


BMJ Open Analysing effects of financial support for regional suicide prevention programmes on methods of suicide completion in Japan between 2009 and 2018 using governmental statistical data

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ABSTRACT

Objectives To explore the mechanisms of reduction of suicide mortality in Japan (from 25.7 to 16.5 per 100 000 population) between 2009 and 2018, the present study determined the effects of execution amounts of regional suicide prevention programmes (Emergency Fund to Enhance Community-Based Suicide Countermeasure: EFECBSC) on gender-specific trends of suicide mortality by disaggregated methods.

Design and setting Stepwise multiple regression analysis was used to determine the effects of execution amounts of 10 subdivisions of execution amounts of financial support for regional suicide prevention programmes (EFECBSC) on suicide methods and gender disaggregated suicide mortalities in Japan between 2009 and 2018 using the statistical data obtained from national governmental database.

Results The suicide mortalities by the most common/frequent suicide methods, hanging, charcoal burning and jumping were significantly decreased between 2009 and 2018. Male hanging suicide was decreased by prefectural enlightenment, municipal development programmes, but female hanging suicide was decreased by municipal personal consultation programmes. Municipal development and enlightenment programmes decreased male and female charcoal-burning suicide mortalities, respectively. Jumping suicide was decreased by prefectural telephone consultation programmes but was unexpectedly increased by municipal personal consultation and enlightenment programmes.

Conclusions This study revealed the contribution of EFECBSC on reduction of suicide mortalities, especially hanging, charcoal-burning and jumping suicides, via enhancement of regional suicide prevention programmes in Japan; however, notably, the 'means substitution' from parts of hanging and charcoal burning to jumping is probably generated by EFECBSC. Therefore, these findings provide important aspects for planning evidence-based and cost-effective regional suicide prevention programmes.

INTRODUCTION

Age-dependent suicide statistics in Japan have been obtained continuously since 1978.¹ During 1978 to 1997, the suicide mortality

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ To better inform Japanese public health policies, the effects of financial support for regional suicide prevention programmes on regional suicide mortality caused by major six methods are analysed using stepwise multiple regression analysis.
- ⇒ Regarding hanging suicide, most frequent method, male suicide mortality was decreased by prefectural enlightenment, municipal development programmes, but woman was decreased by municipal personal consultation programmes.
- ⇒ Municipal development and enlightenment programmes decreased male and female charcoal-burning suicide mortalities, respectively, whereas jumping suicide was decreased by prefectural telephone consultation programmes but was unexpectedly increased by municipal personal consultation and enlightenment programmes.
- ⇒ Japanese financial support for regional suicide prevention programmes revealed the contribution reduction of suicide mortalities, especially hanging, charcoal-burning and jumping suicides, via enhancement of regional suicide prevention programmes in Japan, but probably led to the 'means substitution' from parts of hanging and charcoal burning to jumping.
- ⇒ The present study has several limitations, including only prefectural (but not municipal) suicide mortality and only 'Japanese case' lacking an Asian perspective.

remained to be around 20 per 100 000 populations (standard mortality ratio), but drastically increased from 18.8 to 25.4 in 1998.¹⁻³ This increase in Japanese suicide mortality had persisted for more than a decade (until 2009), during which time the Japanese people were demanding the puissant governmental financial supports for national suicide prevention programme.⁴⁻⁶ In response to the Japanese public health crisis, the Japanese

government enacted the 'Basic Act on Suicide Prevention' in 2006 and the 'General Policies for Comprehensive Measures against Suicide' in 2007.⁷ Based on these two policies, the Japanese government commenced to contribute funds in 2009 to prefectures and municipalities for the development of regional suicide prevention programmes in the form of the 'Emergency Fund to Enhance Community-Based Suicide Countermeasure' (EFECBSC) from cabinet office, in order to encourage a comprehensive suicide prevention programme.^{1 5-8} Indeed, since 2009, the year the EFECBSC commenced, the Japanese suicide mortality has been improving.^{1 2 5 6}

EFECBSC is composed of 10 subdivisions of regional support programmes of five independent prefectural and five municipal suicide prevention programmes^{5 6 8}: personal consultation support (PCS) programme, telephone consultation support (TCS) programme, development programme of leaders and listeners (gatekeepers) (DLL), enlightenment (ELM) programme and intervention model programme (see online supplemental appendix 1 for the detailed operation and activity contents of EFECBSC).^{5 6 8} Recent studies revealed the effects of execution amounts of 10 subdivisions of EFECBSC on the impact of gender-dependence and age-dependence on dynamics of suicide mortality; however, the response of suicide mortality of gender-subgroups and age-subgroups did not distribute evenly across all EFECBSC subdivisions.^{5 6} Indeed, the male suicide mortality was decreased by execution amounts of EFECBSC of both prefectures and municipalities, whereas female suicide mortality was decreased by municipal execution amounts but not by prefectures.⁵ Furthermore, the male suicide mortality of over 50s was decreased by prefectural execution amounts of EFECBSC; however, the sensitivity of suicide mortalities of middle/working-aged groups (20s, 30s and 40s) to execution amounts of EFECBSC was less, meaning that the regional suicide prevention programmes can not address the welfare/social safety nets and regional social protection vulnerability associated with suicide in working-age populations.⁶

EFECBSC was organised to complement the regional welfare and social safety nets leading to improve the vulnerability of regional social protection against suicidal behaviour/ideation.⁵⁻⁸ The data in Japan and Europe revealed that financial supports for welfare/social safety nets and labour market programmes play important roles in reduction of suicide mortality through compensation of regional vulnerability of social protection against suicides.⁵⁻⁹ On the other hand, 'means restriction' is one of the most cost-effective suicide prevention methods.¹⁰ In particular, historically, some of means restriction programmes have been reported to contribute to suicide prevention.¹¹⁻²⁰ The rationale for 'means restriction' is considered that when a lethal method is unavailable at the moment of potential suicidal behaviour, suicide attempts are possibly delayed, so that, at least partially, suicidal impulses will pass without fatal effects.¹⁹ It has been well known that individuals exposed to adverse

living conditions, which increases risk of suicide, probably seek some help before attempting to take their own life.^{21 22} Considering the effectiveness of means restriction, achieving a reduction in suicide mortality via encouragement of regional suicide prevention programmes without drastic legal 'means restriction' in Japan²³ suggests that EFECBSC has probably regulated/suppressed suicide impulses of some of individuals. Therefore, analysing the methods of suicide, for which EFECBSC reduced, provides important aspects for the development of more effective suicide prevention programmes. Based on these backgrounds, the present study determined the effects of execution amounts of 10 subdivisions of EFECBSC on the suicide mortality associated with suicide methods.

