Demographic determinants of suicide rates in Japan from 1979 to 2016

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Demographic Determinants of Suicide Rates in Japan from 1979 to 2016

Abstract

Background: Suicide is a major public health concern in Japan. This study aimed to characterize the trends in suicide mortality in Japan by method since 1979.

Methods: Using data from the Japan vital registration system, I calculated age-standardised rates of suicide mortality separately by sex and method. I conducted a log-linear regression of suicide mortality rates separately by sex, and linear regression analysis of the proportion of deaths due to hanging, including a test for change in level and trend in 1998.

Results: While crude suicide rates were static over the time period, age-adjusted rates declined. The significant increase in suicide mortality in 1998 was primarily driven by large changes in the rate of hanging, with suicide deaths after 1998 having 36.7% higher odds of being due to hanging for men (95% CI: 16.3–60.8%), and 21.9% higher odds of being due to hanging for women (95% CI: 9.2–35.9%). Ageing made a major contribution to the increase in overall crude suicide rates and also among men from 1980 to 2015. Suicide by hanging among men and women followed a similar pattern. About 51.6% of the increase in baseline crude suicide rate by hanging among men was due to ageing.

Conclusion: Hanging has become an increasingly important method for committing suicide over the past 40 years, and although suicide rates have been declining continuously over this time, more effort is needed to prevent hanging and address the potential cultural drivers of suicide if the rate is to continue to decline in the future.

Keywords: suicide; Japan; injury; Poisson regression; mortality; hanging; decomposition

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Acknowledgements

It has been a paradise for me to accomplish the research on the topic *Demographic Determinants of Suicide Rates in Japan from 1979 to 2016***.** Words do not suffice to express my sincere thanks and gratitude to all who enthusiastically helped me complete this work with their valuable support, guidance and cooperation. I am indebted to St. Luke's International University for providing a great opportunity to conduct this research study during the Masters in Public Health Program.

I feel proud and privileged to be supervised by Stuart Gilmour, Professor, Department of Biostatistics and Bioinformatics, St. Luke's International University. I express my heartfelt gratitude to him for his support, guidance and encouragement throughout the study period. I am thankful to the library at St. Luke's for providing the necessary materials and training that was helpful for the study. I appreciate all the help that I received from St. Luke's faculty. I sincerely thank my classmates for their support and valuable suggestions. Lastly, I would like to thank all who have directly or indirectly helped me during the course of my study.

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MHLW	Ministry of Health, Labour and Welfare
ICD	International Classification of Disease
IRR	Incidence Rate Ratio
CI	Confidence Interval
BBS	Bulletin Board Systems

1 INTRODUCTION

1.1 Background information

Suicide has always been a topic of public health concern. In 2016, around 800,000 suicide deaths occurred worldwide, with an annual global age-standardised suicide rate of 10.53 per 100,000 [1]. Globally, suicide is the second-leading cause of death among people aged 15–29 years and accounts for about 1.4% of premature deaths. Histories of medical disorders such as depression, mood disorder, and cognitive impairment have been identified as important risk factors for suicide [2], but sociocultural factors are also likely to play a major role in suicide epidemiology. There are significant sex imbalances in risk, with a ratio of three male deaths for every female death in high-income countries, and three male deaths for every two female deaths in low-income and middle-income countries. The global age-standardised suicide rate fell 26% (23% in men and 32% in women) from 2000 to 2012, but this pattern varies by country or region [3]. Little is known about the reason for large spatial and temporal variations in suicide rates.

Japan had one of the highest suicide rates in the industrialised world for a long time [4]. Japan ranked 14th for suicide rates globally in 2018, and suicide was the sixth leading cause of death in Japan in 2015 [5], [6]. Hanging has been consistently recorded as the most frequently used suicide method, and makes a major contribution to the overall suicide mortality rate, especially among people aged 50 years and above [7]–[10]. As the dominant method of suicide, hanging accounts for more than 60% of suicide deaths in Japan [11]–[13].

