



# Impact of the COVID-19 pandemic on suicide rates in Japan through December 2021: An interrupted time series analysis

Eiji Yoshioka,<sup>a\*</sup> Sharon J.B. Hanley,<sup>b</sup> Yukihiro Sato,<sup>a</sup> and Yasuaki Saijo<sup>a</sup>

<sup>a</sup>Department of Social Medicine, Asahikawa Medical University, Midorigaoka-higashi 2-1-1-1, Asahikawa, Hokkaido 078-8510, Japan

<sup>b</sup>Hokkaido University Center for Environmental and Health Sciences, Kita 12, Nishi 7, Kita-Ku, Sapporo 060-0812, Japan

## Summary

**Background** The COVID-19 pandemic is negatively impacting mental health globally. While increased social cohesion may have initially decreased suicide risk, there are few reports on the long-term impact. We examined the impact of the pandemic on suicide by gender and age through December 2021 in Japan.

**Methods** We analyzed trends in monthly suicide rates by age and gender from January 2016 to December 2021 using provisional mortality data in an interrupted time series analysis. We also considered linear trends in the pre-pandemic period and seasonal variations. Pandemic onset was defined as from April 2020. Estimated excess deaths by suicide that occurred during the pandemic were calculated.

**Findings** Excess number of suicide deaths during the pandemic period was estimated to be 1208 for men and 1825 for women. While there was no statistically significant increase in suicide rates overall for both men and women during the pandemic compared to the pre-pandemic, age-specific analyses showed a statistically significant increase in men 20–29 and 40–49 years, and in women of all age groups, except those under 20, 40–49 and over 80 years.

**Interpretation** The COVID-19 pandemic has had a negative impact on suicide rates in Japan and the impact is most pronounced in women and younger age groups. Subgroup analyses are needed, with a particular focus on those considered to be vulnerable and at increased suicide risk.

**Funding** A Grant-in-Aid for scientific research from the Ministry of Education, Culture, Sports, Science and Technology of Japan (Award Number 21K10462).

**Copyright** © 2022 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

**Keywords:** Suicide; Japan; COVID-19 pandemic; An interrupted time series analysis

## Introduction

The COVID-19 pandemic has led to the introduction of drastic public health measures not seen since the 1918 influenza pandemic such as declaration of health emergencies, lockdowns, the closing of schools and the closing of global borders to prevent the spread of infection. It has been suggested that these restrictions on social mixing can have serious negative impacts on mental public health.<sup>1</sup> Concerns have also been raised that declines in mental health may also increase the risk of suicide.<sup>2</sup>

Previous studies have shown that death by suicide can increase during infectious disease epidemics. A

2020 systematic review reported an association between suicide rates and infectious disease outbreaks such as the Great Influenza, SARS and Ebola epidemics.<sup>3</sup> Regarding the impact of the COVID-19 pandemic on suicide, an international team of researchers analyzed data from 21 middle- and high-income countries, including Japan.<sup>4</sup> They found that in most of the countries studied, there was little change or a decrease in the number of suicides observed in the early stages of the pandemic compared to the number expected before the pandemic. However, the analysis only included suicides up to July 2020.

In Japan, several studies have examined changes in monthly suicide rates during the COVID-19 pandemic.<sup>5–7</sup> Fewer suicides were reported between February and June 2020, but an increase in the number of suicides from July to November 2020 was reported, compared to

DOI of original article: <http://dx.doi.org/10.1016/j.lanwpc.2022.100481>

\*Corresponding author.

E-mail address: [e-yoshi@asahikawa-med.ac.jp](mailto:e-yoshi@asahikawa-med.ac.jp) (E. Yoshioka).

The Lancet Regional Health - Western Pacific  
2022;24: 100480  
Published online xxx  
<https://doi.org/10.1016/j.lanwpc.2022.100480>

## Research in context

### *Evidence before this study*

We searched PubMed for studies published between 1st January 2020 and 31st October 2021, with the keywords "COVID" and "suicid\*." We applied no language, study design, or quality of publication restrictions to the search. The search returned 1009 articles. Most of these were either correspondence, comments, editorials, or research articles analysing events that were not suicide-related deaths, such as self-harm or suicidal ideation. Only 34 studies examined how absolute numbers and suicide rates had changed from the pre-pandemic period to the pandemic period, using reasonably reliable data. Most of these studies have reported no increase in the number of suicides or suicide rates during the pandemic compared with pre-pandemic levels, only a few report an increase. Even within the same country or region, suicide trends have been reported to vary by gender, age, and race. Studies in the US states of Maryland and Connecticut reported a decrease in suicide rates among whites during the pandemic compared to the pre-pandemic period, but an increase in suicide rates among non-whites. In Guangdong province in China, there was an increase in suicide deaths among those aged 10–14 years old during the pandemic. In Hungary, an increase was found in men, while no change was observed in women during the pandemic. In Japan, fewer suicides were initially reported between February and June 2020, compared to the corresponding months in previous years, but there was an increase in the number of suicides from July to November 2020 compared to the corresponding months in previous years. The increases in suicide in Japan were more pronounced among younger generations and in women. Most previous studies have focused on the first year of the pandemic (2020), with the longest period being up to February 2021. No studies have examined suicide trends beyond that date. Moreover, most studies have not considered seasonal variations and pre-pandemic time series trends.