MATERIALS AND METHODS

The data required for this study were mainly obtained according to the same way of our previous study.^{5 6} Suicide methods, gender and prefecture disaggregated number of suicides of all 47 prefectures in Japan between 2009 and 2018 were obtained from the Ministry of Health, Labour and Welfare (MHLW) and the Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC).^{2 24} Basic regional suicide data (MHLW) classified the number of suicides to five types of suicide as means: hanging, charcoal burning, jumping from high places (jumping), poisoning and suicide (throwing).² Annual suicide methods, gender and prefecture disaggregated suicide mortalities were derived from basic regional suicide data (MHLW), and population exposure (denominator) was obtained from the basic resident register (SBMIAC).²⁴ The execution amounts of 10 subdivisions of EFECBSC between 2009 and 2014⁸ of each prefecture were calculated by dividing the EFECBSC for each year by the prefectural population of the same year. The execution amounts of 10 subdivisions of EFECBSC used in this study were same data set of our previous studies.^{5 6 25}

Total (men plus women), male and female suicide mortalities associated with five suicide methods, was calculated separately. 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, gender-disaggregated prefectural suicide mortalities associated with suicide methods were calculated using the empirical Bayes standardised mobile ratio (EBSMR)²⁶ by the EB estimator for the Poisson/gamma model V.2.1 (National Institute of Public Health, Wako, Japan) (https://www.niph.go.jp/soshiki/gijutsu/download/ebpoig/index_j.html).^{5 6}

The least-square method was used to analyse time-dependent trends in the reduction of suicide EBSMR in each prefecture (EBSMR trends) by BellCurve for Excel V.3.2 (BellCurve, Tokyo, Japan). To analyse the relationship between prefectural EBSMR trends associated with suicide methods and financial support for regional prevention programmes (EFECBSC subdivisions), SPSS

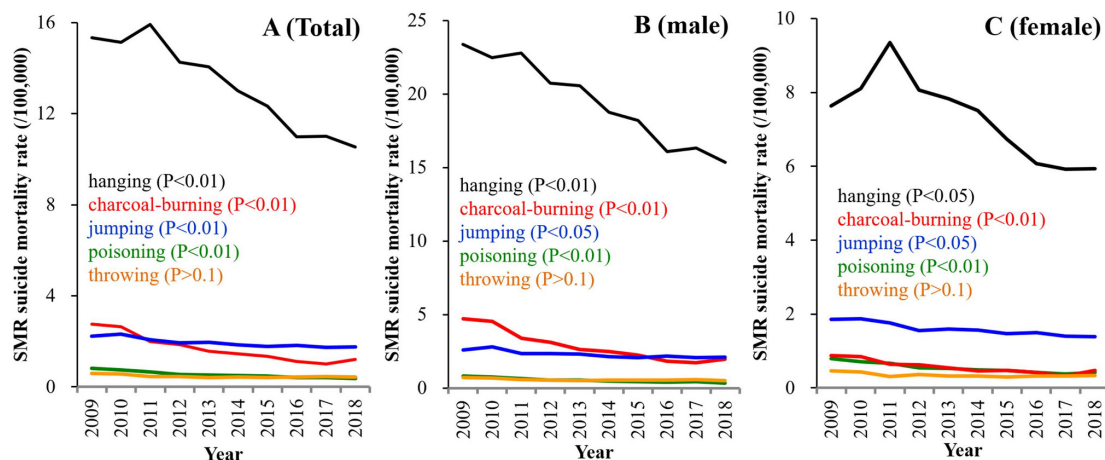


Figure 1 Trends of empirical Bayes standardised mobile ratio of suicide mortality per 100 000 Japanese population (EBSMR) of total (men plus women: (A)), man (B) and woman (C) between 2009 and 2018 analysed by linear regression analysis. Ordinates indicate SMR (per 100 000 population), and abscissas indicate time (year). EBSMR, empirical Bayes standardised mobile ratio.

for Windows V.26 (IBM, Armonk, NewYork, USA) was used to the linear and stepwise multiple regression analyses of the effects of execution amounts of 10 EFECBSC subdivisions on EBSMR trends. Multicollinearity was suspected if the variance inflation factor value was greater than 10.^{5,6}

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.

RESULTS

2009–2018 EBSMR trends for regional suicide mortality ratios associated with method

At 2009, the top five methods for suicide of total (men plus women) and men were hanging, charcoal burning, jumping, poisoning and throwing, in that order, whereas the ranking order of woman was hanging, jumping, charcoal burning, poisoning and throwing.¹ EBSMR of hanging, charcoal burning, jumping and poisoning suicides of total, men and women were significantly reduced ($p < 0.05$), but neither EBSMR of throwing suicide of total, men nor women were changed (figure 1).

The rates of reduction of total EBSMR of suicide method exhibited varies, with swapping the ranking between jumping and charcoal burning in 2011, and between throwing and poisoning in 2016 (figure 1). The reduction rates of male suicide methods EBSMR also exhibited varies, with swapping the ranking between jumping and charcoal burning in 2016, and between throwing and poisoning in 2014 (figure 1). The ranking of female suicide methods EBSMR was swapping between charcoal burning and poisoning in 2014 (figure 1).