Hanging has been shown to be one of the most lethal suicide methods, with a fatality rate of over 83% [14], [15], and small changes in the distribution of methods of suicide can have the potential to drive large changes in the overall rate [16], making action on restricting access to certain methods of suicide a common public health strategy for reducing suicide mortality [17]–[19].

From 1960 until 1995, the crude suicide mortality rate in Japan decreased from 27.7 [20] to 17.1 per 100,000 before increasing suddenly in 1998 to a rate of 25.3 per 100,000. Previous studies have reported that this increase may be closely related to unemployment and economic hardship during the same period [21]. However, it is possible that these changes reflect ageing or changes in the distribution of methods of suicide. In Japan, the suicide rate increases with the increase in age, with rates among men twice those of women [22]. Previous research on suicide typically analysed crude suicide rates [23], which are influenced by the age composition of the population [24], [25]. Since the age distribution of Japan has changed rapidly over time, the use of crude, rather than age-adjusted, rates in the measurement of suicide trends could be misleading.

Population composition plays an important role in mortality and thus should be considered when comparing two different populations or the same population at two different times. Directly standardised rates are calculated adjusting for the difference in the age composition of the population and are used to compare mortality in two populations through the application of age-specific mortality rates in the two populations of interest to a single reference population.

In Japan, from 1980 to 2015, population composition has changed drastically. The proportion of children aged 0-14 has halved (23.5 to 12.5%) while the proportion of those aged 65 years and above has increased three-fold (9.1 to 26.6%) [26]. This shift in the population balance means that even small differences in rates between age groups will have a major effect on the suicide rate over the period from 1979 to 2016, as the population of people most at risk of suicide death grows due to ageing. The change in the crude suicide rate over this period is a result of not just the change in age-specific rates but the change in population composition as well. In order to see the component effects, it is thus necessary to perform decomposition of the rates.

1.2 Objectives

In this study, I analysed patterns of suicide by sex, age, and method to discover the relationship between these risk factors and describe the specific features of suicide mortality in Japan [22].

The objectives of the research are to:

1. Characterize the trends in and risk factors for suicide in Japan
2. Identify the magnitude of the increase in 1998 and the extent to which it is driven by changes in method
3. Decompose the suicide rates in Japan

Analysis of the trends in different methods of suicide helps to understand the overall current trends in countries such as Japan where rapid changes have been observed, especially

in high-income countries, which face a high burden of suicide-related mortality in a rapidly ageing population. It may also help to explain the swift changes that have been observed in Japan during the 1990s, and shed some light on similar rapid changes that occurred at this time in other developed nations such as Australia [27].

2 METHODS

2.1 Data Source

Data on suicide mortality were obtained from the vital statistics registration of the Ministry of Health, Labour, and Welfare (MHLW) in Japan [6]. This database provides complete coverage of all the deaths that have occurred in Japan with the cause of death coded using the International Classification of Disease (ICD)-9 or ICD-10 codes.

Table 1 shows the International Classification of Disease (ICD) codes used to define suicide categories by ICD era.

Table 1: ICD codes used for suicide definition, by year and ICD era

Years	ICD version	Overall ICD codes	ICD codes by method				
			Drowning	Gas	Hanging	Poisoning	Other
1979 – 1994	9	E950–E959	E954	E951, E952	E953	E950	E955, E956, E957, E958
1995 – 2016	10	X60–X84	X71	X67	X70	X60-X66, X68-X69	X72-X83

This data is available upon the submission of an application by researchers based in Japan and holding appropriate authority.

2.2 Standardization

For an analysis of overall trends, I computed age-adjusted directly standardised suicide rates with the 2010 population of Japan as the standard population [28]. In this research, I

divided age into four groups (15–29, 30–59, 60–79, and 80+ years) and compared the trends in suicide by age group and method.