### *Added value of this study*

The results of our study have shown that the pandemic of COVID-19 had a negative impact on trends in suicide rates in Japan, and its impact was particularly strong among women and younger generations. Our findings indicate that the COVID-19 crisis can impact suicide risk overall, but even within the same country or region, trends in suicide rates during the COVID-19 pandemic can differ between gender and age groups, suggesting the importance of sub-group analyses. To our knowledge, this is the first study to examine the impact of the COVID-19 pandemic on suicide over the period up to December 2021, considering pre-pandemic time series trends and seasonal variations.

### *Implications of all the available evidence*

Policy responses to the spread of Covid-19 on suicide and mental health, both in Japan and globally, must not only focus on the population as a whole, but also on

sub-groups of the population who are more socio-economically vulnerable. In Japan, suicides increased during the pandemic period, especially among women and younger generations; both of these sub-groups are considered to be more socioeconomically vulnerable. This would indicate that governments and other agencies need to identify and provide appropriate additional support to specific sub-groups of the population during the pandemic. Finally, since the COVID-19 pandemic is still evolving, continued vigilance and close monitoring of suicide mortality rates and the mental health of populations remains a priority.

corresponding months in previous years. The initial decrease in cases in the early stages of the pandemic may have been due to increased community cohesion and mutual support, as has happened after large natural disasters in the past.<sup>8</sup> However, most previous studies focused on the situation in 2020, with only one study reporting the situation through June 2021. The results of the latter indicated that the prolongation of the COVID-19 pandemic period contributed to increasing suicide mortality in women.<sup>7</sup> Therefore, the pandemic is still evolving, data from previous studies may be outdated and, therefore, it is plausible that suicide rates may have increased further due to worry and stress over the coronavirus itself, prolonged social isolation, and job loss from the resulting global economic recession.<sup>2</sup> In addition, previous studies have mainly compared suicide rates in each month of the past years with rates in the same months in 2020 and 2021, the pandemic period. Consequently, to what extent suicide rates or the time trend in suicide rates changed during the pandemic period as a whole compared to the pre-pandemic period has not yet been fully elucidated.

This study aims to assess the impact of the COVID-19 pandemic on suicide rates in Japan using provisional suicide data from January 2009 to December 2021. We used an interrupted time series analysis to investigate how suicide rates and time trends in suicide rates changed during the pandemic compared to the pre-pandemic period. We further analyzed the results by gender and age group to identify any differences in the effects of the pandemic on these specific sub-groups.

## Methods

### Choice of primary measure

The primary measure of this study was monthly suicide rates (suicides per 100,000 population) by gender and age group. Mortality rates have been used in previous studies on trends in suicide rates during the period of COVID-19 pandemic.<sup>4–6,10,11</sup> We used provisional data

(in Japanese) from the Ministry of Health, Labour and Welfare on total monthly number of suicides collected by the National Police Agency of Japan between January 2009 and December 2021.<sup>12</sup> However, as of 1 April 2022, the provisional monthly suicide data for January 2018 to December 2021 had been replaced by definitive data, and the provisional data used in this study was no longer available. Thus, the provisional suicide data used in this study are presented in Supplementary Appendix 5. In Japan, the cause of death and manner of death are confirmed by a medical doctor. If the manner of death is determined to be unnatural (accident, suicide, homicide, or undetermined), it must be reported to the police. The suicide data used in this study are based on data on unnatural deaths collected by the police agency. Provisional estimates of population by month in Japan for each gender–age category were obtained from the Statistics Bureau of Japan.<sup>13</sup> We stratified mortality data by gender and age. Age was categorized into the following eight categories: <20, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years. We calculated the age-standardized monthly suicide rate per 100,000 persons, using the Japanese population in January 2020 as the standard population.

### Pandemic onset and study period

We used the Joinpoint Regression Program v4.8.0.1 to identify linear trends and corresponding joinpoints in annual suicide rates by gender and age between 2009 and 2019.<sup>14</sup> Crude suicide rates were used as the dependent variables. In particular, we wanted a consistent period of linear trend before the COVID-19 pandemic to be the focus of the interrupted time series analysis. Detailed results of the Joinpoint regression analyses are shown in Supplementary Table 1. We identified a linear trend in all gender-age groups between 2016 and 2019, and thus we included data from 2016 in the current study. While the first COVID-19 case identified in Japan was in January 2020, cases did not increase significantly until April, when the Japanese government announced its first national state of emergency on April 7, 2020. Thus, we defined the pandemic period to be from April 2020 until the writing of the current manuscript in December 2021. Therefore, the total study period used in the analysis is the 72 month-period from January 2016 to December 2021, of which the pandemic period is the 21 months from April 2020 to December 2021.

### Statistical analysis and outcomes

We used an interrupted time series analysis to investigate whether the COVID-19 pandemic impacted on rates and/or trends of suicide in Japan.<sup>9,15</sup> The ‘intervention’ of interest in this study was the COVID-

19 pandemic. We used Prais-Winsten regression with the Cochrane-Orcutt transformation to adjust for first-order serial autocorrelation. We used the following equation:

$$Y_t = \beta_0 + \beta_1 \times T_t + \beta_2 \times X_t + \beta_3 \times P_t + S_t$$

where  $Y_t$  is the age-standardised suicide monthly rate at time  $t$ ;  $T_t$  is a continuous variable indicating time in months from the start of the study;  $X_t$  is a dummy variable indicating the pre-pandemic period (coded 0) or the pandemic period (coded 1);  $P_t$  is a continuous variable counting the number of months during the pandemic, coded 0 before the pandemic and  $(T_t - 51)$  during the pandemic; and  $S_t$  represents the variables that control for seasonality. In this model,  $\beta_0$  represents the baseline level;  $\beta_1$  is the pre-pandemic slope of mortality rate;  $\beta_2$  shows whether mean mortality rate changed immediately after the pandemic; and  $\beta_3$  is the difference in the mortality rate slopes before and after the onset of the pandemic. Seasonal pattern in this study is adjusted by fitting Fourier terms in the regression model.<sup>9,16</sup> This adjustment uses pairs of sine and cosine functions of time with an underlying period reflecting the full seasonal cycle (i.e. calendar month) and is particularly suited to capturing very regular seasonal patterns. In this study, ‘seasonality variables’ is expressed with Fourier terms consisting of two sine/cosine pairs (one fundamental plus one harmonic).

