BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers’ comments and the authors’ responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open’s open peer review process please email info.bmjopen@bmj.com
# Impact of regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan

| Journal:          | BMJ Open           |
|-------------------|--------------------|
| Manuscript ID     | bmjopen-2020-037537|
| Article Type:     | Original research  |
| Date Submitted by the Author: | 06-Feb-2020 |
| Complete List of Authors: | Okada, Motohiro; Mie University, Neuropsychiatry |
|                    | Hasegawa, Toshiki; Mie University |
|                    | Kato, Ryo; Mie University, |
|                    | Shiroyama, Takashi; Mie University, Neuropsychiatry |
| Keywords:         | EPIDEMIOLOGY, HEALTH ECONOMICS, PUBLIC HEALTH, Suicide & self-harm < PSYCHIATRY |
I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd (“BMJ”) its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge (“APC”) for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author’s Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.
Impact of regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan

Motohiro Okada *, Toshiki Hasegawa, Ryo Kato and Takashi Shiroyama

Department of Neuropsychiatry, Division of Neuroscience, Graduate School of Medicine, Mie University; Tsu 514-8507, Japan. t-hasegawa@clin.mediec.mie-u.ac.jp (T.H.), ryo-kato@clin.mediec.mie-u.ac.jp (R.K.), takashi@clin.mediec.mie-u.ac.jp (T.S.), okadamot@clin.mediec.mie-u.ac.jp (M.O.)

* Correspondence: okadamot@clin.mediec.mie-u.ac.jp (M.O.); Tel.: +81-59-231-5018

Word Counts (3281)
Abstract

Objectives: To explore the mechanisms of decreased suicide mortality in Japan decreasing from 25.7 to 16.5 per 100,000 people following the comprehensive suicide prevention programme during 2009 to 2018, the present study determined the relationship among regional suicide mortality, socioeconomic data (GDP per capita, unemployment rates) and financial support for regional suicide prevention programmes.

Design and Setting: Effects of regional GDP per capita, unemployment rates and execution amount of financial support for regional suicide prevention programmes, “Emergency Fund to Enhance Community-Based Suicide Countermeasures” (EFECBSC) on age- and gender-fragmented suicide mortalities in Japan between 2009 and 2018 using stepwise multiple regression analysis. Data on each prefecture’s complete unemployment rate, GDP per capita and execution amount of EFECBSC sub-divisions were derived from official Japanese governmental database.

Results: Both prefectural enlightenment and intervention model programmes were found to lead to a decrease in the male suicide mortality, but were less effective in reducing female suicide mortality. Municipal enlightenment and intervention model programmes were also less effective in reducing suicide mortality. Municipal development programmes for listener and leader led to a greater decrease in suicide mortality for both male and female, compared to such programmes at the prefectural level. Contrary to our expectation, reduced complete unemployment rate reduced only suicide mortality in elder male population without affecting female suicide mortality.

Conclusion: These findings suggest an inverse relationship between financial support and suicide mortality in Japan. Furthermore, independent factors in the reduction of suicide mortality rates provide important information for planning evidence-based and cost-effective regional suicide prevention programmes.

Keywords: Suicide mortality, Japan, Prefecture, Municipality, Financial support

Strengths and limitations of this study

- To better inform public health policies, the effects of regional GDP per capita, unemployment rate and financial support for suicide prevention programmes on regional suicide mortality in Japan are analysed using stepwise multiple regression analysis.
- Financial support for suicide prevention programmes contributes to a greater reduction in male suicide mortality compared with that of female.
- Financial support for suicide prevention programmes and reduced unemployment rate related to reduction of suicide mortality of elder male suicide mortality, but GDP per capita did not affect in Japan.
- These findings reinforce the importance of governmental financial support for regional suicide prevention programmes and improvement of socioeconomic situation through the enhancement of regional resources.
- In spite of increase elder population which is high risk of suicide, the decreasing in national suicide mortality suggest the effectiveness of financial support for regional activities on the suicide mortality rates in other Asian countries which is aging and higher suicide mortality countries.

1. Introduction

Suicide is a major public health concern worldwide. In 2016, the global suicide death rate was approximately 800,000, and the annual global age-standardized suicide rate is 10.53 per 100,000 (WHO-model SDR). It has been well established that suicide mortality rates were increased by socioeconomic disabilities, including unemployment and reduced GDP per capita. In particular, in Japan, following the collapse of the asset bubble in 1991 and immediately following the 1997 Asian economic crisis, suicide mortality and complete unemployment rate in Japan were drastically increased, whereas the GDP per capita was tardily increased. Japan achieved the dubious distinction of having the highest suicide mortality rate among all Organisation for Economic Cooperation and Development countries.

The Japanese government sought to enhance its comprehensive suicide prevention programme, enacting the “Basic Law on Suicide Prevention” in 2006 and establishing the “General Policy on Comprehensive Measures against Suicide” in 2007. As part of this comprehensive suicide prevention programme, the Cabinet...
Office (CAO) established an “Emergency Fund to Enhance Community-Based Suicide Countermeasures” (EFECBSC) which contributed to the development of regional (prefectural/municipal) suicide prevention programmes between 2009-2014. Following the launch of the EFECBSC, Japanese suicide mortality saw a reduction to 12.8 per 100,000 population (WHO-model SDR) in 2018 (Raw data: approximately 26 during 2000-2009 to 16.5 per 100,000 in 2018) (Appendix 1). Furthermore, the complete unemployment rate in Japan was also decreased 50% during 2009-2018 (Appendix 1). Therefore, the detailed analysis of the effects of comprehensive suicide prevention programme and socioeconomic situations on suicide mortality should provide the important information for planning further suicide prevention programmes. EFECBSC was composed of ten independent sub-divisions which supported five independent prefectural and five municipal regional programmes (Figure 1). Each municipality submitted its regional (municipal) suicide prevention programme to its prefecture. Prefectures then submitted their prefectural programmes, along with municipal programmes, to EFECBSC of Cabinet Office (CAO) which allocated funds to each prefecture, including budgets for prefectures and municipalities (Figure 1). In this way, prefectural and municipal suicide prevention programmes were independent of each other (Figure 1).

Recently, our previous study conducted demonstrated that prefectural regional execution amount of EFECBSC size-dependently was related to a decrease in male suicide mortality between 2009 - 2018, but had no effect on female suicide mortality. Municipal execution amount of EFECBSC, however, decreased both male and female suicide mortalities. Interestingly, prefectural execution amount for “personal consultation support programme” was related to increase in male suicide mortality, with no change in female rate. These findings suggest that governmental financial support to improve regional suicide prevention programmes contributes to reduction of Japan’s national suicide mortality. However, sensitivities of male and female suicide mortalities were independent of each other. It has long been established that gender/age/regional factors contribute to suicide mortality risk. Prefectures with lower socioeconomic status, measured according to average yearly income and average savings, have been found to have higher suicide mortality risk. Therefore, based on these findings, and to develop more cost-effective and evidence-based regional suicide prevention programme, this study determined effects of execution amount of EFECBSC, unemployment rate and GDP per capita on age- and gender-fragmented suicide mortalities.

2. Materials and Methods

2.1. Data

Suicide mortality and population data for all 47 Japanese prefectures were obtained by the same methods of our previous study. Age-, gender-, and prefecture-fragmented suicide mortalities of all prefectures between 2009-2018 were obtained from Ministry of Health, Labour and Welfare (MHLW) and from Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC) of Japan (6-15). Annual age-, gender-, and prefecture-fragmented suicide mortalities were derived from “basic regional suicide data” (MHLW), and population exposure (denominator) was obtained from “basic resident register” (SBMIAC) (15).

Data on each prefecture’s complete unemployment rates, GDP per capita and execution amount of EFECBSC sub-divisions were derived from SBMIAC (16), CAO (7) and MHLW (17), respectively. The execution amounts for EFECBSC sub-divisions of each prefecture were calculated by dividing the EFECBSC for each year by the prefectural population of the same year.

2.2. Standardization of suicide mortality rates

Both (male plus female), male and female suicide mortalities were calculated separately within eight age subgroups: less than 19 years (10s), 20–29 years (20s), 30–39 years (30s), 40–49 years (40s), 50–59 years (50s), 60–69 years (60s), 70–79 years (70s), and over 80 years (80s). All 47 prefectures have a large population distribution, with mean±SD=2.7±2.6 million, median=1.7 million, maximum=12.5 million, and minimum=0.6 million. Therefore, to eliminate small population artifacts, age- and gender-fragmented prefectural suicide mortalities were calculated using the empirical Bayes standardized mobile ratio (EBSMR) (8) by the EB 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).

2.3. Statistical analysis
Least squares method was used to analyse time-dependent reduction trends in EBSMR of age/gender/prefectural specific groups during 2009-2018, by BellCurve for Excel ver.3.2 (BellCurve Inc, Tokyo, Japan)\(^2\). Stepwise multiple regression analysis (SPSS for Windows, version 26, IBM, Armonk, NY, USA) was used to explore the effects of execution amounts of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends. Multicollinearity of multiple regression analysis was suspected if the variance inflation factor (VIF) value was greater than 10.0.

2.4. Patient and public involvement

No patient and public were involved in this study. Only secondary data were used for the analyses.

3. Results

Stepwise multiple regression analysis detected significant effects of execution amount of EFECBSC sub-divisions and unemployment rates on EBSMR trends of male plus female, male and female, but in contrast to our expectation, per capita GDP did not affect these EBSMR trends (Table1 and Appendix 2).