Effects of execution amounts of EFECBSC subdivisions on EBSMR trends of suicide means between 2009 and 2018

Stepwise multiple regression analysis detected significant effects of execution amounts of EFECBSC subdivisions on EBSMR trends of total, male and female mortalities of hanging, charcoal-burning and jumping suicides but did not affect EBSMR trends of poisoning or throwing. The detailed statistical values of stepwise multiple regression analysis are indicated in online supplemental appendix 2.

Effects of execution amounts of EFECBSC subdivisions on EBSMR trends of hanging suicide between 2009 and 2018

Total and male EBSMR trends of hanging suicide were significantly/inversely related to execution amount of prefectural ELM and municipal DLL (figure 2A–D); however, female EBSMR trend of hanging for suicide was significantly/inversely related to execution amount of municipal PCS (figure 2E).

Effects of execution amounts of EFECBSC subdivisions on EBSMR trends of charcoal burning suicide between 2009 and 2018

Total and male EBSMRs trend of charcoal-burning suicide were significantly/inversely related to execution amount of municipal ELM and municipal DLL, respectively (figure 3A,B); however, female EBSMR trend of charcoal-burning suicide was significantly/inversely related to execution amount of municipal ELM but significantly/positively related to execution amount of prefectural TCS (figure 3C,D).

Effects of execution amounts of EFECBSC subdivisions on EBSMR trends of jumping suicide between 2009 and 2018

Total EBSMR trend of jumping suicide was significantly/inversely related to execution amount of prefectural TCS, but significantly/positively related to execution amount of prefectural ELM (figure 4A,B). Male EBSMR trend of jumping suicide was significantly/inversely related to execution amount of prefectural TCS but significantly/

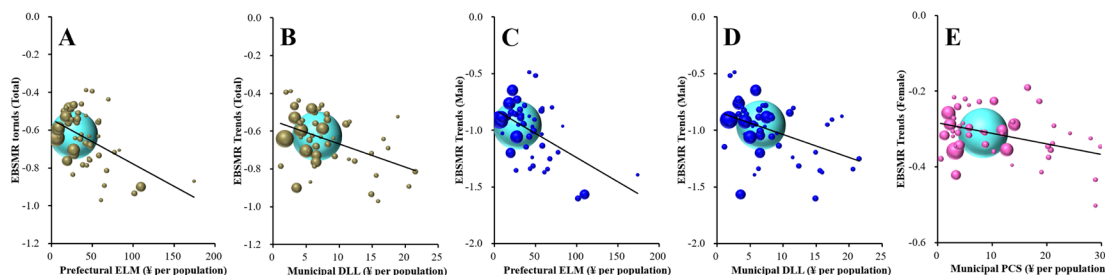


Figure 2 Effects of the execution amount of subdivisions of EFECBSC on EBSMR trends of total (A,B), man (C,D) and woman (E) hanging suicide analysed by stepwise multiple regression analysis. Ordinates indicate EBSMR trends between 2009 and 2018 and abscissas indicate execution amount of EFECBSC subdivisions (¥ per population). Light blue, grey, blue and red spheres indicate national, total (men plus women), male and female EBSMR trends and population sizes, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively. Total EBSMR trends of hanging suicide = $-0.0021 \times (\text{prefectural ELM}) - 0.1028 \times (\text{municipal DLL}) - 0.4703$ (¥47.6 million of prefectural ELM and ¥9.7 million of municipal DLL per 100 000 population decreased total hanging suicide by 1/100 000 per year). Male EBSMR trends by hanging suicide = $-0.004 \times (\text{prefectural ELM}) - 0.016 \times (\text{municipal DLL}) - 0.699$ (¥26.3 million of prefectural ELM and ¥6.1 million of municipal DLL per 100 000 population decreased male hanging suicide by 1/100 000 per year). Contrary, female EBSMR trends of hanging suicide = $-0.003 \times (\text{municipal PCS}) - 0.284$ (¥36.5 million of municipal PCS per 100 000 population decreased female hanging suicide by 1/100 000 per year). EBSMR, empirical Bayes standardised mobile ratio; EFECBSC, Emergency Fund to Enhance Community-Based Suicide Countermeasure; ELM, enlightenment; PCS, personal consultation support.

positively related to execution amount of municipal ELM (figure 4C,D). Female EBSMR trend of jumping suicide was significantly/positively related to execution amount of municipal PCS (figure 4E).

DISCUSSION

In general, the most common/frequent methods for suicide are hanging, pesticide self-poisoning and firearms; however, suicide methods exhibit remarkable various characteristics depending on the social/cultural backgrounds of each country.^{19 27 28} Indeed, the most

common/frequent method for suicide in Japan was hanging, accounting for more than 60%.² Japanese frequency of hanging suicide is higher than those in European countries.^{18 29 30} Total counts during 2009–2018, charcoal-burning suicide was remarkably the common suicide method of Japanese men with ranking second, whereas female charcoal-burning suicide was relatively low with ranking third (almost equal to the counts of poisoning at fourth rank). Furthermore, in Europe, it has been considered that jumping is not common suicide method,²⁰ whereas in East countries, jumping was one