2.3 Statistical analysis

To analyse trends in suicide rates by gender, age, and methods used between 1979–2016, I performed Poisson regression analysis. I used age group, suicide method, year, and a variable indicating whether the suicide occurred before or after 1998 to capture the sudden rise occurring in this year. Then, I included interactions for year, age category, sudden rise, and method of suicide to estimate trends in different methods by age category before and after 1998 as well as to determine the percent change in suicide rates (change in level) after 1998. A linear regression analysis was conducted by sex to estimate changes in the proportion of suicide deaths that were due to hanging.

I excluded children aged under 15 years from the regression analysis due to the very low suicide rate in this age group. I used different models for men and women due to the variation in patterns as well as choice of methods. Linear combinations of the key variables (year, suicide method, age category, 1998 increase) were calculated in order to estimate the change in suicide rate before and after 1998 separately for age and suicide category with 95% confidence intervals. These linear combinations were presented as annual percentage changes (for trends) or absolute percentage changes (for the change in level in 1998). I conducted all analyses in Stata/IC version 15 (Stata Corp LP, College Station, TX, USA).

2.3.1 Analysis of suicide mortality rates

Data were modelled as Poisson distributed, with population included in the model as an offset to ensure that changes in population structure are accounted for. The model was conducted separately by sex and includes a term for a linear time trend, with interaction terms to allow different time trends by age category and method of suicide. A step term (0 before 1998, 1 for 1998 and after) was included to model the impact of the 1998 increase in suicide rates. To answer the key research question, a four-way interaction between suicide type, the step term, age category and time was tested. This four-way interaction, if significant, indicates that the effect of the 1998 step on trend in suicide differed by age and suicide category.

This can be written in equation form for the simplest case as follows. Suppose that at time i we have data on the number of suicide deaths y_i, occurring at rate μ_i in population n_i.

Then we can describe the fundamental distribution of the data as

$$y_i \sim Poisson(\mu_i)$$

where the rate μ_i is related to the covariates through a log-linear expression as follows:

$$\begin{aligned}\ln(\mu_i) = \alpha + \ln(n_i) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} + \beta_5 x_{i1} x_{i2} \\ + \beta_6 x_{i1} x_{i3} + \beta_7 x_{i1} x_{i4} + \beta_8 x_{i2} x_{i3} + \beta_9 x_{i2} x_{i4} + \beta_{10} x_{i3} x_{i4} + \beta_{11} x_{i1} x_{i2} x_{i3} \\ + \beta_{12} x_{i1} x_{i2} x_{i4} + \beta_{13} x_{i1} x_{i3} x_{i4} + \beta_{14} x_{i2} x_{i3} x_{i4} + \beta_{15} x_{i1} x_{i2} x_{i3} x_{i4}\end{aligned}$$

where,

α is the intercept term

x_{i1} is the year, with the first year in the data series (e.g. 1979) set to be 0

x_{i2} is the suicide category (1 for hanging, 2 for gas, 3 for drowning, 4 for poisoning and 5 for other methods)

x_{i3} is the age category (1 for 15-29, 2 for 30-59, 3 for 60-79 and 4 for 80+)

x_{i4} is the step function (0 for years <1998, 1 for 1998 and onward)

In this equation all categorical variables with more than two levels (age group and method) are actually composed as sets of dummy variables, so in fact x_2 is composed of a set of four dummy variables. However, for simplicity in the model equation I have written these sets of dummy variables as a single term. Where interactions are depicted, all dummy variables are entered into the interaction as a single group and removed together, in accordance with standard statistical practice. In this case coefficients of these variables (e.g. β_5) should be interpreted as actually reflecting a set of coefficients attached to all the combinations of dummy variables in the interaction term.

Table 2 shows the coefficients used in the model with their measurement.