### Table 1: Effects of the execution amounts of EFECBSC sub-divisions, unemployment rate and per capita GDP on EBSMR trends

| Gender     | Adjusted R\(^2\) | F     | P   | Factor                      | β    | P   | VIF |
|------------|------------------|-------|-----|------------------------------|------|-----|-----|
| Male+Female| 0.450            | 13.547| 0.001| Prefectural TCS              | -0.234| 0.05| 1.12|
|            |                  |       |     | Prefectural DLL              | 0.376| 0.01| 1.10|
|            |                  |       |     | Prefectural ELM              | -0.598| 0.001| 1.20|
| Male       | 0.264            | 9.247 | 0.001| Prefectural IVM              | -0.323| 0.05| 1.04|
|            |                  |       |     | Municipal ELM                | -0.38 | 0.01| 1.04|
| Female     |                  |       |     | Prefectural PCS              | 0.319| 0.01| 1.02|
|            |                  |       |     | Municipal ELM                | -0.418| 0.001| 1.02|
|            |                  |       |     | Prefectural ELM              | -0.375| 0.01| 1.11|
|            |                  |       |     | Municipal PCS                | 0.369| 0.01| 1.20|
|            |                  |       |     | Municipal ELM                | -0.308| 0.05| 1.11|
|            |                  |       |     | Municipal CUR                | 0.440| 0.001| 1.00|
| Male       | 0.380            | 10.388| 0.001| Prefectural PCS              | 0.319| 0.01| 1.02|
|            |                  |       |     | Prefectural ELM              | -0.418| 0.001| 1.02|
| Female     |                  |       |     | Prefectural PCS              | 0.319| 0.01| 1.02|
|            |                  |       |     | Municipal ELM                | -0.418| 0.001| 1.02|
|            |                  |       |     | Municipal ELM                | -0.375| 0.01| 1.11|
|            |                  |       |     | Municipal PCS                | 0.369| 0.01| 1.20|
|            |                  |       |     | Municipal ELM                | -0.308| 0.05| 1.11|
| Female     |                  |       |     | Municipal CUR                | 0.440| 0.001| 1.00|
| Male       | 0.336            | 6.812 | 0.001| Prefectural IVM              | -0.375| 0.01| 1.11|
|            |                  |       |     | Municipal PCS                | 0.369| 0.01| 1.20|
|            |                  |       |     | Municipal ELM                | -0.308| 0.05| 1.11|
|            |                  |       |     | Municipal CUR                | 0.440| 0.001| 1.00|
| Female     |                  |       |     | Prefectural PCS              | 0.319| 0.01| 1.02|
|            |                  |       |     | Municipal ELM                | -0.418| 0.001| 1.02|
|            |                  |       |     | Municipal ELM                | -0.375| 0.01| 1.11|
|            |                  |       |     | Municipal PCS                | 0.369| 0.01| 1.20|
|            |                  |       |     | Municipal ELM                | -0.308| 0.05| 1.11|
| Female     |                  |       |     | Municipal CUR                | 0.440| 0.001| 1.00|
| Male       | 0.406            | 11.463| 0.001| Prefectural ELM              | -0.300| 0.05| 1.15|
|            |                  |       |     | Municipal PCS                | -0.352| 0.01| 1.15|
|            |                  |       |     | Municipal ELM                | -0.427| 0.001| 1.09|
| Female     |                  |       |     | Prefectural PCS              | -0.268| 0.05| 1.04|
|            |                  |       |     | Municipal ELM                | -0.346| 0.01| 1.08|
|            |                  |       |     | Municipal IVM                | -0.321| 0.05| 1.08|
| Male       | 0.359            | 9.595 | 0.001| Prefectural PCS              | -0.268| 0.05| 1.04|
|            |                  |       |     | Municipal ELM                | -0.346| 0.01| 1.08|
|            |                  |       |     | Municipal IVM                | -0.321| 0.05| 1.08|
| Female     |                  |       |     | Prefectural PCS              | -0.268| 0.05| 1.04|
|            |                  |       |     | Municipal ELM                | -0.346| 0.01| 1.08|
|            |                  |       |     | Municipal IVM                | -0.321| 0.05| 1.08|

- Male
- Female
### Table 1: Effects of execution amount of ECECBSC sub-divisions, unemployment rates and per capita GDP on EBSMR trends of male plus female, male and female analysed by stepwise multiple regression analysis. Black and red painted data indicate the positive and negative factors for suicide prevention. Abbreviations mean personal consultation support programme (PCS), telephone consultation support programme (TCS), development programme of leaders and listeners (DLL), enlightenment programme (ELM) and intervention model programme (IVM).

#### 3.1. Effects of the execution amounts of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female

Stepwise multiple regression analysis detected significant effects of execution amount of ECECBSC sub-divisions and unemployment rates on EBSMR trends of male plus female, but GDP per capita did not affect EBSMR trends of male plus female (Table 1, Figure 2 and Appendix 2). EBSMR trends of 20s was decreased by prefectural “telephone consultation support programme” and “enlightenment programme” but was increased prefectoral “development programme of leaders and listeners”. 30s EBSMR trends was decreased by prefectoral “intervention model programme” and municipal “enlightenment programme”. 50s EBSMR trends was decreased by prefectoral “enlightenment programme” and complete unemployment rates, but was increased by prefectoral “personal consultation support programme”. 60s EBSMR trends was decreased by prefectoral “intervention model programme”, municipal “telephone consultation programme” and “enlightenment programme”, but was increased by municipal “personal consultation support programme”. 70s EBSMR trends was decreased by prefectoral “enlightenment programme”, municipal “telephone consultation programme” and “enlightenment programme”. 80s EBSMR trends was decreased by prefectoral “personal consultation support programme”, “enlightenment programme” and “intervention model programme”. Neither execution amount of EFECBSC, unemployment rate nor GDP per capita affected 40s EBSMR trends of male plus female.

#### 3.2. Effects of the execution amounts of EFECBSC sub-divisions, unemployment rates and per capita GDP on male EBSMR trends

Stepwise multiple regression analysis detected significant effects of execution amount of ECECBSC sub-divisions and unemployment rates on male EBSMR trends, but GDP per capita did not affect male EBSMR trends (Table 1, Figure 3 and Appendix 2). 20s EBSMR trends was decreased by prefectural “enlightenment programme”. 30s EBSMR trends was decreased by prefectural “intervention model programme” and municipal “enlightenment programme”. 40s EBSMR trends was decreased by prefectural “development programme of leaders and listeners”. Both EBSMR trends of 50s and 60s were decreased by prefectural “enlightenment programme” and complete unemployment rates, but was increased by prefectural “personal consultation support programme”. 70s EBSMR trends was decreased by prefectural “enlightenment programme” and municipal “development programme of leaders and listeners”. 80s EBSMR trends was decreased by prefectural “enlightenment programme” and “intervention model programme”, but was increased by municipal “personal consultation support programme”.

#### 3.3. Effects of the execution amounts of EFECBSC sub-divisions, unemployment rates and per capita GDP on female EBSMR trends

Stepwise multiple regression analysis detected significant effects of execution amount of ECECBSC sub-divisions and unemployment rates on female EBSMR trends, but GDP per capita did not affect (Table 1, Figure 4 and Appendix 2). EBSMR trends of 70s and 80s were decreased by municipal “development programme of leaders and listeners” and “enlightenment programme”, respectively. Contrary, EBSMR trends of 50s was
increased by prefectoral “personal consultation support programme”. Neither execution amount of EFECBSC, unemployment rate nor per capita GDP affected female EBSMR trends of 20s, 30s, 40s and 60s.

4. Discussion

4.1. Effects of unemployment rates and execution amount of EFECBSC sub-divisions on suicide mortality

This study indicates the age/gender-specific sensitivities of suicide mortalities to execution amount of EFECBSC and unemployment rate, whereas GDP per capita did not affect. Female EBSMR was not affected by complete unemployment rates and was less sensitive to EFECBSC compared with male EBSMR, since only female EBSMR of elder population (70s and 80s) were sensitive to municipal “development programme of leaders and listener” and “enlightenment programme”, respectively. Contrary to female EBSMR, the age-dependent sensitivity of male EBSMR can be broadly classified into two categories. Male EBSMR of over 50s were decreased by prefectoral “enlightenment programme”, and male EBSMR of 50s and 60s were decreased by reduced complete unemployment rate, but surprisingly increased by prefectoral “personal consultation support programme”. However, male EBSMR of younger 40s could not be detected the specific factors. These results suggest that improvement of socioeconomic condition and comprehensive suicide prevention programme which targeted the elder male suicide mortality have successfully decreased elder male suicide mortality, resulting in the reduced national suicide mortality rates.

In most regions of the world, including Japan, the male suicide mortality is over two times that of female. The suicide mortality of middle/production-aged and elderly populations is also higher than that of younger/adolescent populations in most regions. Moreover, there are gender differences in attitudes toward suicide, with males tending to possess more maladaptive attitudes about suicide. These patterns are found in all age-groups, from adolescents to elderly adults. Furthermore, nonlethal suicide attempts are more common among females, and males are more likely to use more lethal means than females. Taking such robust gender differences into consideration, one might expect that it would be common for validated approaches to suicide prevention to consider gender differences when planning and evaluating interventions. Unfortunately, insufficient attention has been paid to gender differences when considering suicide risk and intervention responses. Several studies have evaluated gender but failed to show gender differences.

In contrast to previous research, prior to the “Basic Act on Suicide Prevention” and “General Policies for Comprehensive Measures against Suicide”, some preliminary research was conducted in Japan regarding intervention model programmes and regional suicide prevention programmes. These preliminary studies reported the reduction in suicide mortality rates among over 65s, and that 70% of the reduced suicide mortality rate was due to addressing female risk factors. The suicide prevention programmes reported in these studies were comprised of workshops run by municipal public health nurses and social, recreational, physical, or volunteering group activities to enhance social support resources. In EFECBSC, these already implemented activities were categorized as municipal “personal consultation support programme”, “developmental programme of leaders and listeners” and “intervention model programme”. Females are less resistant to social/municipal resources and group meetings than males, resulting in the greater sensitivity of females to municipal systems of leaders and listeners. Moreover, the impairment of physical and mental functions associated with aging is exhibited in community and social communication dysfunction. In general, males are more socially affected than females. Therefore, the physical or psychological dysfunctions of elderly partner often means the loss of social relationships for both individuals. For individuals with aging social dysfunction, it is easy to understand why interventional active suicide prevention programmes, such as “personal consultation support programme” and “intervention model programme”, are more effective than passive programmes, such as “enlightenment programme” and “development programme of leaders and listeners”. In fact, based on these concepts, regional suicide prevention programmes in various prefectures have targeted the reduction of suicide mortality rates among the elderly.

As our previous research has suggested, the different sensitivities of male and female suicide mortality rates to prefectural suicide prevention programmes are, at least partially, explained by the gender-specific socioeconomic background of suicide pathology. Based on those previous findings, this study determined the effects of EFECBSC on suicide mortality rates of age- and gender-fragmented populations and hypothesized that enriching prefectoral social community support, including “enlightenment programme” and “intervention model programme”, will prevent an increase in male suicide mortality. Meeting our expectations, prefectoral “enlightenment programme” contributed significantly to the reduction of suicide mortality rates of a wide range
of age groups. However, contrary to expectations, although EFECBSC primarily targets the reduction of male suicide mortality, the effects of EFECBSC were limited to female suicide mortality. Moreover, male and female 40s EBMSR-RR was not related to any sub-division of EFECBSC. The less sensitive suicide mortalities of middle-production-aged groups (20s, 30s and 40s) to EFECBSC means that regional suicide prevention programmes do not address the suicide pathology of production-age populations. These disappointing results may be reasonable because, due to preliminary findings, elderly populations were the primary targets of regional suicide prevention programmes across prefectures and municipalities.29-32

It is considered that the drastically increase in the male suicide mortality in 1998 was not only due to the economic crisis and unemployment, but also due to fear of losing one’s job and/or corporate restructuring.12 38

Indeed, employment insecurity and lack of social protection in economically active environments have been associated with high suicide mortality rates among middle-aged Japanese males.13 Over the past two decades, increases in suicide mortality among middle-aged males as a result of modifications in the corporate environment have been observed in other Asian countries, such as South Korea, Hong Kong, and Taiwan.39 Therefore, improvement of employment insecurity and lack of social protection in economically active environments via regional suicide prevention programme plays important roles in the reduction of male suicide mortality.

