, the rising numbers of infections (SR-AC) were related to increasing SDRs. Regarding fear of COVID-19, the relationship between increased PCR-N and decreased SDRs is subjective, but some considerations could be discussed. The increase in copycat suicides due to celebrity suicide reports[15] on the social/mass media has attracted attention as the cause of suicide increases among females in the second half of 2020.[13] During the second half of 2020, despite being the second wave of the pandemic, the diagnostic PCR examination system was inadequate (Supplementary Figure 1). This compromised medicine and public health management systems, which became dysfunctional. It has been established that accurate and prompt release of information on COVID-19 during a pandemic is important for maintaining peoples' mental health,[9] whereas insufficient diagnostic systems fail not only to disclose information but also to collect the information for disclosure that the public could understand. Therefore, increasing SDRs during the second half of 2020 may be composed of complicated social/mass media factors as well as other factors, such as those related to medical and public health systems.

Third, in 2021, the SDRs among females in both the metropolitan-region and non-metropolitan-region seemed to continue to increase higher than the predicted values, whereas the increase among males only persisted in the non-metropolitan-region and that in the metropolitan-region rapidly returned to predicted levels in 2021. Although the differences in SDRs in 2021 associated with gender and region can be explained by increases in suicide by hanging, the SDRs for males in the non-metropolitan-region were higher than predicted values by hanging, charcoal-burning, and at home. However, in the metropolitan-region, these rates were nearly equal to the predicted SDRs. Notably, SDRs for males by charcoal-burning decreased in both regions in 2020 but increased in the non-metropolitan region in 2021. Furthermore, suicide by charcoal-burning was higher in single-person households and at home compared to suicide by other means.[18] Gatekeeper developmental programmes in regional suicide prevention programmes in Japan have contributed to decreasing SDRs for males by suppressing suicide by hanging and charcoal-burning.[16] Therefore, the effects of the regional suicide prevention programmes in Japan that previously contributed to reducing SDRs over the past decade have been attenuated by the isolation induced by several factors associated with the pandemic, such as social distancing measures, stay-at-home orders, or transformation of individuals' lifestyles (increasing time spent at home) at the individuals' discretion as aspects of COVID-19 prevention, negatively affecting mental health.[2]

Real-time monitoring of suicide mortality represents a critical goal for public health efforts. That is, Japanese suicide statistics are the fastest national-level suicide statistics published in governmental databases worldwide. Therefore, interpretations of real-time monitoring of the quality of life during a pandemic by comparing suicide statistics reports in Japan with those in other countries can help protect lives.

Strengths and limitations

This study had several strengths and limitations. Suicide statistics must consider the possibility of unintentional misclassification based on the cause and/or means of death. Since 2009, the BDSR database has aggregated the number of suicides identified by the jurisdiction of regional police stations, using investigations that included various suicide notes and other documentation, such as medical certificates, clinical records, and testimony of the surviving family, to reduce unintentional misclassification.

Due to the timely dissemination of suicide data, a limitation of this study was that not all suicide data were finalised at the time of monthly data extraction for this study. The data of the number of suicides in the BDSR until December 2020 was a final accounting; however, the records of annual and monthly suicides in 2021 were final and provisional accountings, respectively. In 2021, the annual suicides in the final data of the BDSR and the sum of monthly suicide numbers in the provisional data were 21,007 and 20,984, respectively (the difference was about 0.1%). Therefore, the results of this study using the provisional monthly BDSR data in 2021 may have underestimated the increase and overestimated the decrease in SDRs. However, it is considered that the impacts were limited, since the difference between the annual final number and the sum of monthly numbers in the provisional data was approximately 0.1%. Furthermore, suicide by hanging, jumping, and charcoal-burning accounted for 75%, 12%, and 8%, respectively, of all suicides in Japan; therefore, low numbers of monthly suicides caused by other methods when disaggregated by gender possibly resulted in models with relatively weak power and precision. Suicide by hanging has accounted for more than 65% of all suicides. Therefore, low numbers of prefectural monthly suicides disaggregated by gender caused by other methods may have resulted in models with relatively weak power and precision. An appropriate pre-survey period for the calculation of predicted SDRs is important for pre-/post-comparison studies. Considering the long-term decline in suicide rates in Japan, in the present study, based on joinpoint regression analysis, the predicted SDRs were calculated over three years (during 2017−2019). However, it is well known that longer pre-survey data can better detect underlying long-term trends in the data.

Conclusions

This study found that the fluctuation pattern in monthly suicides during the COVID-19 pandemic in Japan was quite different from before the pandemic. Furthermore, the pandemic's impact on the fluctuation of suicides was inconsistent, and further temporal fluctuation patterns were observed due to the prolongation of the pandemic. During the first wave of the pandemic (between March and June 2020), SDRs were lower than the predicted SDRs, but it became higher in the second half of 2020. The excess female SDRs in both the metropolitan and non-metropolitan regions continued throughout 2021; the excess male SDRs in the non-metropolitan-region also continued marginally, whereas that in the metropolitan region became nearly equal to the predicted SDRs in the first half of 2021. These complicated temporal fluctuations of overall suicide mortality were synchronised with the temporal fluctuation patterns of suicide by hanging, at home, and for residents living in single-person households. Considering the established Japanese suicide statistics indicating that the predominant method and place of suicide were by hanging and at the individual's home, these findings suggest the possibility that transformed lifestyles during the COVID-19 pandemic promoted exposure to hanging suicide risk (by increasing time at home) in Japan.

Contributors

MO conceptualized the study, contributed to the study design and methodology, drafted and reviewed the manuscript. RM contributed to the study design and methodology, verified the underlying data, performed the statistical analysis and generated figures, drafted and reviewed the manuscript. EM contributed to the study design and methodology, coordinated extraction of the data. TS conducted the literature review, contributed to the methodology, and drafted and reviewed the manuscript. MM contributed to the methodology and reviewed the manuscript.

Declaration of interests

None.

Data sharing

All raw data are publicly available to any persons via Japanese national databases from the Basic Data on Suicide in the Region (BDSR) (https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html) in a national database of the Ministry of Health, Labour and Welfare (MHLW), Regional Statistics Database (RSD) (https://www.e-stat.go.jp/en/statistics/00200241) of the System of Social and Demographic Statistics of the Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC), Database of the National Institute of Infectious Diseases (https://www.niid.go.jp/niid/ja/calendar.html) and Sapporo Medical University School of Medicine (https://web.sapmed.ac.jp/canmol/coronavirus/japan.html).

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.lanwpc.2022.100481.

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