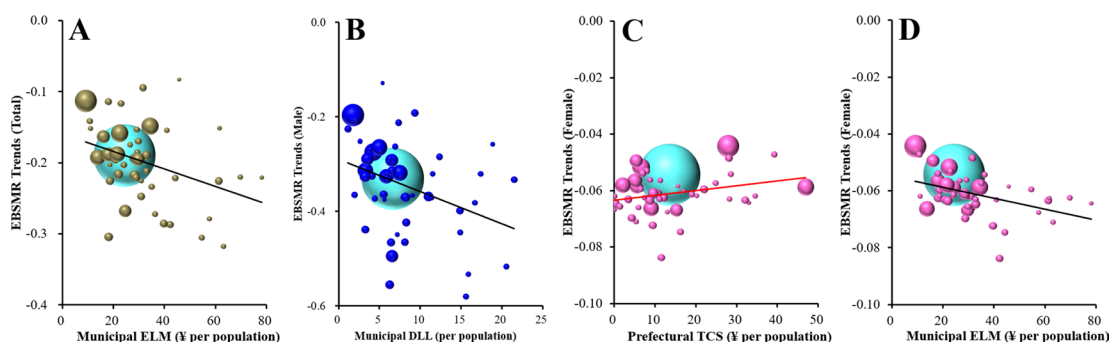


Figure 3 Effects of the execution amount of subdivisions of EFECBSC on EBSMR trends of total (A), man (B) and woman (C,D) charcoal-burning suicide analysed by stepwise multiple regression analysis. Ordinates indicate EBSMR trends between 2009 and 2018 and abscissas indicate execution amount of EFECBSC sub-divisions (¥ per population). Light blue, grey, blue and red spheres indicate national, total (men plus women), male and female EBSMR trends and population sizes, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively. Total EBSMR trends of charcoal-burning suicide = $-0.0012 \times (\text{municipal ELM}) - 0.159$ (¥81.3 million of municipal ELM per 100 000 population decreased total charcoal-burning suicide by 1/100 000 per year). Male EBSMR trends of charcoal-burning suicide = $-0.0068 \times (\text{municipal DLL}) - 0.291$ (¥14.8 million of municipal DLL per 100 000 population decreased male charcoal burning suicide by 1/100 000 per year). Female EBSMR trends of charcoal-burning suicide = $-0.0002 \times (\text{municipal ELM}) + 0.0002 \times (\text{prefectural TCS}) - 0.057$ (¥500 million of municipal ELM per 100 000 population decreased female charcoal-burning suicide by 1/100 000 per year, but ¥526 million of prefectural TCS per 100 000 population increased female charcoal-burning suicide by 1/100 000 per year). DLL, development programme of leaders and listeners; EBSMR, empirical Bayes standardised mobile ratio; EFECBSC, Emergency Fund to Enhance Community-Based Suicide Countermeasure; ELM, enlightenment; TCS, telephone consultation support.

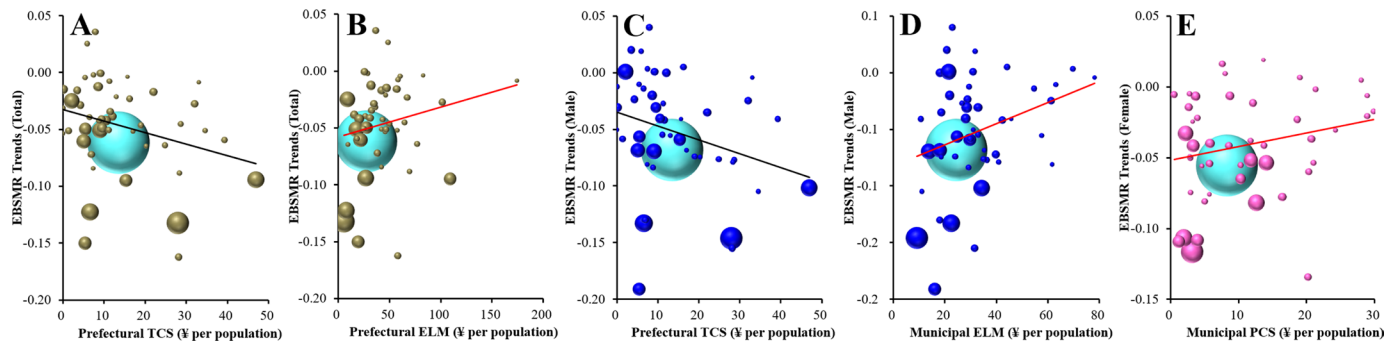


Figure 4 Effects of the execution amount of subdivisions of EFECBSC on EBSMR trends of total (A,B), man (C,D) and woman (E) jumping suicide analysed by stepwise multiple regression analysis. Ordinates indicate EBSMR trends between 2009 and 2018 and abscissas indicate execution amount of EFECBSC subdivisions (¥ per population). Light blue, grey, blue and red spheres indicate national, total (men plus women), male and female EBSMR trends and population sizes, respectively. Black and red lines indicate the regression lines of significantly positive (reduced suicide mortality) and negative (increased suicide mortality) factors, respectively. Total EBSMR trends of jumping suicide = $-0.0011 \times (\text{prefectural TCS}) + 0.0008 \times (\text{prefectural ELM}) - 0.057$ (¥93.5 million of prefectural TCS per 100 000 population decreased total jumping suicide by 1/100 000 per year, but conversely ¥128.2 million of prefectural ELM per 100 000 population increased total jumping suicide by 1/100 000 per year). Male EBSMR trends of jumping suicide = $-0.0013 \times (\text{prefectural TCS}) + 0.00097 \times (\text{municipal ELM}) - 0.065$ (¥77.5 million of prefectural TCS per 100 000 population decreased male jumping suicide by 1/100 000 per year, but conversely ¥103.0 million of municipal ELM per 100 000 population increases male jumping suicide by 1/100 000 per year). Female EBSMR trends by jumping for suicide = $+0.0011 \times (\text{municipal PCS}) + 0.05$ (¥89.3 million of municipal PCS per 100 000 population increased female jumping suicide by 1/100 000 per year). EBSMR, empirical Bayes standardised mobile ratio; EFECBSC, Emergency Fund to Enhance Community-Based Suicide Countermeasure; ELM, enlightenment; PCS, personal consultation support; TCS, telephone consultation support.

of the common/frequent methods for suicide.^{23 31 32} Indeed, total counts during 2009–2018, jumping was also one of the common methods for suicide at third rank of man and at second rank of woman. Therefore, Japanese features of suicide methods are different from those in Europe, but additionally, the suicide methods between man and woman in Japan are also different. A correspondence analysis indicated that the correspondence maps between genders were more similar rather than among countries.²⁷ In this correspondence analysis study, a notable exception that was that European male firearms for suicide replaced female poisoning.²⁷ Therefore, analysing the impact of EFECBSC, which is one of the important programmes in comprehensive suicide prevention, on the gender-specific characteristics of suicide methods provide important implications for the improvement of future suicide prevention programmes.