Although Japanese women have experienced some social advancement, they continue to have primary responsibility for childcare in a social system that offers poor childcare support. Indeed, unemployment rates did not affect female suicide mortality. Many women are forced to play subordinate roles to men, due to limited childcare support resources, leading to temporary employment interruptions and decreasing social circles due to childcare demands.12 In addition, Japan’s declining birth rate and aging population place greater pressure on women to bear and rear children.40-42 If this proves to be a factor in female suicide, then improvements in childcare support resources, and supporting mothers in finding satisfaction in a relatively small childcare community, may contribute to a reduction in female suicide mortality rates. If improvements in socioeconomic disabilities, i.e. supportive system against childcare and employment insecurity, can contribute to prevention of suicide mortality rates, the target of regional suicide prevention programmes must be modified as soon as possible. Although various legal arrangements are required, development of comprehensive support system for commit suicide attempts individuals possibly contribute to reduced female suicide mortality, since nonlethal suicide attempts are more common among females.23

4.2. Limitations

There are several limitations to this study. Suicide mortality rates (EBSMR) were not disaggregated by municipality. Doing so might have provided more detailed information on the role of REAs in regional suicide prevention programmes and aging in the change in level. EFECBSC has contributed to the development of prefectural/municipal suicide prevention programmes, but the management of prefectural/municipal suicide prevention programmes is not limited to EFECBSC, and may also include prefectural/municipal finances. The present results indicated that prefectural “enlightenment programme”, “intervention model programme”, municipal “development programme of leaders and listeners” and “enlightenment programme” are most effective suicide prevention programmes; however, more detailed research is needed to confirm this conclusion. Because, we cannot deny the execution amount threshold for the function of each suicide prevention programmes. In other words, it should be considered that prefectural “development programme of leaders and listeners”, and prefectural and municipal “personal consultation programme” have not yet been developed sufficiently to contribute to reducing the suicide mortality. Indeed, the execution amount of prefectural “enlightenment programme” (28%), “intervention model programme” (17%), and municipal “enlightenment programme” (13%) executed the largest amount in the 10 EFECBSC sub-divisions, whereas the execution amount of prefectural “development programme of leaders and listeners” (7%), prefectural (6%) and municipal “personal consultation support programme” (5%) were smaller.

5. Conclusions

Further interventions for production-age populations (20s–40s) and females are necessary in order to further address the major causes of suicide mortality in Japan. Indeed, this study determined that EFECBSC is less effective in reducing the female suicide mortality rate compared to the male rate. In an aging country, such as Japan, having a detailed understanding of suicide mortality based on age structure, and identifying specific
innovations in suicide prevention programmes are essential for effective suicide prevention. Nevertheless, the general downward trend in suicide mortality suggests that Japan is making progress in developing a comprehensive prevention programme. Regional public health planners and policymakers at prefectural and municipal levels should consider specific actions to reduce regional suicide mortality by identifying the social drivers, and by offering programmes, such as personal and telephone consultation support, development programme of leaders and listeners, enlightenment programme, intervention model and unemployment. In the future, the budget structure should be made more cost-effective and, following several more detailed observations of suicide mortality rates in Japan, other Asian countries with aging populations and high suicide mortality rates can also reduce their suicide mortality rates.

Contributions: All authors were responsible for the development of the study design. MO is responsible for conceptualization. MO, TH and RK are responsible for data collection and statistical analysis. MO and TS have been involved in writing manuscript. All authors have read manuscript, contributed to and approved the manuscript.

Funding: This study was supported by Regional Suicide Countermeasures Emergency Enhancement Fund of Mie Prefecture.

Competing interests: The authors state no conflict of interest.

Data sharing statement: All raw data are available to any persons from Japanese National databases in Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC) 6 15 16, Cabinet Office (CAO) 7 and Ministry of Health, Labour and Welfare (MHLW) 17.

References

1. World Health Organization. Suicide Rates (per 100,000 Population). Global Health Observatory, Switzerland; WHO; 2016 [Available from: https://www.who.int/gho/mental_health/suicide_rates/en/ accessed 2019.12.1 2019.

2. Alothman D, Fogarty A. Global differences in geography, religion and other societal factors are associated with sex differences in mortality from suicide: An ecological study of 182 countries. J Affect Dis 2020;260:67-72. doi: 10.1016/j.jad.2019.08.093 [published Online First: 2019/09/08]

3. Norstrom T, Gronqvist H. The Great Recession, unemployment and suicide. J Epidemiol Community Health 2015;69(2):110-6. doi: 10.1136/jech-2014-204602 [published Online First: 2014/10/24]

4. Blasco-Fontecilla H, Perez-Rodriguez MM, Garcia-Nieto R, et al. Worldwide impact of economic cycles on suicide trends over 3 decades: differences according to level of development. A mixed effect model study. BMJ open 2012;2(3): doi: 10.1136/bmjopen-2011-000785

5. The Japanese Institute for Labour Policy and Training. Complete unemployment rate and effective opening-to-application rate 2020 [Available from: https://www.jil.go.jp/kokunai/statistics/timeseries/html/g0301.html accessed 2019.11.12.

6. Ministry of Health, Labour and Welfare. Basic data on suicide in the region 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html accessed 2019.11.12.

7. Cabinet Office. GDP Statistics 2019 [Available from: https://www.esri.cao.go.jp/jp/sna/menu.html accessed 2020.1.21 2020.

8. OECD. Suicide Rates (Indicator) 2018 [Available from: https://data.oecd.org/healthstat/suicide-rates.htm accessed 2019.11.12 2019.

9. Ministry of Health, Labour and Welfare. National Plan for Prevention of Suicide 2018 [Available from: https://www.mhlw.go.jp/kokoro/nation/about.html accessed 2019.11.12.

10. Ministry of Health, Labour and Welfare. Regional Suicide Countermeasures Emergency Enhancement Fund 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000134741.html accessed 2019.11.12.

11. Nakanishi M, Yamauchi T, Takeshima T. National strategy for suicide prevention in Japan: impact of a national fund on progress of developing systems for suicide prevention and implementing initiatives among local authorities. Psychiatry Clin Neurosci 2015;69(1):55-64. doi: 10.1111/pcn.12222

12. Kato R, Okada M. Can Financial Support Reduce Suicide Mortality Rates? International journal of environmental research and public health 2019;16(23):4797. doi: 10.3390/ijerph16101794
13. Kim SY, Kim MH, Kawachi I, et al. Comparative epidemiology of suicide in South Korea and Japan: effects of age, gender and suicide methods. *Crisis* 2011;32(1):5-14. doi: 10.1027/0227-5910/a000046 [published Online First: 2011/03/05]

14. Suzuki E, Kashima S, Kawachi I, et al. Prefecture-level economic conditions and risk of suicide in Japan: a repeated cross-sectional analysis 1975-2010. *Eur J Public Health* 2014;24(6):949-54. doi: 10.1093/eurpub/cku023 [published Online First: 2014/03/13]

15. Statistics Bureau of the Ministry of Internal Affairs and Communications. Population, demographics and number of households based on Basic Resident Register 2019 [Available from: http://www.soumu.go.jp/main_sosiki/jichi_gyousei/daityo/jinkou_jinkoudoutai-setaisuu.html] accessed 2019.11.12 2019.

16. Statistics Bureau of the Ministry of Internal Affairs and Communications. Labor force survey 2019 [Available from: https://www.stat.go.jp/data/roudou/pref/index.html accessed 2020.1.21 2020.]

17. Ministry of Health, Labour and Welfare. Bugets for suicide prevention programmes 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000133838.html accessed 2019.11.12 2019.]

18. Kawaguchi H, Koike S. Association between the Density of Physicians and Suicide Rates in Japan: Nationwide Ecological Study Using a Spatial Bayesian Model. *PLoS One* 2016;11(2):e0148288. doi: 10.1371/journal.pone.0148288 [published Online First: 2016/02/04]

19. World Health Organization. Suicide data 2017 [Available from: https://www.who.int/mental_health/prevention/suicide/countrydata/en/ accessed 2019.12.1.

20. Gould MS, Velting D, Kleinman M, et al. Teenagers’ attitudes about coping strategies and help-seeking behavior for suicidality. *J Am Acad Child Adolesc Psychiatry* 2004;43(9):1124-33. doi: 10.1097/01.chi.0000132811.06547.31 [published Online First: 2004/08/24]

21. World Health Organization. Preventing suicide: A global imperative: World Health Organization 2014.

22. Centers for Disease Control and Prevention. Suicide among adults aged 35-64 years—United States, 1999-2010. *MMWR Morb Mortal Wkly Rep* 2013;62(17):321-5. [published Online First: 2013/05/03]

23. Tsirigotis K, Gruszczynski W, Tsirigotis M. Gender differentiation in methods of suicide attempts. *Med Sci Monit* 2011;17(6):PH165-70. doi: 10.12659/msm.881887 [published Online First: 2011/08/02]

24. Gould MS, Kramer RA. Youth suicide prevention. *Suicide and life-threatening behavior* 2001;31(Supplement to Issue 1):6-31.

25. Weisz JR, Sandler IN, Durlak JA, et al. Promoting and protecting youth mental health through evidence-based prevention and treatment. *American psychologist* 2005;60(6):628.

26. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies: a systematic review. *JAMA* 2005;294(16):2064-74. doi: 10.1097/jama.294.16.2064 [published Online First: 2005/10/27]

27. Klimes-Dougan B, Klingbeil DA, Meller SJ. The impact of universal suicide-prevention programs on the help-seeking attitudes and behaviors of youths. *Crisis* 2013;34(2):82-97. doi: 10.1027/0227-5910/a000178

28. Oliver RJ, Spilsbury JC, Osiecki SS, et al. Brief report: Preliminary results of a suicide awareness mass media campaign in Cuyahoga County, Ohio. *Suicide and Life-Threatening Behavior* 2008;38(2):245-49.