To estimate excess deaths that occurred during the pandemic, we used coefficients from the aforementioned equation and compared expected mortality rates per 100,000 population for the period after the pandemic onset with expected rates if the pre-pandemic trend had continued.<sup>17,18</sup> We then multiplied the cumulative differences between estimated values with and without the pandemic by the mean Japanese population. We also performed the same analysis by gender and age category. In this case, we used the crude suicide rate at each age as the dependent variable.

Furthermore, in order to check the robustness of results with regards to varying a range of modeled assumptions, we conducted three sensitivity analyses. In February 2020, the first death due to COVID-19 was confirmed in Japan, and the number of cases gradually increased.<sup>19</sup> Consequently, because anxiety about the spread of COVID-19 might have increased after this period and might have affected the suicidal patterns in Japan, we conducted a sensitivity analysis using a different pandemic starting point (February 2020). Previous studies have adjustment for seasonality in several ways.<sup>16</sup> One way is the method used in this study.<sup>20</sup> Adjusting for dummy variables each month is another option.<sup>21</sup> Therefore, we performed a second sensitivity analysis using a regression model with dummy variables for each month to see how the results were affected using this different method of adjustment. And as a

third sensitivity analysis, a regression analysis was carried out using confirmed monthly suicide figures from January 2018 to December 2021 in order to clarify the differences between the results of the analysis using provisional values and those using confirmed values. All analyses were conducted using the statistical packages Stata version 17 for Windows.

### Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the paper. All authors had full access to the data presented in the study and all had responsibility for the decision to submit for publication.

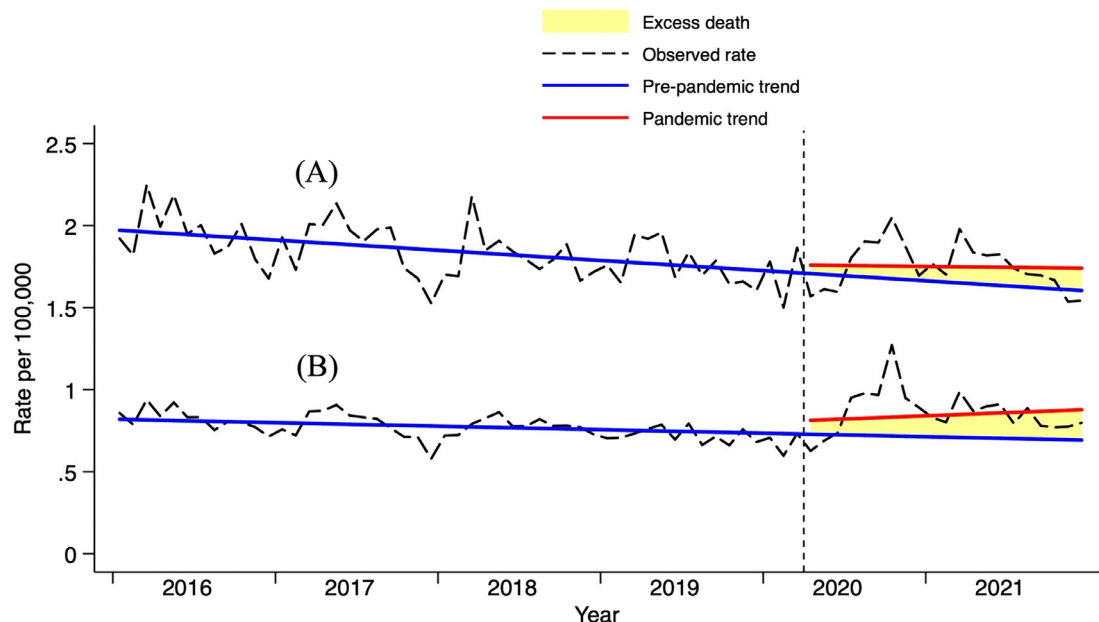
### Results

The number of suicides in Japan during the period between January 2016 and December 2021 was 78,969 for men and 37,609 for women. Mean monthly suicide rates during the pandemic period were 1.75 per 100,000 for men and 0.86 per 100,000 for women compared to pre-pandemic rates of 1.84 and 0.77 per 100,000 for men and women, respectively. [Figure 1](#) illustrates secular monthly trends in suicide rates for men and women in Japan before (January 2016–March 2020) and after (April 2020–December 2021) the onset of the pandemic. The solid red line represents the seasonally adjusted linear trend of monthly suicide rates after the onset of the pandemic while the solid blue line represents the trend of monthly suicide rates before the onset of the pandemic. The area between both lines

represents estimated excess deaths. Results of the interrupted time series regression analyses and estimates of cumulative excess suicides deaths during the pandemic for men and women of all ages in Japan are shown in [Table 1](#). For both men and women overall, no statistically significant changes in suicide rates were observed when comparing the pre-pandemic and the pandemic periods. Estimates of excess suicide deaths were also not statistically significant, with 1,208 estimated excess deaths for men and 1,825 estimated excess deaths for women.