Table 2: Coefficients in the model and the corresponding measure of effects

β_1	measures the time trend in hanging related mortality for people aged 15-29 before the 1998 increase
β_2	measures the rate ratio of mortality among suicide methods for people aged 15-29 at the starting year
β_3	measures the rate ratio of mortality among various age categories who committed suicide before 1998 by hanging
β_4	measures the sudden increase or decrease in suicide mortality in 1998 relative to 1997
β_5	measures the difference in trend for various suicide methods among people aged 15-29 in the period before 1998
β_6	measures the trend in hanging mortality by age categories before 1998
β_7	measures the change in trend in hanging among people aged 15-29 in 1998
β_8	measures the rate ratio of mortality by various suicide methods in different age categories before 1998
β_9	measures the sudden increase or decrease in suicide rates in 1998 relative to 1997 for hanging suicide among people aged 15-29 (the additional impact of the 1998 step on the level of suicide rates by various methods)
β_{10}	measures the change in step in 1998 by age category for hanging suicide
β_{11}	measures the difference in trend for various suicide methods among people aged 15-29 in the period before 1998

β_{12}	measures the change in trend in various suicide methods among 15-29 aged people in 1998
β_{13}	measures the change in hanging trend in various age categories in 1998
β_{14}	measures the increase in step in 1998 by age and suicide categories
β_{15}	measures the additional change in trend in suicide by various age and suicide categories in 1998

The study estimates these key parameters for suicide, separately by sex, adjusting for broad age groups and categorizing by age group and methods of suicide.

2.3.2 Analysis of proportion of suicide deaths due to hanging

A linear regression analysis was performed by sex by including year variable and a step term to measure the effect of hanging by suicide.

The model takes the form,

$$logY_i = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \epsilon_i$$

where,

Y_i is the estimate of the odds of proportion of suicides due to hanging in the i-th year

β_0 is the intercept term

x_{i1} is the year, with the first year in the data series (e.g. 1979) set to be 0

β_1 measures the trend in proportion of deaths due to hanging before 1998

x_{i2} is the step function (0 for years <1998, 1 for 1998 and onward)

β_2 measures the increase in proportion of suicide deaths in 1998 compared to 1997 that is attributed to hanging

ϵ_i is the random error

2.4 Decomposition analysis

Standardization and decomposition techniques are widely used to estimate the confounding effect of population structure on the rate [29]. Das Gupta [30] proposed a two-component decomposition for data classified by one factor where the average of factor specific rates and the average of population structure are used as the standard to calculate rate effect and composition effect respectively. For example, if a data contains one factor, namely, age (I), then decomposition analysis enables calculation of the proportion of change in the data due to the effect of age (called the age (I)-effect), and the proportion of change due to changes in the rate of the outcome (called the rate (R)-effect). It is possible for the crude rate of a disease or death to change due to population ageing even though age-specific rates have not changed at all, and the Das Gupta method provides a mechanism for estimating what proportion of the change is due to this effect.

In this study, I wish to identify what proportion of the change in crude suicide mortality rates from 1980 to 2015 was due to population ageing, and what proportion was due to any changes in age-specific rates that may have been identified in the log-linear regression. In this section I considered 1980 as population 1 and 2015 as population 2, and calculated the proportion of change in population 2 that was due to differences in age structure between them, and what proportion due to difference in age-specific rates.

First of all, crude rates in 1980 and 2015 were calculated and the difference in crude rates in these years were computed. This difference in crude rates is the total effect, which was then divided into rate-effect and age-effect.

The Das Gupta [30] method for the case of one factor, age, was used to decompose the rates into the effect of age structure and age-specific rate. It follows from Das Gupta [30] that,

$$Difference\ (effects)(t-T) = R\ (rate)\ effect + I\ (age)\ effect$$

$$t - T = [R(\bar{t}) - R(\bar{T})] + [I(\bar{a}) - I(\bar{A})]$$

where,

$$R(\bar{T}) = \sum_i \frac{\left(\frac{n_i}{n}\right) + \left(\frac{N_i}{N}\right)}{2} * T_i$$

$$R(\bar{t}) = \sum_i \frac{\left(\frac{n_i}{n}\right) + \left(\frac{N_i}{N}\right)}{2} * t_i$$

$$I(\bar{A}) = \sum_i \frac{t_i + T_i}{2} * A_i$$

$$I(\bar{a}) = \sum_i \frac{t_i + T_i}{2} * a_i$$

$R(\bar{t})$ and $R(\bar{T})$ are the age-standardised rate in the year 2015 and 1980 respectively. The difference in the age-standardised rate in 2015 and 1980 i.e. $R(\bar{t}) - R(\bar{T})$ was calculated which is the rate effect. Similarly, $I(\bar{a})$ and $I(\bar{A})$ are the rate-standardised rate in the year 2015 and 1980 respectively. The difference in the rate-standardised rates in 2015 and 1980 i.e. $I(\bar{a}) - I(\bar{A})$ which is the age-effect was also calculated.