29. Oyama H, Watanabe N, Ono Y, et al. Community-based suicide prevention through group activity for the elderly successfully reduced the high suicide rate for females. *Psychiatry Clin Neurosci* 2005;59(3):337-44. doi: 10.1111/j.1440-1819.2005.01379.x

30. Oyama H, Sakashita T, Ono Y, et al. Effect of community-based intervention using depression screening on elderly suicide risk: a meta-analysis of the evidence from Japan. *Community Ment Health J* 2008;44(5):311-20. doi: 10.1007/s10597-008-9132-0 [published Online First: 2008/03/26]

31. Oyama H, Koida J, Sakashita T, et al. Community-based prevention for suicide in elderly by depression screening and follow-up. *Community Ment Health J* 2004;40(3):249-63. [published Online First: 2004/07/21]

32. Oyama H, Goto M, Fujita M, et al. Preventing elderly suicide through primary care by community-based screening for depression in rural Japan. *Crisis* 2006;27(2):58-65. doi: 10.1027/0227-5910.27.2.58

33. Drapeau A, Boyer R, Lesage A. The influence of social anchorage on the gender difference in the use of mental health services. *J Behav Health Serv Res* 2004;31(3):372-84. doi: 10.1016/s1141-009-9168-0 [published Online First: 2009/03/03]

34. Sugimoto T, Sakurai T, Ono R, et al. Epidemiological and clinical significance of cognitive frailty: A mini review. *Aging Res Rev* 2018;44:1-7. doi: 10.1016/j.arr.2018.03.002 [published Online First: 2018/03/17]

35. Hamilton E, Klimes-Dougan B. Gender differences in suicide prevention responses: implications for adolescents based on an illustrative review of the literature. *International journal of environmental research and public health* 2015;12(3):2359-72. doi: 10.3390/ijerph12032359

36. Lapierre S, Erlangsen A, Waern M, et al. A systematic review of elderly suicide prevention programs. *Crisis* 2011;32(2):88-98. doi: 10.1027/0227-5910/a000076
Figure Legends

Figure 1: The ‘Emergency Fund to Enhance Community-Based Suicide Countermeasures’ (EFECBSC) submission and allocation process.

The EFECBSC was composed of five prefectoral sub-divisions: “personal consultation support programme”(PCS), “telephone consultation support programme”(TCS), “development programme of leaders and listeners”(DLL), “enlightenment programme”(ELM), and “intervention model programme”(IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM. Each municipality submitted its suicide prevention programmes to its prefecture. Each prefecture then submitted its own programme, together with the municipal programmes to the EFECBSC of the Cabinet office (CAO). The EFECBSC then allocated funds to each prefecture, which including budgets for both prefectures and municipalities[10].

Figure 2: Effects of the execution amount of EFECBSC sub-divisions and complete unemployment rate on EBSMR trends of male plus female.

Ordinates indicate EBSMR trends of male plus female of age-fragmented populations, and abscissas indicate execution amount of EFECBSC sub-divisions: “personal consultation support programme”(PCS), “telephone consultation support programme”(TCS), “development programme of leaders and listeners”(DLL), “enlightenment programme”(ELM), and “intervention model programme”(IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Brown and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.

Figure 3: Effects of the execution amount of EFECBSC sub-divisions and complete unemployment rate on male EBSMR trends.

Ordinates indicate male EBSMR trends of age-fragmented populations, and abscissas indicate execution amount of EFECBSC sub-divisions: “personal consultation support programme”(PCS), “telephone consultation support programme”(TCS), “development programme of leaders and listeners”(DLL), “enlightenment programme”(ELM), and “intervention model programme”(IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Blue and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.

Figure 4: Effects of the execution amount of EFECBSC sub-divisions and complete unemployment rate on female EBSMR trends.

Ordinates indicate female EBSMR trends of age-fragmented populations, and abscissas indicate execution amount of EFECBSC sub-divisions: “personal consultation support programme”(PCS), “telephone consultation support programme”(TCS), “development programme of leaders and listeners”(DLL), “enlightenment programme”(ELM), and “intervention model programme”(IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Blue and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.
Ordinates indicate female EBSMR trends of age-fragmented populations, and abscissas indicate execution amount of EFECBSC sub-divisions: “personal consultation support programme” (PCS), “telephone consultation support programme” (TCS), “development programme of leaders and listeners” (DLL), “enlightenment programme” (ELM), and “intervention model programme” (IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Red and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.
For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

101x123mm (300 x 300 DPI)
423x167mm (300 x 300 DPI)
1 Supplemental Data

2 Appendix 1: Trends in crude suicide mortality per 100,000 population, complete unemployment rate and GDP per capita between 1990 and 2018 in Japan. (p2).

4 Appendix 2: Effects of the execution amount of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female, male and female. (p3).
Appendix 1: Trends in crude suicide mortality per 100,000 population, complete unemployment rate and GDP per capita between 1990 and 2018 in Japan.

Note: The graph shows the relative data to the year 2009 of GDP per capita, complete unemployment rate, and suicide mortalities of male plus female, male, and female (%). Abscissas indicate years.
Appendix 2: Effects of the execution amount of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female, male and female.

Green and red columns indicate significant factors for reduced and increased EBSMR trends (standardised suicide mortality) of age/gender-fragmented Japanese populations detected by stepwise multiple regression analysis.
# STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

| Item No | Recommendation |
|---------|-----------------|
| 1       | (a) Indicate the study’s design with a commonly used term in the title or the abstract. |
|         | (b) Provide in the abstract an informative and balanced summary of what was done and what was found. |
| 2       | Explain the scientific background and rationale for the investigation being reported. |
| 3       | State specific objectives, including any prespecified hypotheses. |
| 4       | Present key elements of study design early in the paper. |
| 5       | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. |
| 6       | (a) Give the eligibility criteria, and the sources and methods of selection of participants. |
| 7       | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. |
| 8       | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. |
| 9       | Describe any efforts to address potential sources of bias. |
| 10      | Explain how the study size was arrived at. |
| 11      | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. |
| 12      | (a) Describe all statistical methods, including those used to control for confounding. |
|         | (b) Describe any methods used to examine subgroups and interactions. |
|         | (c) Explain how missing data were addressed. |
|         | (d) If applicable, describe analytical methods taking account of sampling strategy. |
|         | (e) Describe any sensitivity analyses. |
| 13      | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. |
|         | (b) Give reasons for non-participation at each stage. |
|         | (c) Consider use of a flow diagram. |
| 14      | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. |
|         | (b) Indicate number of participants with missing data for each variable of interest. |
| 15      | Report numbers of outcome events or summary measures. |
| 16      | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included. |
(b) Report category boundaries when continuous variables were categorized
(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 4-6 |

**Discussion**

| Key results | 18 | Summarise key results with reference to study objectives | 6-7 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 6-7 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 6-7 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 6-7 |

**Other information**

| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 8 |

*Give information separately for exposed and unexposed groups.*

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at [http://www.plosmedicine.org/](http://www.plosmedicine.org/), Annals of Internal Medicine at [http://www.annals.org/](http://www.annals.org/), and Epidemiology at [http://www.epidem.com/](http://www.epidem.com/)). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).
Analysing regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan using governmental statistical data

| Journal:       | BMJ Open          |
|---------------|-------------------|
| Manuscript ID | bmjopen-2020-037537.R1 |
| Article Type: | Original research |
| Date Submitted by the Author: | 25-Apr-2020 |
| Complete List of Authors: | Okada, Motohiro; Mie University, Neuropsychiatry Hasegawa, Toshiki; Mie University Kato, Ryo; Mie University, Shiroyama, Takashi; Mie University, Neuropsychiatry |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Health economics |
| Keywords: | EPIDEMIOLOGY, HEALTH ECONOMICS, PUBLIC HEALTH, Suicide & self-harm < PSYCHIATRY |
I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd (“BMJ”) its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge (“APC”) for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author’s Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.
Analysing regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan using governmental statistical data

Motohiro Okada *, Toshiki Hasegawa, Ryo Kato and Takashi Shiroyama

Department of Neuropsychiatry, Division of Neuroscience, Graduate School of Medicine, Mie University; Tsu 514-8507, Japan. t-hasegawa@clin.medic.mie-u.ac.jp (T.H.), ryo-kato@clin.medic.mie-u.ac.jp (R.K.), takashi@clin.medic.mie-u.ac.jp (T.S.), okadamot@clin.medic.mie-u.ac.jp (M.O.)

* Correspondence: okadamot@clin.medic.mie-u.ac.jp (M.O.); Tel.: +81-59-231-5018

Word Counts (3714)
Abstract

Objectives: To explore the mechanisms of decreased suicide mortality in Japan decreasing from 25.7 to 16.5 per 100,000 people following the comprehensive suicide prevention programme during 2009 to 2018, this present study determined the relationship among regional suicide mortality, socioeconomic data (GDP per capita, unemployment rates) and financial support for regional suicide prevention programmes.

Design and Setting: Effects of regional GDP per capita, unemployment rates and implementation amount of financial support for regional suicide prevention programmes, “Emergency Fund to Enhance Community-Based Suicide Countermeasures” (EFECBSC) on age- and gender-disaggregated suicide mortalities in Japan between 2009 and 2018 using stepwise multiple regression analysis. Data on each prefecture’s complete unemployment rates, GDP per capita and implementation amount of EFECBSC sub-divisions were derived from official Japanese governmental database.

Results: Both prefectural enlightenment and intervention model programmes were found to lead to a decrease in the male suicide mortality, but were less effective in reducing female suicide mortality. Municipal enlightenment and intervention model programmes were also less effective in reducing suicide mortality. Municipal development programmes for listener and leader led to a greater decrease in suicide mortality for both male and female, compared to such programmes at the prefectural level. Contrary to our expectation, reduced complete unemployment rate reduced only suicide mortality in elder male population without affecting female suicide mortality.

Conclusion: These findings suggest an inverse relationship between financial support and suicide mortality in Japan. Furthermore, independent factors in the reduction of suicide mortality rates provide important information for planning evidence-based and cost-effective regional suicide prevention programmes.

Keywords: Suicide mortality, Japan, Prefecture, Municipality, Financial support

Strengths and limitations of this study

- To better inform public health policies, the effects of regional GDP per capita, regional unemployment rate and financial support for regional suicide prevention programmes on regional suicide mortality in Japan are analysed using stepwise multiple regression analysis.
- Financial support for suicide prevention programmes and reduced unemployment rate related to reduction of suicide mortality of elder male suicide mortality, but GDP per capita did not affect in Japan, and this financial support contributes to a greater reduction in male suicide mortality compared with that of female.
- These findings reinforce the importance of governmental financial support for regional suicide prevention programmes and improvement of socioeconomic disability through the enhancement of regional welfare/social safety nets and improvement of regional social protection vulnerability.
- In spite of increase elder population which is high risk of suicide, the decreasing in national suicide mortality suggest the effectiveness of financial support for regional activities on the suicide mortality rates in other Asian countries which is aging and higher suicide mortality countries.
- The present study has several limitations, including only prefectural (but not municipal) suicide mortality and only “Japanese case” lacking an Asian perspective.