It has been established that ‘means restriction’, which suppresses the access to common/frequent suicide methods, provides the reduction of suicide mortality.¹⁹ A number of studies reported the effectiveness of means restriction for suicide prevention, via suppression of access to drugs, pesticides, charcoal, gun and barriers on bridges, railway platforms and high-rise buildings.^{11–20} In Japan, the limitation of use of hypnotics decreased suicide mortality by poisoning in 1956, whereas, following then, there have been no intervention or postevaluation analyses regarding the effects of means restriction on suicide mortality.^{15 23} Prevention programmes in Japan have enhanced community welfare and social safety nets, rather than ‘means restriction’.^{5–8} The strategy of Japanese suicide prevention programmes is influenced by

the features of Japanese suicide methods, most common suicide method was hanging, that is hardly regulated by ‘means restriction’.^{2 18} The majority place of hanging was the person’s home, custody, prisons and psychiatric wards.¹⁸ Most common tools for hanging were rope, belts, electric flex, rafters/beams, bannisters, hooks, doorknobs and trees.¹⁸ Furthermore, a study of lethal suicide attempters reported that 24% took less than 5 min between decision and suicide action and 70% within 1 hour.³³ It has been established the theory of means restriction that suppression of access to lethal suicide methods converts to other methods with lower risk of lethality or allows time for reduction of suicide impulsivity during suicide impulsivity.^{14 19} Therefore, the characteristics of hanging suicide, the place of execution (place of daily life) and the tools (fundamental items used in daily life) make it difficult to set the intervention targets for an effective means restriction against hanging suicide.¹⁸

In spite of these hardships regarding prevention of hanging suicide, the decrease in hanging contributed significantly to the decrease in the number of suicides in Japan.² It is easy to expound that combination between ELM activities within relatively wide-range live spheres (prefecture) and enhancement of qualitative activities of community-based (municipality) gatekeepers contributes to reduction of total and male hanging suicides; however, unexpectedly, municipal PCS related to the decrease in female hanging suicide mortality. Previous EFECBSC cost-effectiveness analysis studies could not detect the significant effects other than the negative effects of municipal PCS on suicide mortality of elders.^{5 6} Although this study cannot specify the detailed mechanism of this



valuable finding, the positive effects of municipal PCS on prevention of female hanging suicide, which is the most frequent suicide method of Japanese woman, probably provide some suggestions for improving the ECFCBSC, which failed to detect clear contribution on a decrease in female suicide mortality due to additional qualitative researches.

An increase charcoal-burning suicide is a specific phenomenon in East/Southeast Asia in the early 21st century. After extensive media reporting about charcoal-burning suicide in Hong Kong, initially, charcoal-burning suicide was increased in Chinese-speaking countries, Hong Kong (1998), Taiwan (1999), Macau and Singapore (2001), followed by different language countries, Japan (2002) and South Korea (2008).¹³ In Hong Kong, the government, police and community had collaborated to implement means restrictions on charcoal burning resulting in prevention of charcoal-burning suicide.^{13 16 17} Initially, in also Japan, internet involvement was noted, as young Japanese charcoal-burning suicides were involved in several suicide agreements on charcoal-burning suicides.^{13 34 35} In 2005, a voluntary guideline was regulated by associations managing internet provider service in Japan to suppress suicidal attempts via internet³⁵ without implementation of direct means restrictions against charcoal burning¹⁷; however, charcoal-burning suicide continued to increase until 2009. In the present study, municipal DLL and ELM decreased male and female suicide mortalities, respectively. Therefore, charcoal-burning suicide, which was once increased by the internet at the domestic level, could not be improved by suppressing the increasing factors alone, but prevention of charcoal-burning suicide required additional careful actions, including community-based municipal DLL and ELM. In other words, the risk and preventative factors for suicide are not necessarily identical, but combination between suppressing suicide risk and performing prevention factors of suicide probably contributes to effective suicide prevention. Based on the situation where many young people use social networking service (SNS) as a means of daily communication, recently MHLW has been promoting a 'consultation service using SNS for the suicide prevention',³ a few years later, the evaluation regarding this programme probably provide the important aspects about the impact of virtual support for suicide prevention via internet.

Although the reduction in jumping suicide was mild compared with those of suicides by hanging and charcoal burning, the impacts of EFECBSC subdivisions on jumping suicide were complicated. Total jumping suicide was decreased and increased by respective prefectural TCS and ELM, respectively. Male jumping suicide was also decreased and increased by respective prefectural TCS and municipal ELM, whereas female jumping suicide was increased by municipal PCS. Prefectural TCS was one of the least effective subdivisions of ECFCBSC, with only a weakly suppression on the suicide mortality of young populations.^{5 6} The possibility that prefectural TCS

contributes to the reduction of jumping suicides, in a situation where the decrease in jumping suicide is stagnant, it is important information for encouragement of suicide prevention programmes in the future. Contrary, the interpretation of mechanisms of increasing male jumping suicide by prefectural and municipal ELM, which were the most effective subdivisions of EFECBSC,^{5 6} is incomprehensible and requires careful consideration.