In the above equation,

t = crude rate in 2015

T = crude rate in 1980

N_i = number of persons in the ith category of age in 1980

n_i = number of persons in the ith category of age in 2015

T_i = rate for the ith category of age in 1980

t_i = rate for the ith category of age in 2015

N = total number of persons in 1980

n = total number of persons in 2015

The total effect is the sum of the rate-effect and age-effect. Percent distribution of effect was calculated as follows:

Percent distribution of age-effect $= \frac{age\ effect}{crude\ rate\ in\ 1980} * 100$

Percent distribution of rate-effect $= \frac{rate\ effect}{crude\ rate\ in\ 1980} * 100$

This will give the additive contributions of the effects of the differences in the compositional or rate factors in between population of 1980 and 2015 to the baseline crude rate in the year 1980.

3 RESULTS

This study analysed suicide data for a period of 38 years from 1979 to 2016. During this period, there was more than 20,000 deaths due to suicide every year with a total of 308,728 deaths among women and 664,316 deaths among men. Results has been divided into 3 subsections: suicide trends, change in suicide level in 1998 and decomposition of suicide rates.

3.1 Crude and age-standardised trends in suicide mortality

Figure 1 shows the age-standardised and crude suicide rates for the period 1979 to 2016. It is clear that after age standardisation, the trend in suicide was decreasing until 1995; this was in contrast to the trend in crude rates, which were stable between 1979 and 1995. The sudden rise in 1998 did not appear to change the broad downward trend in suicide.