Results of the interrupted time series regression analyses and estimates of cumulative excess suicides deaths during the pandemic for Japanese men by age category are shown in [Table 2](#). Across all age groups in men, no statistically significant changes in suicide rates were observed when comparing the pre-pandemic and the pandemic periods. With regard to the cumulative excess estimates of suicide deaths during the pandemic, statistically significant results were observed among men aged 20–29 and 40–49 years, with 466 (95%CI: 169 to 763) excess deaths in the former and 423 (95%CI: 97 to 749) in the latter.

Results of the interrupted time series regression analyses and estimates of cumulative excess suicides deaths during the pandemic for Japanese women by age category are shown in [Table 3](#). A statistically significant change in suicide rates was observed for women aged 30–39 and 60–69 years. Estimates of excess suicide deaths were statistically significant for women in all age groups, except those aged under 20, 40–49, and 80 years or over. Among them, the highest number of excess deaths was observed in women 30–39 years



**Figure 1.** Secular trends in monthly suicide rates in Japan, (A) for males, (B) for females. The dashed vertical line at April 2020 show the onset of the pandemic.

	Pre-pandemic trend <sup>a</sup>	Pandemic trend <sup>b</sup>	Rate change <sup>c</sup>	Trend change <sup>d</sup>	Cumulative excess death <sup>e</sup>
	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)
<b>Male</b>	−0.0052*** (−0.0076 to −0.0027)	−0.0009 (−0.0137 to 0.0119)	0.0475 (−0.1563 to 0.2513)	0.0042 (−0.0088 to 0.0173)	1208 (−212 to 2629)
<b>Female</b>	−0.0018 (−0.0041 to 0.0005)	0.0032 (−0.0130 to 0.0194)	0.0798 (−0.1913 to 0.3510)	0.0050 (−0.0109 to 0.0209)	1825 (−23 to 3672)

**Table 1: Summaries of interrupted time series regression analyses of the impact of the COVID-19 pandemic on suicide and estimated number of cumulative excess deaths by suicide during the pandemic period for males and females of all ages in Japan.**

<sup>a</sup>"Pre-pandemic trend" means the pre-pandemic slope of mortality rates and is the coefficient  $\beta_1$  of the regression equation shown in the text.

<sup>b</sup>"Pandemic trend" means the slope of mortality rates after the onset of the pandemic and is the sum of  $\beta_1$  and  $\beta_2$ .

<sup>c</sup>"Rate change" means the change in the mortality rates between before and after the onset of the pandemic, and is  $\beta_2$ .

<sup>d</sup>"Trend change" means the difference in the mortality rate slopes before and after the onset of the pandemic, and is  $\beta_3$ .

<sup>e</sup>Cumulative difference in suicide rates during the pandemic is calculated using  $\beta_2$  and  $\beta_3$ . Cumulative excess deaths are obtained by multiplying the cumulative difference by the mean monthly population. For more details on the computations, please refer to the Stata code in Supplementary .

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

	Pre-pandemic trend <sup>a</sup>	Pandemic trend <sup>b</sup>	Rate change <sup>c</sup>	Trend change <sup>d</sup>	Cumulative excess death <sup>e</sup>
	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)
<b>Under 20 years</b>	0.0013 (−0.000,002 to 0.0025)	−0.0041 (−0.0105 to 0.0023)	0.0745 (−0.0204 to 0.1694)	−0.0054 (−0.0118 to 0.0011)	34 (−107 to 175)
<b>20–29 years</b>	−0.0055* (−0.0097 to −0.0013)	−0.0037 (−0.0275 to 0.0202)	0.3185 (−0.0410 to 0.6780)	0.0018 (−0.0225 to 0.0262)	466** (169 to 763)
<b>30–39 years</b>	−0.0021 (−0.0068 to 0.0026)	−0.0007 (−0.0269 to 0.0254)	0.0357 (−0.3569 to 0.4282)	0.0014 (−0.0251 to 0.0279)	76 (−275 to 427)
<b>40–49 years</b>	−0.0070*** (−0.0107 to −0.0032)	0.0117 (−0.0079 to 0.0313)	0.0150 (−0.2889 to 0.3189)	0.0187 (−0.0013 to 0.0387)	423* (97 to 749)
<b>50–59 years</b>	−0.0086*** (−0.0120 to −0.0052)	0.0091 (−0.0086 to 0.0268)	−0.1575 (−0.4348 to 0.1199)	0.0177 (−0.0003 to 0.0357)	66 (−206 to 338)
<b>60–69 years</b>	−0.0051*** (−0.0078 to −0.0025)	−0.0071 (−0.0203 to 0.006)	−0.0089 (−0.1941 to 0.1763)	−0.0020 (−0.0154 to 0.0114)	−49 (−241 to 142)
<b>70–79 years</b>	−0.0081*** (−0.0111 to −0.0052)	−0.0040 (−0.0144 to 0.0064)	0.0143 (−0.1416 to 0.1702)	0.0041 (−0.0066 to 0.0148)	94 (−85 to 273)
<b>80 years or older</b>	−0.0094** (−0.0149 to −0.0039)	−0.0179 (−0.0360 to 0.0003)	0.2751 (−0.0141 to 0.5642)	−0.0085 (−0.0272 to 0.0102)	163 (−41 to 368)

**Table 2: Summaries of interrupted time series regression analyses of the impact of the COVID-19 pandemic on suicide and estimated number of cumulative excess deaths by suicide during the pandemic period by age among Japanese men.**

<sup>a</sup>"Pre-pandemic trend" means the pre-pandemic slope of mortality rates and is the coefficient  $\beta_1$  of the regression equation shown in the text.