1. Introduction

Suicide is a major public health concern in worldwide. In 2016, the global suicide mortality was approximately 800,000, and the annual global age-standardized suicide rate is 10.53 per 100,000 population (WHO-model SDR). It has been well known that both unemployment and recessions are fundamental risk factors in increasing suicide mortality as “economic suicide” in Europe, North America and Asia. Indeed, in Japan, following the collapse of the asset bubble in 1991 and Asian economic crisis in 1997, both unemployment rate and suicide mortality in Japan was also drastically increased (Appendix1). This Japanese public health crisis turned to improvement at 2009. Suicide mortality had been kept approximately 26 per 100,000 during 2000-2009 (raw data), but has been decreasing to 16.5 per 100,000 at 2018 (Appendix 1).
The complete unemployment rate in Japan was also decreased 50% during 2010-2018 synced with the reduction of suicide mortality (Appendix 1)\textsuperscript{11}. Contrary to rates of suicide mortality and complete unemployment, Japanese GDP per capita has remained to be tardily/slightly increasing during early 1990s to 2018 (Appendix1)\textsuperscript{13}. Therefore, change of period for suicide crisis in Japan is considered to be 2009.

In the face of this public health crisis, at change of period (2009), Cabinet Office (CAO) established an “Emergency Fund to Enhance Community-Based Suicide Countermeasures” (EFECBSC) which contributed to the development of regional (prefectural/municipal) suicide prevention programmes during 2009-2014 \textsuperscript{10} \textsuperscript{14} \textsuperscript{15}. The main frame of EFECBSC was the enhancement of regional (prefectural/municipal) welfare/social safety nets and social protection system, and was composed of 10 independent sub-divisions which supported 5 independent prefectural and 5 municipal regional programmes, such as “personal consultation support programme”(PCS), “telephone consultation support programme”(TCS), “development programme of leaders and listeners”(DLL), “enlightenment programme”(ELM), and “intervention model programme”(IVM) (Figure1) \textsuperscript{14}. Each municipality submitted its municipal suicide prevention programme to its prefecture. Prefectures then submitted their prefectural programmes, along with municipal programmes, to EFECBSC of CAO which allocated funds to each prefecture, including budgets for prefectures and municipalities (Figure 1) \textsuperscript{14}. In this way, prefectural and municipal suicide prevention programmes were independent of each other (Figure 1) \textsuperscript{14}. EFECBSC enhanced regional welfare/social safety nets and improved regional social protection vulnerability\textsuperscript{10}. Therefore, these data in Japan suggest the possibility that financial support, such as EFECBSC, plays important roles in the reduction of suicide mortality via enhancement of regional welfare/social safety nets and social protection system.

Until recently, numerous public health studies reported that suicide mortality were increased by recessions and increasing unemployment rate; however, recent studies reported that suicide mortality is affected by not only simply unemployment/recessions but very complex multifactorial interaction among socioeconomic disabilities including unemployment, reduced GDP per capita, social protection vulnerability, recessions and austerity\textsuperscript{5-10} \textsuperscript{16} \textsuperscript{17}. Exactly, vulnerability of social protection system and high annual economic growth enhance and prevent the impact of unemployment on suicide mortality, respectively \textsuperscript{6} \textsuperscript{8}. Furthermore, the interaction between recession and austerity also increases the suicide mortality as a double boost \textsuperscript{16}. Against these multifactorial risks interaction, enhancements of welfare/social safety nets and labour market programmes supported by governmental finance contribute to improvement of suicide mortality in Europe, North America and Asia \textsuperscript{5} \textsuperscript{7} \textsuperscript{10} \textsuperscript{16}.

Based on achievements in reducing the suicide mortality in the past decade, in 2019, the Japanese government introduced a new national suicide prevention programme, ‘Law Concerning the Promotion of Research and Utilisation of Results to Contribute to the Comprehensive and Effective Implementation of Suicide Prevention’, of which major objectives include developing more cost-effective/evidence-based regional (prefectural/municipal) suicide prevention programme compared with EFECBSC \textsuperscript{12}. According to the new governmental suicide prevention programme, we recently demonstrated that regional (prefectural/municipal) implementation amount of EFECBSC was size-dependently and gender-specifically related to a decrease in suicide mortality during 2009-2018 \textsuperscript{10}. Especially, prefectural implementation amount of EFECBSC size-dependently decreased male suicide mortality, but had no effect on female suicide mortality; however, municipal implementation amount of EFECBSC decreased both male and female suicide mortalities\textsuperscript{10}. These findings suggest that governmental financial support to enhancement of regional suicide prevention programmes contributes to reduction of Japanese national suicide mortality, whereas sensitivities of male and female suicide mortalities were independent of each other \textsuperscript{10}. The gender-specific suicide mortality\textsuperscript{15} \textsuperscript{18} sensitivity is also observed in Europe, North America and Asia that economic downturns were associated with increased mainly male suicide mortality, whereas severe economic crises were associated with increased suicide mortalities of both male and female \textsuperscript{5} \textsuperscript{7} \textsuperscript{9}. In particular, in Italy governmental expenditure to active labour market programs provided the buffering mechanisms for the negative effect of socioeconomic disability on male suicide mortality aged 45-54 \textsuperscript{7}. Therefore, these gender/age-specific sensitivities against suicide mortality increasing and decreasing factors should be notable findings \textsuperscript{7} \textsuperscript{10}; however, the effects of EFECBSC on gender/age-specific suicide mortality has remained to be clarified.

In this study, we hypothesised that suicide mortality has gender/age-specific sensitivity to unemployment rate, GDP per capita and EFECBSC, based on above previous findings regarding the impacts of macroeconomic factors and governmental financial support on suicide mortality\textsuperscript{5-10}. Therefore, to develop more cost-effective/evidence-based regional suicide mortality prevention programme, in this study, we analyse the
impacts of prefecture-disaggregated unemployment rate, GDP per capita and regional (prefectural/municipal) implementation amount of EFECBSC 10 sub-divisions on gender/age-disaggregated suicide mortalities, during 2009-2018 at which national suicide mortality has been decreasing.

2. Materials and Methods

2.1. Data

Suicide mortality and population data for all 47 Japanese prefectures were obtained by the same methods of our previous study. Age-, gender-, and prefecture-disaggregated suicide mortalities of all 47 prefectures during 2009-2018 were obtained from Ministry of Health, Labour and Welfare (MHLW) and from Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC) of Japan. Annual age-, gender-, and prefecture-disaggregated suicide mortalities were derived from “basic regional suicide data”(MHLW), and population exposure(denominator) was obtained from “basic resident register” (SBMIAC). Data on each prefectural complete unemployment rates, GDP per capita during 2009-2018 and regional (prefectural/municipal) implementation amount of EFECBSC 10 sub-divisions during 2009-2014 were derived from SBMIAC, CAO and MHLW, respectively. The implementation amounts of 10 EFECBSC sub-divisions during 2009-2014 of each prefecture were calculated by dividing the EFECBSC for each year by the prefectural population of the same year.

2.2. Standardization of suicide mortality rates

Both (male plus female), male and female suicide mortalities were calculated separately within eight age subgroups: less than 19 years (10s), 20–29 years (20s), 30–39 years (30s), 40–49 years (40s), 50–59 years (50s), 60–69 years (60s), 70–79 years (70s), and over 80 years (80s). All 47 prefectures have a large population distribution, with mean±SD=2.7±2.6 million, median=1.7 million, maximum=12.5 million, and minimum=0.6 million. Therefore, to eliminate small population artefacts, age- and gender-disaggregated prefectural suicide mortalities were calculated using the empirical Bayes standardized mobile ratio (EBSMR) by the EB 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).

2.3. Statistical analysis

Least squares method was used to analyse time-dependent reduction trends in EBSMR of age/gender/prefectural specific groups during 2009-2018, by BellCurve for Excel ver.3.2 (BellCurve Inc, Tokyo, Japan). The trends of complete unemployment rate and GDP per capita during 2009-2018 were also calculated by least squares method (BellCurve for Excel ver.3.2). Implementation amounts of 10 EFECBSC sub-divisions, including prefectural and municipal PCS, TCS, DLL, ELM and IVM were calculated as sum of implementation amounts of EFECBSC 10 sub-divisions in each year during 2009-2014. This study was conducted to improve financial budget structures for activation of regional suicide prevention programme via cost-effective evaluation of ECEFBSC and clarification of specific vulnerabilities which was insufficiently covered by EFECBSC in regional welfare/social safety nets and regional social protection. Therefore, the present study, to quantify the effects of regional implementation amounts of EFECBSC 10 sub-divisions, unemployment rate and GDP per capita on regional EBSMR trends, adopted stepwise multiple regression analysis for these analyses. Stepwise multiple regression analysis with p values of 0.05 and 0.10 for respective entry and removal (SPSS for Windows, version 26, IBM, Armonk, NY, USA) was used to explore the effects of implementation amounts of EFECBSC 10 sub-divisions, regional trends of unemployment rate and GDP per capita on regional EBSMR trends of three groups, male, female and male plus female. The assumptions of multiple regression models were verified by Normal P-P plot for standardized residual regression (SPSS for Windows, version 26). Multicollinearity of multiple regression analysis was suspected if the variance inflation factor (VIF) value was greater than 2.5.

2.4. Patient and public involvement

No patient and public were involved in this study. Only secondary data were used for the analyses. This study was exempt from ethical approval from Mie University.
3. Results

Stepwise multiple regression analysis detected significant effects of implementation amount of ECECBSC sub-divisions and unemployment rates on EBSMR trends of male plus female, male and female, but in contrast to our expectation, GDP per capita did not affect these EBSMR trends (Table 1 and Appendix 2).