It has been well known that means restriction leads to switching suicide methods, so-called 'means substitution'.¹⁹ The complicated responsiveness of jumping suicide to EFECBSC subdivisions possibly suggests that prefectural and municipal ELM and municipal PCS generate 'mean substitution' from hanging and charcoal-burning suicides to jumping suicide. Indeed, prefectural ELM decreased and increased total hanging and jumping suicides, showing the exact opposite effects (figure 5). Municipal PCS also decreased and increased female hanging and jumping suicides, showing the exact opposite effects (figure 5). In the present study, stepwise multiple regression analysis could not detect the significant effect of execution amount of municipal ELM on make charcoal-burning suicide (figure 3), whereas additional linear regression analysis detected the inhibitory effect of municipal ELM on male charcoal-burning suicide (online supplemental appendix 3). Therefore, the possibility, that municipal ELM decreased male charcoal burning but increased jumping, cannot be completely denied. Based on these dynamics of suicide mortalities, prefectural ELM and municipal PCS probably replace a part of hanging suicides to jumping suicides, and municipal ELM also replace a part of charcoal-burning suicide to jumping suicide. Although drastic legal mean restrictions have not been implemented against charcoal burning or hanging suicides in Japan,²³ a part of charcoal-burning and hanging (more frequent suicide methods rather than jumping in Japan), possibly, was unexpectedly substituted to jumping by municipal PCS and prefectural and municipal ELM. In other words, means substitution can be generated by not only with means restriction but also with welfare/social safety nets and regional social protection. Clarification of whether prefectural TCS selectively suppressed jumping suicide or mean substitution induced reaction can provide important aspects for improving future regional suicide prevention programmes.

CONCLUSIONS

The present study indicates the possibility that governmental financial support, EFECBSC contributes to a reduction of suicide mortality in Japan. Especially, prefectural ELM, municipal DLL and ELM extensively decreased male hanging and charcoal-burning suicides, but increased male jumping suicide. Contrary, municipal PCS decreased female hanging suicide, but increased female jumping suicide. These results suggest that 'mean substitution' was conducted by not only 'means restriction' but also regional ELM and community-based gatekeeping

		Prefecture					Municipality				
		PCS	TCS	DLL	ELM	IVM	PCS	TCS	DLL	ELM	IVM
Total (male+female)	Hanging				■				■		
	Charcoal-burning								■		
	Jumping		■		■						
	Poisoning										
	Throwing										
Male	Hanging				■				■		
	Charcoal-burning							■			
	Jumping		■						■		
	Poisoning										
	Throwing										
Female	Hanging						■				
	Charcoal-burning		■						■		
	Jumping						■				
	Poisoning										
	Throwing										

Figure 5 Effects of the execution amounts of EFECBSC subdivisions on total (men plus women), male and female EBSMR trends by suicide methods. Blue and red columns indicate significant factors for reduced and increased EBSMR trends by suicide methods, hanging, charcoal burning, jumping, poisoning and throwing detected by stepwise multiple regression analysis. DLL, development programme of leaders and listeners; EBSMR, empirical Bayes standardised mobile ratio; EFECBSC, Emergency Fund to Enhance Community-Based Suicide Countermeasure; ELM, enlightenment; IVM, intervention model; PCS, personal consultation support; TCS, telephone consultation support.

activities. These present findings provide important information for planning a scientifically evidence-based and more cost-effective suicide prevention programme.

Contributors All authors were responsible for the development of the study design. TH and MO are responsible for conceptualisation. TH and MO are responsible for data collection and statistical analysis. MO, RM and YY have been involved in writing manuscript. All authors have read manuscript, contributed to and approved the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study was exempt from ethical approval from Mie University, since all data used in this study were obtained from national governmental database in Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC), Cabinet Office (CAO) and Ministry of Health, Labour and Welfare (MHLW).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. Data are available upon reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information. All raw data are available to any persons from Japanese National databases in Statistics Bureau of the Ministry of Internal Affairs and Communications (SBMIAC), Cabinet Office (CAO) and Ministry of Health, Labour and Welfare (MHLW).

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REFERENCES

- Ministry of Health LaW. 2020 white paper on suicide prevention, 2020. Available: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/seikatsuhogo/jisatsu/jisatsuhakusyo2020.html [Accessed 14 Nov 2020].
- Ministry of Health LaW. Basic data on suicide in the region, 2020. Available: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/seikatsuhogo/jisatsu/jisatsutoukei-jisatsusyasu.html [Accessed 18 Nov 2020].
- Ministry of Health LaW. 2019 white paper on suicide prevention, 2019. Available: <https://www.mhlw.go.jp/wp/hakusyo/jisatsu/19/index.html> [Accessed 14 Nov 2020].
- 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;69:55–64.
- Kato R, Okada M. Can financial support reduce suicide mortality rates? *Int J Environ Res Public Health* 2019;16:4797.
- Okada M, Hasegawa T, Kato R, et al. Analysing regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan using governmental statistical data. *BMJ Open* 2020;10:e037537.
- Ministry of Health LaW. National plan for prevention of suicide 2018, 2020. Available: <https://www.mhlw.go.jp/kokoro/nation/about.html> [Accessed 18 Nov 2020].
- Ministry of Health LaW. Regional suicide countermeasures emergency enhancement fund 2020, 2020. Available: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/seikatsuhogo/jisatsu/kyoukakikin.html [Accessed 18 Nov 2020].
- Mattei G, Pistoressi B, De Vogli R. Impact of the economic crises on suicide in Italy: the Moderating role of active labor market programs. *Soc Psychiatry Psychiatr Epidemiol* 2019;54:201–8.
- Kreitman N. The coal gas story. United Kingdom suicide rates, 1960–71. *Br J Prev Soc Med* 1976;30:86–93.
- Chapman S, Alpers P, Agho K, et al. Australia's 1996 gun law reforms: faster falls in firearm deaths, firearm suicides, and a decade without mass shootings. *Inj Prev* 2006;12:365–72.
- Havårneanu GM, Burkhardt J-M, Paran F. A systematic review of the literature on safety measures to prevent Railway suicides and trespassing accidents. *Accid Anal Prev* 2015;81:30–50.
- Chang S-S, Chen Y-Y, Yip PSF, et al. Regional changes in charcoal-burning suicide rates in East/Southeast Asia from 1995 to 2011: a time trend analysis. *PLoS Med* 2014;11:e1001622.