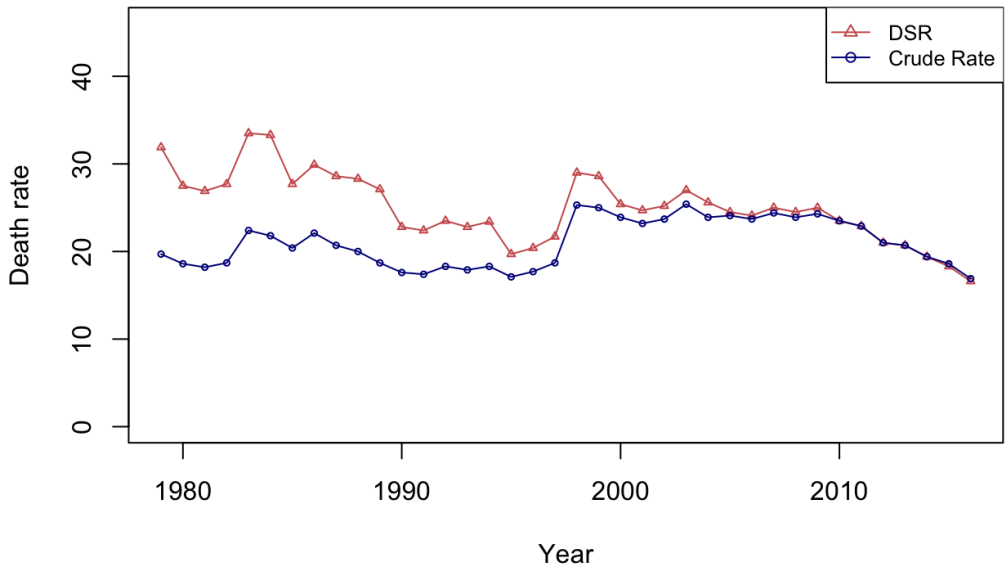
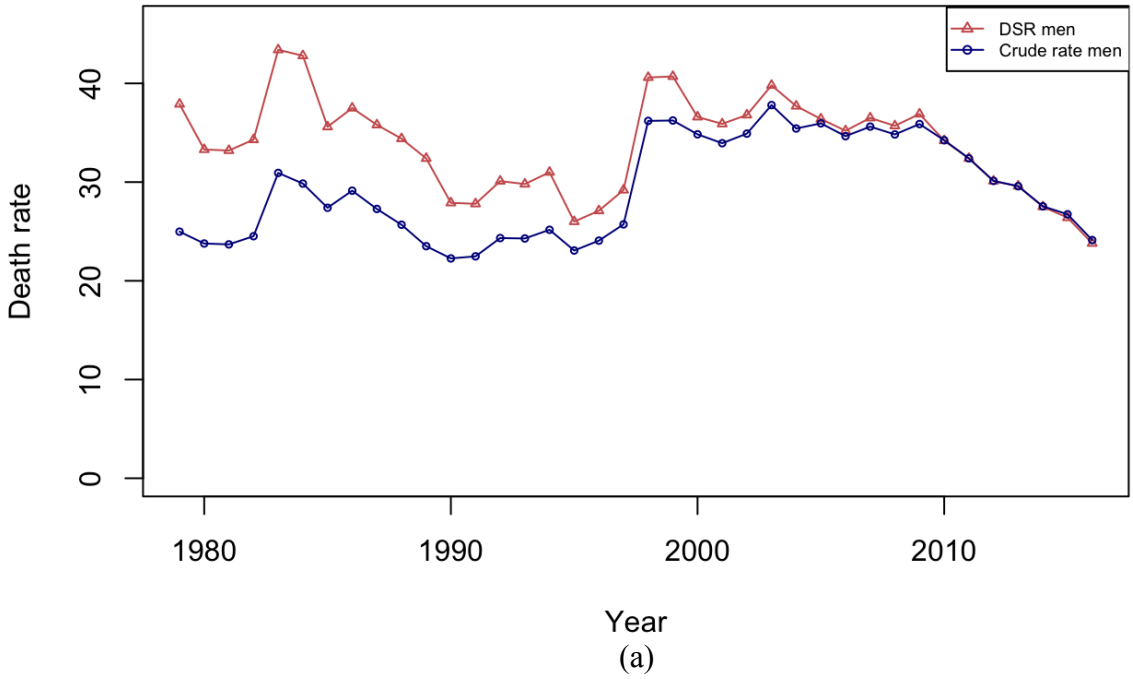


Figure 1: Crude and standardised suicide rates from 1979 to 2016

Figure 2 shows the age-standardised and crude suicide rates by gender. From the figure, it is evident that the suicide rate among men is higher than that among women. For men and women, the age-adjusted rate was decreasing between 1979–1997, rose sharply in 1998, and then declined steadily, whereas the crude rates plateaued for about 10 years after reaching their highest level in 1998. This suggests that crude rates in Japan over the past 30 years have been heavily affected by the ageing of the population, which drives a growing proportion of the population into higher-risk age groups.