Table 1: Effects of implementation amounts of EFECBSC sub-divisions, unemployment rates and per capita GDP on EBSMR trends

| Male+Female | Adjusted $R^2$ | F    | $P$  | Factor      | $\beta$ | $P$  | VIF |
|-------------|---------------|------|------|-------------|---------|------|-----|
| 20s         | 0.450         | 13.547 | 0.001 | Prefectural TCS | -0.234  | 0.05 | 1.12 |
|             |               |       |      | Prefectural DLL | 0.376   | 0.01 | 1.10 |
|             |               |       |      | Prefectural ELM | -0.598  | 0.001 | 1.20 |
| 30s         | 0.264         | 9.247 | 0.001 | Prefectural IVM | -0.323  | 0.05 | 1.04 |
|             |               |       |      | Municipal ELM   | -0.38   | 0.01 | 1.04 |
| 40s         | 0.380         | 10.388 | 0.001 | Prefectural PCS | 0.319   | 0.01 | 1.02 |
|             |               |       |      | Prefectural ELM | -0.418  | 0.001 | 1.02 |
|             |               |       |      | CUR           | 0.440   | 0.001 | 1.00 |
| 50s         | 0.336         | 6.812 | 0.001 | Prefectural IVM | -0.375  | 0.01 | 1.11 |
|             |               |       |      | Municipal PCS  | 0.369   | 0.01 | 1.20 |
|             |               |       |      | Municipal ELM | -0.308  | 0.05 | 1.11 |
|             |               |       |      | CUR           | 0.325   | 0.05 | 1.11 |
| 60s         | 0.406         | 11.463 | 0.001 | Prefectural ELM | -0.300  | 0.05 | 1.15 |
|             |               |       |      | Municipal PCS  | 0.352   | 0.01 | 1.15 |
|             |               |       |      | Municipal ELM | -0.427  | 0.001 | 1.09 |
| 70s         | 0.359         | 9.595 | 0.001 | Prefectural PCS | -0.268  | 0.05 | 1.04 |
|             |               |       |      | Prefectural ELM | -0.346  | 0.01 | 1.08 |
|             |               |       |      | Prefectural IVM | -0.321  | 0.05 | 1.08 |

| Male        | Adjusted $R^2$ | F    | $P$  | Factor      | $\beta$ | $P$  | VIF |
|-------------|---------------|------|------|-------------|---------|------|-----|
| 20s         | 0.419         | 34.151 | 0.001 | Prefectural ELM | -0.657  | 0.001 | 1.00 |
| 30s         | 0.196         | 6.613 | 0.01 | Prefectural IVM | -0.328  | 0.05 | 1.04 |
|             |               |       |      | Municipal ELM | -0.295  | 0.05 | 1.04 |
| 40s         | 0.133         | 8.034 | 0.01 | Municipal DLL | -0.389  | 0.01 | 1.00 |
| 50s         | 0.497         | 16.122 | 0.001 | Prefectural PCS | 0.265   | 0.05 | 1.02 |
|             |               |       |      | Prefectural ELM | -0.552  | 0.001 | 1.02 |
|             |               |       |      | CUR           | 0.455   | 0.001 | 1.00 |
| 60s         | 0.291         | 7.281 | 0.001 | Prefectural PCS | 0.267   | 0.05 | 1.02 |
|             |               |       |      | Prefectural ELM | -0.417  | 0.01 | 1.02 |
|             |               |       |      | CUR           | 0.363   | 0.01 | 1.00 |
| 70s         | 0.322         | 11.934 | 0.001 | Prefectural ELM | -0.460  | 0.001 | 1.03 |
|             |               |       |      | Municipal DLL | -0.305  | 0.05 | 1.03 |
| 80s         | 0.343         | 8.995 | 0.001 | Prefectural ELM | -0.408  | 0.01 | 1.07 |
|             |               |       |      | Municipal PCS  | 0.274   | 0.05 | 1.09 |

| Female      | Adjusted $R^2$ | F    | $P$  | Factor      | $\beta$ | $P$  | VIF |
|-------------|---------------|------|------|-------------|---------|------|-----|
| 20s         |               |      |      |             |         |      |     |
| 30s         | 0.136         | 8.264 | 0.01 | Prefectural PCS | 0.394   | 0.01 | 1.00 |
| 40s         |               |      |      |             |         |      |     |
| 50s         | 0.217         | 13.726 | 0.01 | Municipal DLL | -0.483  | 0.001 | 1.00 |
| 60s         | 0.146         | 8.854 | 0.01 | Municipal ELM | -0.405  | 0.01 | 1.00 |

Table 1: Effects of implementation amount of ECECBSC 10 sub-divisions, trends of complete unemployment rates (CUR) and GDP per capita on EBSMR trends of male plus female, male and female analysed by stepwise multiple regression analysis. Black and red painted data indicate the
positively and negatively significant factors for suicide mortality. Abbreviations mean personal consultation support programme (PCS), telephone consultation support programme (TCS), development programme of leaders and listeners (DLL), enlightenment programme (ELM), intervention model programme (IVM) and complete unemployment rate (CUR).

3.1. Effects of the implementation amounts of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female

Stepwise multiple regression analysis detected significant effects of implementation amount of EFECBSC sub-divisions and unemployment rates on EBSMR trends of male plus female, but GDP per capita did not affect EBSMR trends of male plus female (Table 1, Figure 2 and Appendix 2). EBSMR trends of 20s was decreased by prefectural TCS (telephone consultation support programme) and ELM (enlightenment programme) but was increased prefectural DLL (development programme of leaders and listeners). 30s EBSMR trends was decreased by prefectural IVM (intervention model programme) and municipal ELM. 50s EBSMR trends was decreased by prefectural ELM and CUR (complete unemployment rate), but was increased by prefectural PCS (personal consultation support programme). 60s EBSMR trends was decreased by prefectural IVM, municipal TCS and ELM, but was increased by municipal PCS. 70s EBSMR trends was decreased by prefectural ELM, municipal TCS and ELM. 80s EBSMR trends was decreased by prefectural PCS, ELM and IVM. Neither implementation amount of EFECBSC, CUR nor GDP per capita affected 40s EBSMR trends of male plus female.

3.2. Effects of the implementation amounts of EFECBSC sub-divisions, unemployment rates and per capita GDP on male EBSMR trends

Stepwise multiple regression analysis detected significant effects of implementation amount of EECBSC sub-divisions and unemployment rates on male EBSMR trends, but GDP per capita did not affect male EBSMR trends (Table 1, Figure 3 and Appendix 2). 20s EBSMR trends was decreased by prefectural ELM (enlightenment programme). 30s EBSMR trends was decreased by prefectural IVM (intervention model programme) and municipal ELM (enlightenment programme). 40s EBSMR trends was decreased by prefectural DLL (development programme of leaders and listeners). Both EBSMR trends of 50s and 60s were decreased by prefectural ELM and CUR (complete unemployment rate), but was increased by prefectural PCS (personal consultation support programme). 70s EBSMR trends was decreased by prefectural ELM and municipal DLL. 80s EBSMR trends was decreased by prefectural ELM and IVM, but was increased by municipal PCS.

3.3. Effects of the implementation amounts of EFECBSC sub-divisions, unemployment rates and per capita GDP on female EBSMR trends

Stepwise multiple regression analysis detected significant effects of implementation amount of EECBSC sub-divisions and unemployment rates on female EBSMR trends, but GDP per capita did not affect (Table 1, Figure 4 and Appendix 2). EBSMR trends of 70s and 80s were decreased by municipal DLL (development programme of leaders and listeners) and ELM (enlightenment programme), respectively. Contrary, EBSMR trends of 50s was increased by prefectural PCS (personal consultation support programme). Neither implementation amount of EFECBSC, CUR (complete unemployment rate) nor GDP per capita affected female EBSMR trends of 20s, 30s, 40s and 60s.

4. Discussion

This study indicates the age/gender-specific sensitivities of suicide mortalities to implementation amount of EFECBSC and unemployment rate, whereas GDP per capita did not affect. In highly environments which individual (possibly masculine) identity is bound up with work, unemployment poses greater status threat; whereas conversely, where women’s labour force participation rates are lower, the threat or experience of unemployment may less significantly affect women’s mental health. Similarly, economic downturns could increase only male suicides mortality, whereas recession increased both male and female suicide mortalities. Taken together with these previous findings in Europe and North America, the present results suggest that unemployment is risk factor of an increase in male suicide mortality compared with female suicide.
Female EBSMR was not affected by complete unemployment rates and was less sensitive to EFECBSC compared with male EBSMR, since only female EBSMR of elder population (70s and 80s) were sensitive to municipal “development programme of leaders and listener” and “enlightenment programme”, respectively. Contrary to female EBSMR, the age-dependent sensitivity of male EBSMR can be broadly classified into two categories. Male EBSMR of over 50s were decreased by prefectural “enlightenment programme”, and male EBSMR of 50s and 60s were decreased by reduced complete unemployment rate, but surprisingly increased by prefectural “personal consultation support programme”. However, male EBSMR of younger 40s could not be detected the specific factors. These results suggest that improvement of socioeconomic condition and comprehensive suicide prevention programme which targeted the elder male suicide mortality have successfully decreased elder male suicide mortality, resulting in the reduced national suicide mortality rates.

In most regions of the world, including Japan, the male suicide mortality is over two times that of female. Decreased elder male suicide mortality, resulting in the reduced national suicide mortality rates. Comprehensive suicide prevention programme which targeted the elder male suicide mortality have successfully detected the specific factors. These results suggest that improvement of socioeconomic condition and comprehensive suicide prevention programme which targeted the elder male suicide mortality have successfully decreased elder male suicide mortality, resulting in the reduced national suicide mortality rates.

In most regions of the world, including Japan, the male suicide mortality is over two times that of female. The suicide mortality of middle/working-aged and elderly populations is also higher than that of younger/adolescent populations in most regions. Moreover, there are gender differences in attitudes toward suicide, with males tending to possess more maladaptive attitudes about suicide. These patterns are found in all age-groups, from adolescents to elderly adults. Furthermore, nonlethal suicide attempts are more common among females, and males are more likely to use more lethal means than females. Taking such robust gender differences into consideration, one might expect that it would be common for validated approaches to suicide prevention to consider gender differences when planning and evaluating interventions. Unfortunately, insufficient attention has been paid to gender differences when considering suicide risk and intervention responses. Several studies have evaluated gender but failed to show gender differences.

In contrast to previous research, prior to the “Basic Act on Suicide Prevention” and “General Policies for Comprehensive Measures against Suicide”, some preliminary research was conducted in Japan regarding intervention model programmes and regional suicide prevention programmes. These preliminary studies reported the reduction in suicide mortality rates among over 65s, and that 70% of the reduced suicide mortality rate was due to addressing female risk factors. The suicide prevention programmes reported in these studies were comprised of workshops run by municipal public health nurses and social, recreational, physical, or volunteering group activities to enhance social support resources. In EFECBSC, these already implemented activities were categorized as municipal “personal consultation support programme”, “developmental programme of leaders and listeners” and “intervention model programme”. Females are less resistant to social/municipal resources and group meetings than males, resulting in the greater sensitivity of females to municipal systems of leaders and listeners. Moreover, the impairment of physical and mental functions associated with aging is exhibited in community and social communication dysfunction. In general, males are more socially affected than females. Therefore, the physical or psychological dysfunctions of elderly partner often means the loss of social relationships for both individuals. For individuals with aging social dysfunction, it is easy to understand why interventional active suicide prevention programmes, such as “personal consultation support programme” and “intervention model programme”, are more effective than passive programmes, such as “enlightenment programme” and “development programme of leaders and listeners”. In fact, based on these concepts, regional suicide prevention programmes in various prefectures have targeted the reduction of suicide mortality rates among the elderly.