<sup>b</sup>"Pandemic trend" means the slope of mortality rates after the onset of the pandemic and is the sum of  $\beta_1$  and  $\beta_2$ .

<sup>c</sup>"Rate change" means the change in the mortality rates between before and after the onset of the pandemic, and is  $\beta_2$ .

<sup>d</sup>"Trend change" means the difference in the mortality rate slopes before and after the onset of the pandemic, and is  $\beta_3$ .

<sup>e</sup>Cumulative difference in suicide rates during the pandemic is calculated using  $\beta_2$  and  $\beta_3$ . Cumulative excess deaths are obtained by multiplying the cumulative difference by the mean monthly population. For more details on the computations, please refer to the Stata code in Supplementary Appendix 6.

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

(421, 95%CI: 242 to 600), followed by 396 (95%CI: 189 to 603) in women 60–69 years, 352 (95%CI: 117 to 587) in women 20–29 years, 325 (95%CI: 98 to 551) in women 70–79 years, and 322 (95%CI: 63 to 582) in women 50–59 years.

Results of the sensitivity analyses investigating an earlier start to the pandemic (Supplementary Table 2), adjusting for month as seasonality (Supplementary Table 3), and using confirmed suicide figures from January 2018 to December 2021

(Supplementary Table 4) did not substantially differ from the main analyses.

## Discussion

Previous studies have reported that the number of suicides in Japan at the beginning of pandemic (February to June 2020) were lower than corresponding months in previous years, but increased after July 2020.<sup>5–7</sup> However, these studies did not investigate how time

	Pre-pandemic trend <sup>a</sup>	Pandemic trend <sup>b</sup>	Rate change <sup>c</sup>	Trend change <sup>d</sup>	Cumulative excess death <sup>e</sup>
	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)
<b>Under 20 years</b>	0.0015** (0.0006 to 0.0024)	0.0019 (−0.0036 to 0.0073)	0.0375 (−0.0452 to 0.1201)	0.0004 (−0.0051 to 0.0059)	89 (−14 to 191)
<b>20–29 years</b>	0.0023 (−0.0009 to 0.0055)	0.0066 (−0.0173 to 0.0306)	0.2254 (−0.140 to 0.5909)	0.0043 (−0.0196 to 0.0282)	352** (117 to 587)
<b>30–39 years</b>	−0.0040*** (−0.0060 to −0.0019)	−0.0025 (−0.0196 to 0.0145)	0.2778* (0.0060 to 0.5496)	0.0014 (−0.0156 to 0.0185)	421*** (242 to 600)
<b>40–49 years</b>	−0.0009 (−0.0045 to 0.0026)	−0.0048 (−0.0250 to 0.0154)	0.1945 (−0.1439 to 0.5328)	−0.0038 (−0.0242 to 0.0165)	285 (−91 to 661)
<b>50–59 years</b>	−0.0033* (−0.0064 to −0.0002)	0.0029 (−0.0158 to 0.0215)	0.1164 (−0.1714 to 0.4043)	0.0062 (−0.0125 to 0.0249)	322* (63 to 582)
<b>60–69 years</b>	−0.0050*** (−0.0076 to −0.0025)	−0.0019 (−0.0145 to 0.0106)	0.2040* (0.0150 to 0.3930)	0.0031 (−0.0097 to 0.0159)	396*** (189 to 603)
<b>70–79 years</b>	−0.0061*** (−0.0088 to −0.0034)	−0.0022 (−0.0133 to 0.0089)	0.1325 (−0.0506 to 0.3156)	0.0039 (−0.0074 to 0.0152)	325** (98 to 551)
<b>80 years or older</b>	−0.0057*** (−0.0081 to −0.0033)	0.0021 (−0.0128 to 0.0171)	0.0078 (−0.2286 to 0.2442)	0.0078 (−0.0071 to 0.0228)	148 (−54 to 350)

**Table 3: Summaries of interrupted time series regression analysis of the impact of the COVID-19 pandemic on suicide and estimated number of cumulative excess deaths by suicide during the pandemic period by age among Japanese women.**

<sup>a</sup>Pre-pandemic trend" means the pre-pandemic slope of mortality rates and is the coefficient  $\beta_1$  of the regression equation shown in the text.

<sup>b</sup>Pandemic trend" means the slope of mortality rates after the onset of the pandemic and is the sum of  $\beta_1$  and  $\beta_2$ .

<sup>c</sup>Rate change" means the change in the mortality rates between before and after the onset of the pandemic, and is  $\beta_2$ .

<sup>d</sup>Trend change" means the difference in the mortality rate slopes before and after the onset of the pandemic, and is  $\beta_3$ .

<sup>e</sup>Cumulative difference in suicide rates during the pandemic is calculated using  $\beta_2$  and  $\beta_3$ . Cumulative excess deaths are obtained by multiplying the cumulative difference by the mean monthly population. For more details on the computations, please refer to the Stata code in Supplementary Appendix 6.