- 14 Miller M, Hemenway D. Guns and suicide in the United States. *N Engl J Med* 2008;359:989–91.
- 15 Yamasawa K, Nishimukai H, Ohbora Y, *et al.* A statistical study of suicides through intoxication. *Acta Med Leg Soc* 1980;30:187–92.
- 16 Yip PSF, Lee DTS. Charcoal-burning suicides and strategies for prevention. *Crisis* 2007;28(Suppl 1):21–7.
- 17 Yoshioka E, Saijo Y, Kawachi I. Spatial and temporal evolution of the epidemic of charcoal-burning suicide in Japan. *Soc Psychiatry Psychiatr Epidemiol* 2016;51:857–68.
- 18 Gunnell D, Bennewith O, Hawton K, *et al.* The epidemiology and prevention of suicide by hanging: a systematic review. *Int J Epidemiol* 2005;34:433–42.
- 19 Yip PSF, Caine E, Yousuf S, *et al.* Means restriction for suicide prevention. *Lancet* 2012;379:2393–9.
- 20 Okolie C, Wood S, Hawton K, *et al.* Means restriction for the prevention of suicide by jumping. *Cochrane Database Syst Rev* 2020;2:CD013543.
- 21 Cavanagh JT, Owens DG, Johnstone EC. Life events in suicide and undetermined death in south-east Scotland: a case-control study using the method of psychological autopsy. *Soc Psychiatry Psychiatr Epidemiol* 1999;34:645–50.
- 22 Chamberlain P, Goldney R, Delfabbro P, *et al.* Suicidal ideation. The clinical utility of the K10. *Crisis* 2009;30:39–42.
- 23 Yoshioka E, Hanley SJ, Kawanishi Y, *et al.* Time trends in method-specific suicide rates in Japan, 1990–2011. *Epidemiol Psychiatr Sci* 2016;25:58–68.
- 24 Ministry of Internal Affairs and Communications. Population, demographics and number of households based on basic resident register, 2020. Available: http://www.soumu.go.jp/main_sosiki/jichi_gyousei/daiyo/jinkou_jinkoudoutai-setaisuu.html [Accessed 18 Nov 2020].
- 25 Nakano T, Hasegawa T, Okada M. Analysing the impacts of financial support for regional suicide prevention programmes on suicide mortality caused by major suicide motives in Japan using statistical government data. *Int J Environ Res Public Health* 2021;18. doi:10.3390/ijerph18073414. [Epub ahead of print: 25 03 2021].
- 26 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:e0148288.
- 27 Ajdacic-Gross V, Weiss MG, Ring M, *et al.* Methods of suicide: international suicide patterns derived from the who mortality database. *Bull World Health Organ* 2008;86:726–32.
- 28 World Health Organization. Suicide: one person dies every 40 seconds 2019. Available: <https://www.who.int/news/item/09-09-2019-suicide-one-person-dies-every-40-seconds> [Accessed 18 Nov 2020].
- 29 Morovatdar N, Moradi-Lakeh M, Malakouti SK, *et al.* Most common methods of suicide in eastern Mediterranean region of who: a systematic review and meta-analysis. *Arch Suicide Res* 2013;17:335–44.
- 30 Hedegaard H, Curtin SC, Warner M. QuickStats: Age-Adjusted Suicide Rates* for Females and Males, by Method(†) - National Vital Statistics System, United States, 2000 and 2014. *MMWR Morb Mortal Wkly Rep* 2016;65:503.
- 31 Wong PWC, Chan WSC, Lau TK, *et al.* Suicides by jumping from iconic bridges in Hong Kong. *Crisis* 2009;30:79–84.
- 32 Park S, Lee HB, Lee SY, *et al.* Trends in suicide methods and rates among older adults in South Korea: a comparison with Japan. *Psychiatry Investig* 2016;13:184–9.
- 33 Simon OR, Swann AC, Powell KE, *et al.* Characteristics of impulsive suicide attempts and attempters. *Suicide Life Threat Behav* 2001;32:49–59.
- 34 Hagihara A, Miyazaki S, Abe T. Internet suicide searches and the incidence of suicide in young people in Japan. *Eur Arch Psychiatry Clin Neurosci* 2012;262:39–46.
- 35 Hitosugi M, Nagai T, Tokudome S. A voluntary effort to save the youth suicide via the Internet in Japan. *Int J Nurs Stud* 2007;44:157.

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Supplementary Data

Appendix 1: Operation and activity of 'Emergency Fund to Enhance Community-Based Suicide Countermeasure' (EFECBSC). (p2).

Appendix 2: Effects of the execution amounts of EFECBSC sub-divisions on total (male plus female), male and female EBSMR trends of hanging, charcoal-burning and jumping suicides. (p3)

Appendix 3: Effects of the execution amounts of municipal ELM of EFECBSC on EMSMR trends of male charcoal-burning suicide analysed by linear regression analysis. (p4)

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Appendix 1: Operation and activity of ‘Emergency Fund to Enhance Community-Based Suicide Countermeasure’ (EFECBSC).

‘Emergency Fund to Enhance Community-Based Suicide Countermeasure’ (EFECBSC) is composed of ten sub-divisions of regional support programmes of five independent prefectural and five municipal suicide prevention programmes [1-3]: 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) [1-3]).