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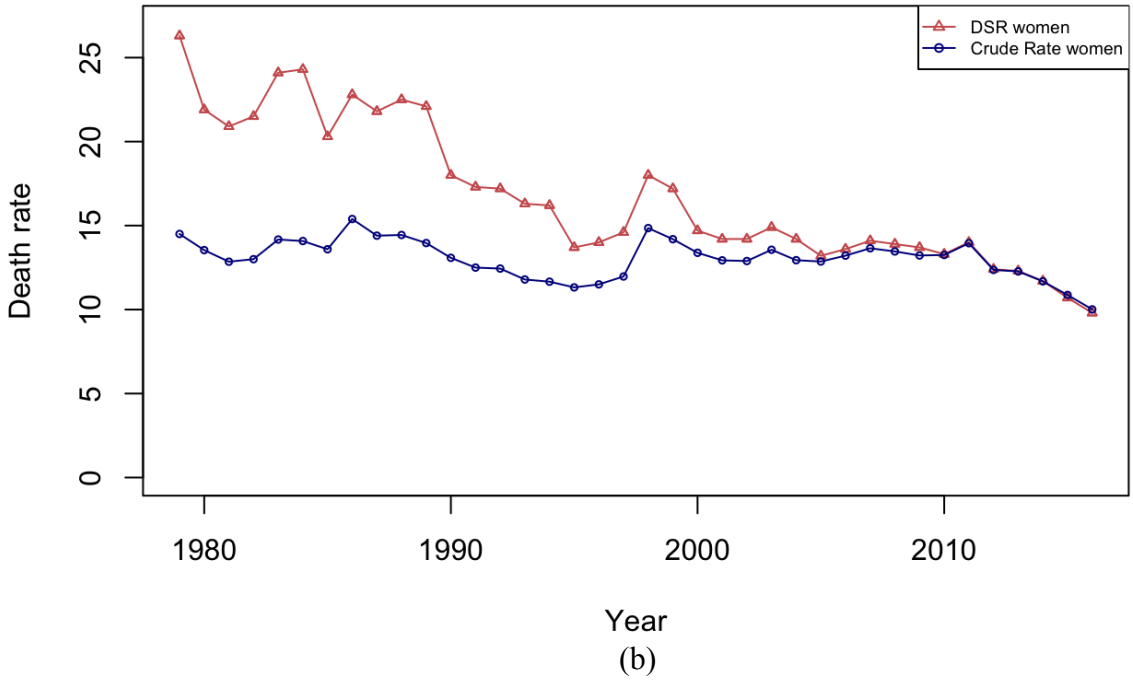
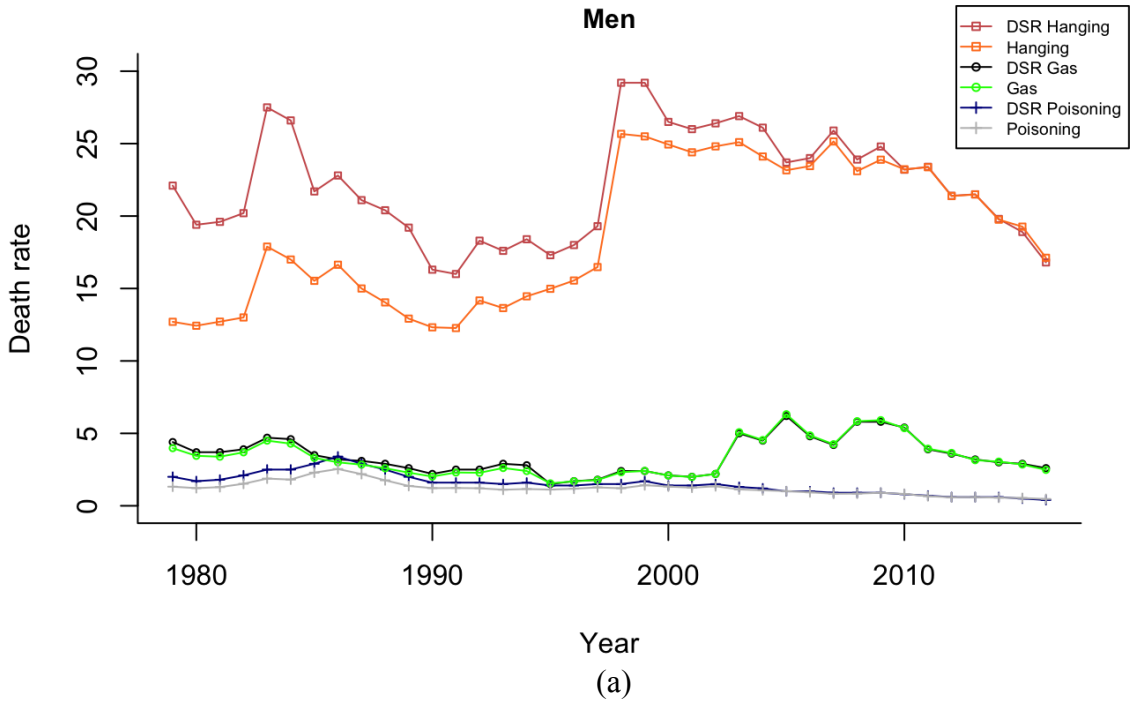