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

trends in suicide rates changed after the onset of the pandemic compared to the pre-pandemic period. One international study by Pirkis et al. used suicide data from 5 middle- and 16 high-income countries, including Japan, to investigate suicide trends during the early stages of the pandemic (through July 2020) compared to the pre-pandemic period (from January 2019).<sup>4</sup> They also reported no significant increase in any country. However, none of these studies stratified data by age or gender and no low-income or lower-middle-income countries were included.

In our interrupted time series analysis that considered linear trends in the pre-pandemic period and seasonal variations to investigate the impact of the COVID-19 pandemic on suicide rates in Japan, we focused on gender and age-group. We did not find statistically significant results of the impact of the pandemic on suicide rates for men and women overall. However, gender-/age-specific analyses revealed that the impact of the pandemic on suicide rates varied considerably by gender and age. While younger (20–29 years) and middle aged (40–49 years) men were significantly affected, for women, only those under 20, 40–49 and 80 years or older, were not significantly impacted. Our results, therefore, suggest that the pandemic had a greater impact on women than on men and on the young working generation than on older generations. These findings are consistent with previous Japanese

studies.<sup>5–7</sup> In addition to women and the younger generation, Matsumoto et al. reported that those living alone or those living in metropolitan areas were also at increased risk.<sup>7</sup> Increased suicide rates have also been reported in economically disadvantaged countries such as Malawi, Nepal, and Thailand.<sup>4,22,23</sup> Furthermore, studies in the US states of Maryland and Connecticut reported a decrease in suicide rates among whites during the pandemic compared to the pre-pandemic period, but an increase in suicide rates among non-whites.<sup>10,11</sup> Findings from low-income or lower-middle-income countries, Japan and the US indicate that further studies investigating the impact of the pandemic on suicide trends need to focus not only on the population as a whole but also on subgroups of the population, with particular attention to the socioeconomically vulnerable, such as women, younger generations, those living alone, and ethnic minorities. The increase in suicides in Japan during the pandemic period may be due to the recent increase in the proportion of vulnerable people in Japan and the lack of public and non-public support in place to support such people. In those countries and regions where suicides have not significantly increased during the pandemic, public and non-public support systems for residents may have worked more effectively than in Japan. However, this needs to be studied further in future studies.



Recent studies have investigated reasons for suicide and factors associated with worsening mental health among Japanese during the COVID-19 pandemic. Koda et al. examined monthly trends in suicide rates by reason up to May 2021.<sup>24</sup> The results showed that Japanese women experienced an increase in suicide in all reason categories during the pandemic, and in particular, an increase in suicides for reasons related to family, health and work. Ando et al. examined whether the COVID-19-induced employment shocks are associated with an increase in suicides in the second and third quarters of 2020.<sup>25</sup> They found that if a region experienced a one-percentage-point increase in the unemployment rate caused by the COVID-19 crisis in the second quarter of 2020, this was associated with a 60.5% and 26.5% increase in female and male suicide rates, respectively in July 2020 compared with July 2019. Sasaki et al. conducted a cross-sectional study in August–September 2020 of 12,249 Japanese workers aged 20–65 years on the association between the various factors and suicidal ideation.<sup>26</sup> The results showed that newly developed suicidal ideation after the pandemic was significantly higher among people of a young age, employees in the drinking/eating/hotel business industry, and those having a history of psychiatric disease than among their counterparts. Ueda et al. conducted a monthly internet survey of Japanese people's employment status and symptoms of depression and anxiety from April to October 2020.<sup>6</sup> The results showed that young women's mental health status was deteriorating in the pandemic and that young female workers were more likely to have experienced a job or income loss than any other group, suggesting adverse economic conditions surrounding them. These findings suggest that during the pandemic period, Japanese people, especially women and the younger generation, were exposed to various types of stress in their employment and living situations, which resulted in a deterioration of their mental health and consequently an increase in suicides. Our study shows that trends in suicide rates in Japan have changed substantially in the period from April 2020 to December 2021 compared to before the COVID-19 pandemic. And the findings of our study may indicate that the various policies implemented so far in Japan during the pandemic period have not been sufficient to prevent suicide. Therefore, it will be necessary not only to further investigate the factors associated with suicide risk in more detail in the future, but also to conduct further research for effective suicide prevention. In addition, extensive media coverage of the suicides of famous actors and actresses after July 2020 may have influenced the younger generation to commit suicide.<sup>27</sup> An analysis of reasons for suicide by Koda et al. also suggests that copycat suicides may have increased among women.<sup>24</sup>

Strengths of this study are that it used the most recently published national suicide data in Japan and