Each municipality submitted its municipal suicide prevention programme (PSC, TCS, DLL, ELM and IVM) 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. These prefectural and municipal suicide prevention programmes were independent of each other [1-4].

PCS supports the development of a multidisciplinary support system and community support consultation sessions against economic problems (unemployment, bankruptcy and multiple debts) and health problems that are risk factors for suicide, as well as a system of broad collaboration between professionals such as "lawyers, psychiatrists, social workers, and public health nurses [1-4].

TCS supports the enhancement of the system required for telephone and internet support implemented by the prefecture, municipality and private organisations (sharing of telephone numbers, free 24-hour support, etc.) [1-4].

DLL organises workshops for human resources training to provide consultation support for persons at high risk of suicide, persons who have attempted suicide and bereaved family members (gatekeeper, leader, and listener) [1-4].

ELM provides financial support for public relations such as newspapers, television, radio, pamphlets, symposiums, lectures, etc. in order to raise awareness of social and public support for high-risk people [1-4].

IVM supports survey and support programmes against high-risk individuals independently implemented by prefectures and municipalities [1-4].

References

1. Okada, M.; Hasegawa, T.; Kato, R.; Shiroyama, T. Analysing regional unemployment rates, GDP per capita and financial support for regional suicide prevention programme on suicide mortality in Japan using governmental statistical data. *BMJ open* **2020**, *10*, e037537.
2. Kato, R.; Okada, M. Can Financial Support Reduce Suicide Mortality Rates? *International journal of environmental research and public health* **2019**, *16*, 4797.
3. Ministry of Health, L.a.W. Regional Suicide Countermeasures Emergency Enhancement Fund. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/seikatsuhogo/jisatsu/kyoukaki_kin.html (accessed on 2020.11.18).
4. Ministry of Health, L.a.W. National Plan for Prevention of Suicide. Available online: <https://www.mhlw.go.jp/kokoro/nation/about.html> (accessed on 2020.11.18).

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Appendix 2: Effects of the execution amounts of EFECBSC sub-divisions on total (male plus female), male and female EBSMR trends of hanging, charcoal-burning and jumping suicides.

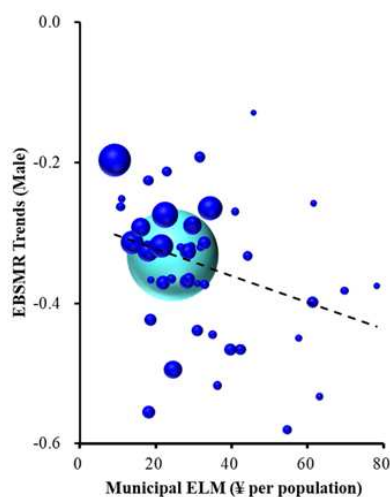
Total(male+female)	Adjusted R ²	F value	(degrees of freedom)	P value	Factor		β	t value	P	VIF
hanging	0.375	13.203	(2,44)	0.01	Prefectural	ELM	-0.429	-3.549	0.01	1.03
					Municipal	DLL	-0.371	-3.066	0.01	1.03
charcoal-burning	0.124	6.345	(1,45)	0.05	Municipal	ELM	-0.352	-2.519	0.05	1.00
Jumping	0.173	4.587	(2,44)	0.05	Prefectural	TCS	-0.296	-2.156	0.05	1.00
					Prefectural	ELM	0.306	2.230	0.05	1.00
Male										
hanging	0.385	13.775	(2,44)	0.01	Prefectural	ELM	-0.460	-3.833	0.01	1.03
					Municipal	DLL	-0.347	-2.891	0.01	1.03
charcoal-burning	0.128	6.591	(1,45)	0.05	Municipal	DLL	-0.357	-2.567	0.05	1.00
Jumping	0.182	4.890	(2,44)	0.05	Prefectural	TCS	-0.299	-2.189	0.05	1.00
					Municipal	ELM	0.319	2.338	0.05	1.00
Female										
hanging	0.143	7.517	(1,45)	0.01	Municipal	PCS	-0.378	-2.742	0.01	1.00
charcoal-burning	0.263	7.862	(2,44)	0.01	Municipal	ELM	-0.437	-3.370	0.01	1.00
					Prefectural	TCS	0.292	2.253	0.05	1.00
Jumping	0.090	4.448	(1,45)	0.05	Municipal	PCS	0.300	2.109	0.05	1.00

Effects of execution amount of 10 EFECBSC sub-divisions on EBSMR trends of total, male and female were analysed by stepwise multiple regression analysis. Red painted sub-divisions of EFECBSC indicate the negative effects on prevention of suicide mortality.

DLL, development programme of leaders and listeners; EFECBSC, Emergency Fund to Enhance Community-Based Suicide Countermeasure; ELM, enlightenment programme; PCS, personal consultation support programme; TCS, telephone consultation support programme; VIF, variance inflation factor.

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Appendix 3: Effects of the execution amounts of municipal ELM of EFECBSC on EMSMR trends of male charcoal-burning suicide analysed by linear regression analysis.



Ordinates indicate EBSMR trends between 2009 and 2018, and abscissas indicate execution amount of municipal ELM of EFECBSC (per population). Light blue and deep blue spheres indicate national and prefectural male EBSMR trends and population sizes, respectively. Black line indicates the regression lines of significantly positive (reduced suicide mortality) factor.

Stepwise multiple regression analysis could not detect the significant/inversely relation between execution amounts of municipal ELM and male EBSMR trends of charcoal-burning suicide, whereas linear regression analysis revealed the significant inhibitory effects of execution amounts of municipal ELM on male EBSMR trends of charcoal-burning suicide.

Male EBSMR trends by charcoal-burning suicide = $-0.0188 \times (\text{municipal ELM}) - 0.2851$ ($R^2 = 0.0923$, $P < 0.05$) (¥53.1 million of municipal ELM decreased male charcoal-burning suicide suicides by 1/100,000 per year).