As our previous research has suggested, the different sensitivities of male and female suicide mortality to prefectural suicide prevention programmes are, at least partially, explained by the gender-specific socioeconomic background of suicide. Based on those previous findings, this study determined the effects of EFECBSC on suicide mortality of gender/age-disaggregated populations and hypothesized that enriching prefectural social community support, including “enlightenment programme” and “intervention model programme”, will prevent an increase in male suicide mortality. Meeting our expectations, prefectural “enlightenment programme” contributed significantly to the reduction of suicide mortalities of a wide range of age groups. However, contrary to expectations, although EFECBSC primarily targets the reduction of male suicide mortality, the effects of EFECBSC were limited to female suicide mortality. Moreover, male plus female and female 40s EBSMR trends were not related to any sub-division of EFECBSC. The less sensitive suicide mortalities of middle/working-aged groups (20s, 30s and 40s) to EFECBSC means that regional suicide prevention programmes do not address the welfare/social safety nets and regional social protection vulnerability associated with suicide of working-age populations. These disappointing results may be reasonable because, due to preliminary findings, elderly populations were the primary targets of regional suicide prevention programmes across prefectures and municipalities.
5. Conclusions

After the collapse of the asset bubble in 1991, unemployment rate was increasing but neither male nor female suicide mortalities were not changed (Appendix1). Following Asian economic crisis in 1997, both suicide mortalities of male and female in Japan were drastically increased (Appendix1). Therefore, the drastic increasing Japanese suicide mortality in 1998 was affected by double-boost recessions complex influences between collapse of the asset bubble in 1991 and Asian economic crisis in 1997. In detail, the increased suicide mortality was due to the synergistic effects of unemployment and long-term unemployment (more than 12 months) induced by these two recessions, similar to Italy case. Long-term unemployment increases the incidence of several mental disorder via being lower level of social integration. Additionally, fear of losing one’s job and/or corporate restructuring are risk factor for suicide. Indeed, over the past two decades, increases in suicide mortality among middle-aged (working-age) males as a result of modifications in the corporate environment have been observed in other Asian countries, such as South Korea, Hong Kong, and Taiwan. Enhancement of welfare/social safety nets and labour market programme supported by governmental finance protected against socioeconomic disability induced suicide in Japan and Europe. Conversely, employment insecurity and lack of social protection in economically active environments have been associated with high suicide mortality rates among middle-aged Japanese males. Therefore, improvement of employment insecurity, welfare/social safety nets and social protection vulnerability via regional suicide prevention programmes supported by EFECBSC plays important roles in the reduction of male suicide mortality in Japan.

Contrary to male suicide mortality, female suicide mortality was affected by severe economic downturns rather than financial cycle fluctuations. Although Japanese women have experienced some social advancement, they continue to have primary responsibility for childcare in a social system that offers poor childcare support. Indeed, unemployment rates did not affect female suicide mortality. Many women are forced to play subordinate roles to men, due to limited childcare support resources, leading to temporary employment interruptions and decreasing social circles due to childcare demands. In addition, Japan’s declining birth rate and aging population place greater pressure on women to bear and rear children. If this proves to be a factor in female suicide, then improvements in childcare support resources, and supporting mothers in finding satisfaction in a relatively small childcare community, may contribute to a reduction in female suicide mortality. If improvements in socioeconomic disabilities, i.e. supportive system against childcare and employment insecurity, can contribute to prevention of suicide mortality rates, the target of regional suicide prevention programmes must be modified as soon as possible. Although various legal arrangements are required, development of comprehensive support system for commit suicide attempts individuals possibly contribute to reduced female suicide mortality, since nonlethal suicide attempts are more common among females.

Although the present study demonstrated that the impact governmental financial support for regional suicide prevention programme plays important roles in the reduction of suicide mortality of gender/age-specific vulnerable groups, the present study has several limitations. Suicide mortality (EBSMR) was disaggregated by prefecture but could not by municipality. Doing so might have provided more detailed information on the role of implementation amount of financial supports in regional suicide prevention programmes and aging in the change in level. EFECBSC has contributed to the development of prefectural/municipal suicide prevention programmes, but the management of prefectural/municipal suicide prevention programmes is not limited to EFECBSC, and may also include prefectural/municipal finances. The present results indicated that prefectural “enlightenment programme”, “intervention model programme”, municipal “development programme of leaders and listeners” and “enlightenment programme” are most effective suicide prevention programmes; however, more detailed research is needed to confirm this conclusion. Because, we cannot deny the implementation amount threshold for the function of each suicide prevention programmes. In other words, it should be considered that prefectural “development programme of leaders and listeners”, and prefectural and municipal “personal consultation programme” have not yet been developed sufficiently to contribute to reducing the suicide mortality. Indeed, the implementation amount of prefectural “enlightenment programme” (28%), “intervention model programme” (17%), and municipal “enlighten programme” (13%) executed the largest amount in the 10 EFECBSC sub-divisions, whereas the implementation amount of prefectural “development programme of leaders and listeners” (7%), prefectural (6%) and municipal “personal consultation support programme” (5%) were smaller.
Further interventions for working-age populations (20s~40s) and females are necessary in order to further address the major causes of suicide mortality in Japan. Indeed, this study determined that EFECBSC is less effective in reducing the female suicide mortality rate compared to the male rate. In an aging country, such as Japan, having a detailed understanding of suicide mortality based on age structure, and identifying specific innovations in suicide prevention programmes are essential for effective suicide prevention. Nevertheless, the general downward trend in suicide mortality suggests that Japan is making progress in developing a comprehensive prevention programme. Regional public health planners and policymakers at prefectural and municipal levels should consider specific actions to reduce regional suicide mortality by identifying the social drivers, and by offering programmes, such as personal and telephone consultation support, development programme of leaders and listeners, enlightenment programme, intervention model and unemployment. In the future, the budget structure should be made more cost-effective and, following several more detailed observations of suicide mortality rates in Japan, other Asian countries with aging populations and high suicide mortality rates can also reduce their suicide mortality rates.

Contributions: All authors were responsible for the development of the study design. MO is responsible for conceptualization. MO, TH and RK are responsible for data collection and statistical analysis. MO and TS have been involved in writing manuscript. All authors have read manuscript, contributed to and approved the manuscript.

Funding: This study was supported by Regional Suicide Countermeasures Emergency Enhancement Fund of Mie Prefecture.

Competing interests: None declared.

Data sharing statement: All raw data are available to any persons from Japanese National databases in Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC) 12, 20, 21, Cabinet Office (CAO) 13 and Ministry of Health, Labour and Welfare (MHLW) 22.

References

1. World Health Organization. Suicide Rates (per 100,000 Population). Global Health Observatory Geneva, Switzerland.; WHO; 2016 [Available from: https://www.who.int/gho/mental_health/suicide_rates/en/ accessed 2019.12.1 2019.

2. Alothman D, Fogarty A. Global differences in geography, religion and other societal factors are associated with sex differences in mortality from suicide: An ecological study of 182 countries. J Affect Disord 2020;260:67-72. doi: 10.1016/j.jad.2019.08.093 [published Online First: 2019/09/08]

3. Norstrom T, Gronqvist H. The Great Recession, unemployment and suicide. J Epidemiol Community Health 2015;69(2):110-6. doi: 10.1136/jech-2014-204602 [published Online First: 2014/10/24]

4. Blasco-Fontecilla H, Perez-Rodriguez MM, Garcia-Nieto R, et al. Worldwide impact of economic cycles on suicide trends over 3 decades: differences according to level of development. A mixed effect model study. BMJ open 2012;2(3): doi: 10.1136/bmjopen-2011-000785

5. Reeves A, McKee M, Stuckler D. Economic suicides in the Great Recession in Europe and North America. The British journal of psychiatry : the journal of mental science 2014;205(3):246-7. doi: 10.1192/bjp.bp.114.144766

6. Toffolotti V, Suhrcke M. Assessing the short term health impact of the Great Recession in the European Union: a cross-country panel analysis. Preventive medicine 2014;64:54-62. doi: 10.1016/j.ypmed.2014.03.028

7. Mattei G, Pistoresi B, De Vogli R. Impact of the economic crises on suicide in Italy: the moderating role of active labor market programs. Social psychiatry and psychiatric epidemiology 2019;54(2):201-08. doi: 10.1007/s00127-018-1625-8

8. Mattei G, Pistoresi B. Unemployment and suicide in Italy: evidence of a long-run association mitigated by public unemployment spending. The European journal of health economics : HEPAC : health economics in prevention and care 2019;20(4):569-77. doi: 10.1007/s10198-018-1018-7

9. Chang SS, Gunnell D, Sterne JA, et al. Was the economic crisis 1997-1998 responsible for rising suicide rates in East/Southeast Asia? A time-trend analysis for Japan, Hong Kong, South Korea, Taiwan, Singapore and Thailand. Soc Sci Med 2009;68(7):1322-31. doi: 10.1016/j.socscimed.2009.01.010

10. Kato R, Okada M. Can Financial Support Reduce Suicide Mortality Rates? International journal of environmental research and public health 2019;16(23):4797. doi: 10.3390/ijerph16101794

11. Training TJIfLPa. Complete unemployment rate and effective opening-to-application rate 2020 [Available from: https://www.jil.go.jp/kokunai/statistics/timeseries/html/g0301.html accessed 2019.11.12.
12. Ministry of Health, Labour and Welfare. Basic data on suicide in the region 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html accessed 2019.11.12.2019.

13. Cabinet Office. GDP Statistics 2019 [Available from: https://www.esri.cao.go.jp/jp/sna/menu.html accessed 2020.1.21.2020.

14. Ministry of Health, Labour and Welfare. Regional Suicide Countermeasures Emergency Enhancement Fund 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000134741.html accessed 2019.11.12.2019.

15. Nakanishi M, Yamauchi T, Takeshima T. National strategy for suicide prevention in Japan: impact of a national fund on progress of developing systems for suicide prevention and implementing initiatives among local authorities. Psychiatry Clin Neurosci 2015;69(1):55-64. doi: 10.1111/pcn.12222

16. Toffolutti V, Suhrcke M. Does austerity really kill? Economics and human biology 2019;33:211-23. doi: 10.1016/j.ehb.2019.03.002

17. Stuckler D, Basu S, Suhrcke M, et al. The public health effect of economic crises and alternative policy responses in Europe: an empirical analysis. Lancet 2009;374(9686):315-23. doi: 10.1016/S0140-6736(09)61124-7

18. Kim SY, Kim MH, Kawachi I, et al. Comparative epidemiology of suicide in South Korea and Japan: effects of age, gender and suicide methods. Crisis 2011;32(1):5-14. doi: 10.1027/0227-5910/a000046 [published Online First: 2011/03/05]

19. Suzuki E, Kashima S, Kawachi I, et al. Prefecture-level economic conditions and risk of suicide in Japan: a repeated cross-sectional analysis 1975-2010. Eur J Public Health 2014;24(6):949-54. doi: 10.1093/eurpub/cku023 [published Online First: 2014/03/13]

20. Statistics Bureau of the Ministry of Internal Affairs and Communications. Population, demographics and number of households based on Basic Resident Register 2019 [Available from: http://www.soumu.go.jp/main_sosiki/jichi_gyousei/daityou/jinkou_jinkoudoutai-setaisuu.html accessed 2019.11.12.2019.