assessed the impact of the pandemic on suicide risk through a regression model that accounted for pre-pandemic time trends and seasonal variations. In addition, analyses were conducted separately for gender and age group to identify potential differences in socioeconomically vulnerable subgroups. However, there are several limitations that also need to be considered. Firstly, the data on suicides used in this study is provisional. Confirmed monthly data on suicides in Japan were not available prior to December 2017, and only provisional figures were available. For this reason, although the study analyses time-series trends in suicide rates from January 2016 to December 2021, provisional values are unavoidably also used for the period between January 2018 and December 2021 in order to maintain consistency in data quality. Consequently, we conducted a sensitivity analysis using the confirmed values for the period between January 2018 and December 2021. This produced roughly the same results as the main analysis using the provisional values for the period between January 2016 and December 2021. Therefore, we believe our analysis using provisional suicide data can be considered reliable. Secondly, since this study was stratified by gender and age group, some categories may not have had sufficient power to detect any statistically significant change. We failed to detect any statistically significant changes in trends of monthly suicide rates before and after the pandemic in women by age group, which may have been due to the low number of overall suicides in women. Third, our study did not focus on suicide methods used. One previous study reported that among the main suicide methods, only suicide by hanging increased in the second half of 2020 and the first half of 2021, compared to pre-pandemic levels in Japan.<sup>7</sup> According to the suicide statistics, suicide by hanging was the most commonly used suicide method in 2021, accounting for 66.6% of suicides.<sup>12</sup> Therefore, the finding, where a significant increase was observed only for suicide by hanging during the pandemic period, suggests that the distribution of suicide method has not changed much in Japan before and after the onset of the pandemic. However, because the findings on suicide methods used may be useful for suicide prevention and monitoring, an analysis of suicide methods used during the pandemic will need to be adequately addressed in the future. Fourth, the study does not examine the relationship between suicide rates and socioeconomic factors such as unemployment rates since the purpose of this study is to determine the direct and indirect impact of the pandemic on suicide rates in Japan. Measures to prevent the spread of COVID-19 have led to many social restrictions, both globally and in Japan. The findings of our study indicate a dramatic increase in suicides in Japan after the onset of the pandemic compared to the pre-pandemic period. Since there seems to be no other plausible factor that could have induced this increase, we believe the COVID-19

pandemic and resulting social restriction are the reason for the increase and, consequently, we believe that the models used in our analysis are valid.

Regrading implications for public health policies and future research. This study found that even within the same country, trends in suicide rates during the COVID-19 pandemic differed by gender and by age. Previous studies have also shown that suicide rates during the pandemic period vary greatly by ethnic groups.<sup>10,11</sup> Therefore, the impact of the COVID-19 crisis on the suicide and mental health of a population should not only be analyzed at the population level, but also in subgroups by gender, age, ethnicity and socioeconomic status, etc.

In Japan, it has been pointed out that during the COVID-19 pandemic, socioeconomic disparities that existed before the pandemic became even more disparate.<sup>28</sup> The Japanese government has been providing financial support to its citizens during the COVID-19 pandemic such as giving every citizen 100,000 yen (around US \$870).<sup>29</sup> However, not all citizens have been adversely affected financially by the pandemic, so providing more targeted financial support to more socioeconomically vulnerable groups such as women and younger generations is something that the Japanese government needs to consider. This solution, however, does not address the root cause of one of the problems, namely, having a large proportion of the woman workforce in part-time and non-permanent jobs. Japan has historically created incentives for married women to limit their employment to lower paid noncareer track jobs, so they and their husband can take advantage of spousal deduction benefits. This not only makes women financially dependent on men but also creates a situation where it is difficult to leave them if they become victims of domestic violence.

Finally, while this study was conducted using data through December 2021, the COVID-19 epidemic is still evolving, particularly with the emergence of new vaccine-evading variants. The longer the pandemic continues, the greater the negative impact on mental public health is likely to be. Therefore, continued vigilance and close monitoring of suicide mortality rates and the mental health of populations remains a priority. Future studies will also need to identify specific factors associated with changes in suicide rates during the COVID-19 pandemic so that targeted public health interventions can be made to help those at greatest risk of suicide.

#### Contributors

EY contributed to the conception, design, funding acquisition, acquisition of data, and analysis and interpretation of data. He drafted the article and approved the final version to be published. SJBH contributed to the analysis and interpretation of data, drafted the

article and approved the final version to be published. YS contributed to the analysis and interpretation of data and revised it critically for important intellectual content and approved the final version to be published. YS contributed to the analysis and interpretation of data and revised it critically for important intellectual content and approved the final version to be published.

#### Declaration of interests

We declare no competing interests.

#### Data sharing

The suicide data used in the main analysis of this study is presented in Supplementary Appendix 5. The rest of the data used in this manuscript are publicly available.

Suicide data are available from the website of suicide statistics (<https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html>).

Data about population estimate are available from the website of Statistics Bureau of Japan (<https://www.e-stat.go.jp/stat-search/files?page=1&toukei=00200241&tstat=000001039591>).

#### Acknowledgments

This work is supported by a Grant-in-Aid for scientific research from the Ministry of Education, Culture, Sports, Science and Technology of Japan (Award Number 21K10462). We thank Dr Paul Corcoran for kindly responding to our email questions about his paper, which was very useful in the analysis of this paper.

#### Supplementary materials

Supplementary material associated with this article can be found in the online version at doi: [10.1016/j.lanwpc.2022.100480](https://doi.org/10.1016/j.lanwpc.2022.100480).

#### References

- Pierce M, Hope H, Ford T, et al. Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. *Lancet Psychiatry*. 2020;7:883–892.
- Gunnell D, Appleby L, Arensman E, et al. Suicide risk and prevention during the COVID-19 pandemic. *Lancet Psychiatry*. 2020;7:468–471.
- Zortea TC, Brenna CTA, Joyce M, et al. The impact of infectious disease-related public health emergencies on suicide, suicidal behavior, and suicidal thoughts: a systematic review. *Crisis*. 2021;42:474–487.
- Pirkis J, John A, Shin S, et al. Suicide trends in the early months of the COVID-19 pandemic: an interrupted time-series analysis of preliminary data from 21 countries. *Lancet Psychiatry*. 2021;8:579–588.
- Tanaka T, Okamoto S. Increase in suicide following an initial decline during the COVID-19 pandemic in Japan. *Nature Human Behav*. 2021;5:229–238.
- Ueda M, Nordström R, Matsubayashi T. Suicide and mental health during the COVID-19 pandemic in Japan. *J Public Health (Bangkok)*. 2021. <https://doi.org/10.1093/pubmed/fdab113>. published online April 13.



- 7 Matsumoto R, Motomura E, Fukuyama K, Shiroyama T, Okada M. Determining what changed Japanese suicide mortality in 2020 using governmental database. *J Clin Med*. 2021;10. <https://doi.org/10.3390/jcm10215199>.
- 8 Kölves K, Kölves KE, de Leo D. Natural disasters and suicidal behaviours: a systematic literature review. *J Affect Disord*. 2013;146:1–14.
- 9 Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. *Int J Epidemiol*. 2017;46:348–355.
- 10 Bray MJ, Daneshvari NO, Radhakrishnan I, et al. Racial Differences in Statewide Suicide Mortality Trends in Maryland during the Coronavirus Disease 2019 (COVID-19) Pandemic. *JAMA Psychiatry*. 2021;78:444–447.
- 11 Mitchell TO, Li L. State-Level Data on Suicide Mortality During COVID-19 quarantine: early evidence of a disproportionate impact on racial minorities. *Psychiatry Res*. 2021;295:113629.
- 12 Ministry of Health, Labor and Welfare. Suicide statistics [in Japanese]. 2022. <https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html>. Accessed 8 April 2022.
- 13 Statistics of Japan. Population estimates in Japan. 2021. [https://www.e-stat.go.jp/en/stat-search/files?page=1&layout=datalist&toukei=00200524&tstat=000000090001&cycle=1&tclass1=000001011678&cycle\\_facet=tclass1%3Acycle&tclass2val=0](https://www.e-stat.go.jp/en/stat-search/files?page=1&layout=datalist&toukei=00200524&tstat=000000090001&cycle=1&tclass1=000001011678&cycle_facet=tclass1%3Acycle&tclass2val=0). Accessed 1 December 2021.
- 14 National Cancer Institute. Joinpoint Trend Analysis Software. 2021. <http://surveillance.cancer.gov/joinpoint/>. Accessed 1 December 2021.
- 15 Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27:299–309.
- 16 Bhaskaran K, Gasparrini A, Hajat S, Smeeth L, Armstrong B. Time series regression studies in environmental epidemiology. *Int J Epidemiol*. 2013;42:1187–1195.
- 17 Corcoran P, Griffin E, Arensman E, Fitzgerald AP, Perry IJ. Impact of the economic recession and subsequent austerity on suicide and self-harm in Ireland: an interrupted time series analysis. *Int J Epidemiol*. 2015;44:969–977.
- 18 Laliotis I, Ioannidis JPA, Stavropoulou C. Total and cause-specific mortality before and after the onset of the Greek economic crisis: an interrupted time-series analysis. *Lancet Public Health*. 2016;1:e56–e65.
- 19 National Institute of Infectious Diseases. Coronavirus disease (COVID-19). <https://www.niid.go.jp/niid/en/2019-ncov-e/9495-covid19-en.html>. Accessed 5 March 2022.
- 20 Bernal JAL, Gasparrini A, Artundo CM, McKee M. The effect of the late 2000s financial crisis on suicides in Spain: an interrupted time-series analysis. *Eur J Public Health*. 2013;23:732–736.
- 21 Chang YH, sen Chang S, Hsu CY, Gunnell D. Impact of pandemic on suicide: excess suicides in Taiwan during the 1918–1920 influenza pandemic. *J Clin Psychiatry*. 2020;81. <https://doi.org/10.4088/JCP.2013454>.
- 22 Ketphan O, Juthamanee S, Racial SJ, Bunpitaksakun D. The mental health care model to support the community during the covid-19 pandemic in Thailand. *Belitung Nurs J*. 2020;6. <https://doi.org/10.33546/bnj.1193>.
- 23 Pokhrel S, Sedhai YR, Atreya A. An increase in suicides amidst the coronavirus disease 2019 pandemic in Nepal. *Med Sci Law*. 2021;61:161–162.
- 24 Koda M, Harada N, Eguchi A, Nomura S, Ishida Y. Reasons for suicide during the COVID-19 pandemic in Japan. *JAMA Netw Open*. 2022. <https://doi.org/10.1001/jamanetworkopen.2021.45870>.
- 25 Ando M, Furuichi M. The association of COVID-19 employment shocks with suicide and safety net use: an early-stage investigation. *PLoS One*. 2022;17: e0264829.
- 26 Sasaki N, Tabuchi T, Okubo R, Ishimaru T, Kataoka M, Nishi D. Temporary employment and suicidal ideation in COVID-19 pandemic in Japan: a cross-sectional nationwide survey. *J Occup Health*. 2022;64:e12319.
- 27 Japan suicide countermeasures promotion center. Immediate report: analysis on suicide trends during the COVID-19 pandemic (Interim Report) [in Japanese]. 2020 [https://jscp.or.jp/research/kinkyureport\\_201021.html](https://jscp.or.jp/research/kinkyureport_201021.html). Accessed 1 March 2022.
- 28 Kikuchi S, Kitao S, Mikoshiba M. Heterogeneous Vulnerability to the COVID-19 crisis and implications for inequality in Japan. *RIETI Discussion Paper Series*. 2020. <https://www.rieti.go.jp/jp/publications/dp/20e039.pdf>. Accessed 1 December 2021.
- 29 Ando M, Furukawa C, Nakata D, Sumiya K. Fiscal responses to the COVID-19 crisis in Japan: the first six months. *Natl Tax J*. 2020;73:901–926.