21. Statistics Bureau of the Ministry of Internal Affairs and Communications. Labor force survey 2019 [Available from: https://www.stat.go.jp/data/roudou/pref/index.html accessed 2020.1.21.2020.

22. Ministry of Health LaW. Bugets for suicide prevention programmes 2019 [Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000133838.html accessed 2019.11.12.2019.

23. Kawaguchi H, Koike S. Association between the Density of Physicians and Suicide Rates in Japan: Nationwide Ecological Study Using a Spatial Bayesian Model. PLoS One 2016;11(2):e0148288. doi: 10.1371/journal.pone.0148288 [published Online First: 2016/02/04]

24. Allison PD. Multiple Regression: A Primer. 1st edition ed: SAGE Publications, Inc 1999.

25. Organization WH. Suicide data 2017 [Available from: https://www.who.int/mental_health/prevention/suicide/countrydata/en/ accessed 2019.12.1.

26. Gould MS, Velting D, Kleinman M, et al. Teenagers’ attitudes about coping strategies and help-seeking behavior for suicidality. J Am Acad Child Adolesc Psychiatry 2004;43(9):1124-33. doi: 10.1097/01.chi.0000132811.06547.31 [published Online First: 2004/08/24]

27. World Health Organization. Preventing suicide: A global imperative: World Health Organization 2014.

28. Centers for Disease C, Prevention. Suicide among adults aged 35-64 years--United States, 1999-2010. MMWR Morb Mortal Wkly Rep 2013;62(17):321-5. [published Online First: 2013/05/03]

29. Tsirigotis K, Gruszczynski W, Tsirigotis M. Gender differentiation in methods of suicide attempts. Med Sci Monit 2011;17(8):PH65-70. doi: 10.12659/msm.881887 [published Online First: 2011/08/02]

30. Gould MS, Kramer RA. Youth suicide prevention. Suicide and life-threatening behavior 2001;31(Supplement to Issue 1):6-31.

31. Weisz JR, Sandler IN, Durlak JA, et al. Promoting and protecting youth mental health through evidence-based prevention and treatment. American psychologist 2005;60(6):628.

32. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies: a systematic review. JAMA 2005;294(16):2064-74. doi: 10.1001/jama.294.16.2064 [published Online First: 2005/10/27]

33. Klimes-Dougan B, Klingbeil DA, Meller SJ. The impact of universal suicide-prevention programs on the help-seeking attitudes and behaviors of youths. Crisis 2013;34(2):82-97. doi: 10.1027/0227-5910/a000178

34. Oliver RJ, Spilsbury JC, Osiecki SS, et al. Brief report: Preliminary results of a suicide awareness mass media campaign in Cuyahoga County, Ohio. Suicide and Life - Threatening Behavior 2008;38(2):245-49.
35. Ministry of Health Law. National Plan for Prevention of Suicide 2018 [Available from: https://www.mhlw.go.jp/kokoro/nation/about.html accessed 2019.11.12.

36. Oyama H, Sakashita T, Ono Y, et al. Effect of community-based intervention using depression screening on elderly suicide risk: a meta-analysis of the evidence from Japan. Community Ment Health J 2008;44(5):311-20. doi: 10.1007/s10597-008-9132-0 [published Online First: 2008/03/26]

37. Drapeau A, Boyer R, Lesage A. The influence of social anchorage on the gender difference in the use of mental health services. J Behav Health Serv Res 2009;36(3):372-84. doi: 10.1007/s11414-009-9168-0 [published Online First: 2009/03/03]

38. Sugimoto T, Sakurai T, Ono R, et al. Epidemiological and clinical significance of cognitive frailty: A mini review. Ageing Res Rev 2018;44:1-7. doi: 10.1016/j.arr.2018.03.002 [published Online First: 2018/03/17]

39. Hamilton E, Klimes-Dougan B. Gender differences in suicide prevention responses: implications for adolescents based on an illustrative review of the literature. International journal of environmental research and public health 2015;12(3):2359-72. doi: 10.3390/ijerph12032359

40. Lapierre S, Erlangsen A, Waern M, et al. A systematic review of elderly suicide prevention programs. Crisis 2011;32(2):88-98. doi: 10.1027/0227-5910/a000076

41. Umberson D, Wortman CB, Kessler RC. Widowhood and Depression: Explaining Long-Term Gender Differences in Vulnerability. Journal of Health and Social Behavior 1992;33(1):10. doi: 10.2307/2136854

42. Chen YY, Wu KC, Yousuf S, et al. Suicide in Asia: opportunities and challenges. Epidemiol Rev 2012;34:129-44. doi: 10.1093/epirev/mxr025

43. Phillips MR, Li X, Zhang Y. Suicide rates in China, 1995-99. Lancet 2002;359(9309):835-40. doi: 10.1016/S0140-6736(02)07954-0 [published Online First: 2002/03/19]

44. Pearson V. Goods on which one loses: women and mental health in China. Soc Sci Med 1995;41(8):1159-73. doi: 10.1016/0277-9536(94)00424-r [published Online First: 1995/10/01]

45. Ji J, Kleinman A, Becker AE. Suicide in contemporary China: a review of China’s distinctive suicide demographics in their sociocultural context. Harv Rev Psychiatry 2001;9(1):1-12. [published Online First: 2001/02/13]

Figure Legends

Figure 1: The ‘Emergency Fund to Enhance Community-Based Suicide Countermeasures’ (EFECBSC) submission and allocation process.

The EFECBSC was composed of five prefectural sub-divisions: “personal consultation support programme” (PCS), “telephone consultation support programme” (TCS), “development programme of leaders and listeners” (DLL), “enlightenment programme” (ELM), and “intervention model programme” (IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM. Each municipality submitted its suicide prevention programmes to its prefecture. Each prefecture then submitted its own programme, together with the municipal programmes to the EFECBSC of the Cabinet office (CAO). The EFECBSC then allocated funds to each prefecture, which including budgets for both prefectures and municipalities.

Figure 2: Effects of the implementation amount of EFECBSC sub-divisions and complete unemployment rate on EBSMR trends of male plus female.

Ordinates indicate EBSMR trends of male plus female of age-disaggregated populations, and abscissas indicate implementation amount of EFECBSC sub-divisions: “personal consultation support programme” (PCS), “telephone consultation support programme” (TCS), “development programme of leaders and listeners” (DLL), “enlightenment programme” (ELM), and “intervention model programme” (IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Brown and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.

Figure 3: Effects of the implementation amount of EFECBSC sub-divisions and complete unemployment rate on male EBSMR trends.
Ordinates indicate male EBSMR trends of age-disaggregated populations, and abscissas indicate implementation amount of EFECBSC sub-divisions: “personal consultation support programme” (PCS), “telephone consultation support programme” (TCS), “development programme of leaders and listeners” (DLL), “enlightenment programme” (ELM), and “intervention model programme” (IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Blue and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.

Figure 4: Effects of the implementation amount of EFECBSC sub-divisions and complete unemployment rate on female EBSMR trends.

Ordinates indicate female EBSMR trends of age-disaggregated populations, and abscissas indicate implementation amount of EFECBSC sub-divisions: “personal consultation support programme” (PCS), “telephone consultation support programme” (TCS), “development programme of leaders and listeners” (DLL), “enlightenment programme” (ELM), and “intervention model programme” (IVM), and five municipal sub-division: PCS, TCS, DLL, ELM and IVM (¥ per population). Red and light blue spheres indicate prefectural and national EBSMR trends and population size, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively.
Supplemental Data

Appendix 1: Trends in crude suicide mortality per 100,000 population, complete unemployment rate and GDP per capita between 1990 and 2018 in Japan. (p2).

Appendix 2: Effects of the execution amount of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female, male and female. (p3).
Appendix 1: Trends in crude suicide mortality per 100,000 population, complete unemployment rate and GDP per capita between 1990 and 2018 in Japan. Ordinates indicate the relative to data in 2009 of GDP per capita, complete unemployment rate and suicide mortalities of male plus female, male and female (%). Abscissas indicate years.
Appendix 2: Effects of the execution amount of EFECBSC sub-divisions, unemployment rate and GDP per capita on EBSMR trends of male plus female, male and female.

| Prefecture | PCS | TCS | DLL | ELM | IVM |
|------------|-----|-----|-----|-----|-----|
| Male+Female| 20s | 30s | 40s | 50s | 60s |
| Male       | 20s | 30s | 40s | 50s | 60s |
| Female     | 20s | 30s | 40s | 50s | 60s |

Green and red columns indicate significant factors for reduced and increased EBSMR trends (standardised suicide mortality) of age/gender-fragmented Japanese populations detected by stepwise multiple regression analysis.

Page 20 of 21
### STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| Item No | Recommendation | Page No |
|---------|----------------|---------|
| **Title and abstract**  | 1 (a) Indicate the study’s design with a commonly used term in the title or the abstract  
(b) Provide in the abstract an informative and balanced summary of what was done and what was found | 1 2 |
| **Introduction**  | 2 Explain the scientific background and rationale for the investigation being reported | 2-3 |
| **Objectives**  | 3 State specific objectives, including any prespecified hypotheses | 3 |
| **Methods**  | 4 Present key elements of study design early in the paper  
5 Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 3-4 |
| **Participants**  | 6 (a) Give the eligibility criteria, and the sources and methods of selection of participants | 3-4 |
| **Variables**  | 7 Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 3-4 |
| **Data sources/measurement**  | 8* For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 3-4 |
| **Bias**  | 9 Describe any efforts to address potential sources of bias | 3-4 |
| **Study size**  | 10 Explain how the study size was arrived at | 3-4 |
| **Quantitative variables**  | 11 Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 3-4 |
| **Statistical methods**  | 12 (a) Describe all statistical methods, including those used to control for confounding  
(b) Describe any methods used to examine subgroups and interactions  
(c) Explain how missing data were addressed  
(d) If applicable, describe analytical methods taking account of sampling strategy  
(e) Describe any sensitivity analyses | 3-4 |
| **Results**  | 13* (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed  
(b) Give reasons for non-participation at each stage  
(c) Consider use of a flow diagram | 4-6 4-6 4-6 |
| **Descriptive data**  | 14* (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders  
(b) Indicate number of participants with missing data for each variable of interest | 4-6 4-6 |
| **Outcome data**  | 15* Report numbers of outcome events or summary measures | 4-6 |
| **Main results**  | 16 (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 4-6 |
(b) Report category boundaries when continuous variables were categorized for peer review only

(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

| Other analyses | 17 | Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses |
|----------------|----|------------------------------------------------------------------------------------------------|

### Discussion

| Key results | 18 | Summarise key results with reference to study objectives |
|-------------|----|--------------------------------------------------------|
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

### Other information

| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for exposed and unexposed groups.*

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