(b)

Figure 2: Crude and standardised suicide rates by sex: (a) men, (b) women

Figure 3 shows the trends in age-standardised and crude suicide mortality by the top three methods for men and women. These figures clearly show that in all years from 1979 to 2016, hanging was the most commonly used method to commit suicide among both men and women. Suicide by hanging was higher in men compared to women. Hanging was followed by gas and poisoning in men and by poisoning and drowning in women. Both the figures show that the rates of drowning, poisoning, and gas did not increase sharply in 1998, leaving hanging as the main method of suicide. In men (a), suicide by poisoning increased during the mid-1980s, after which it levelled at very low rates until 2016. Suicide by gassing among men, which did not increase much around 1998, instantaneously became more common among men after 2002. The age-standardised suicide rate for drowning among women (b) was declining steeply throughout the period studied compared to the crude rate. Suicide by poisoning and drowning among women, which was often high, suddenly plateaued after 1998.



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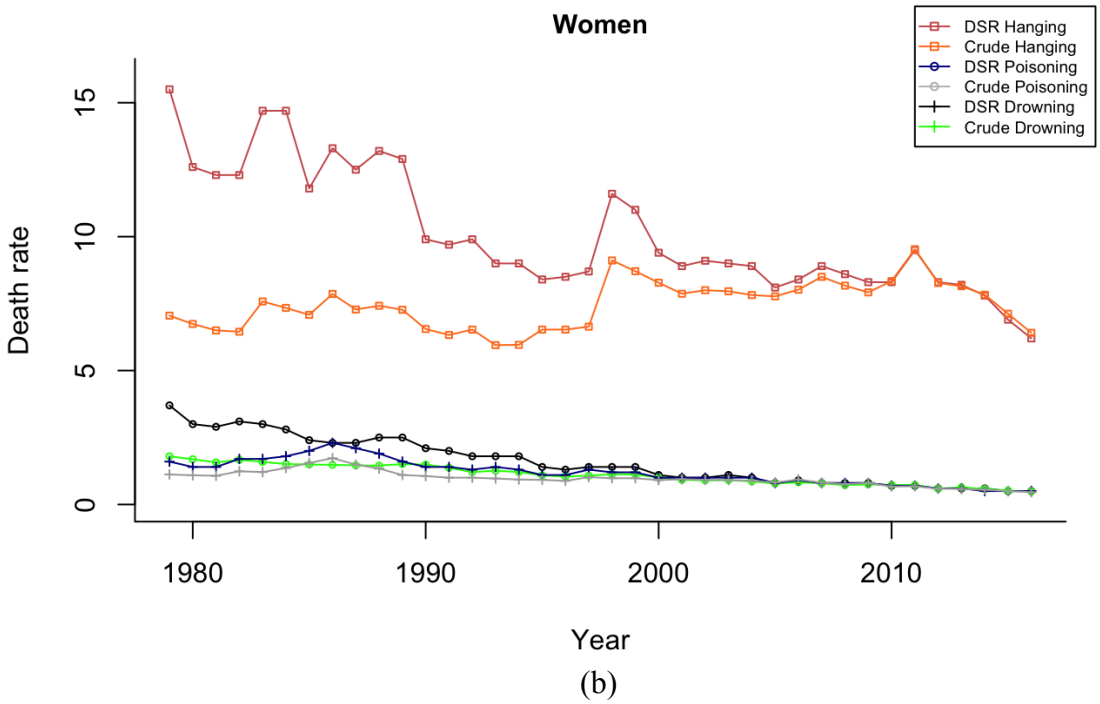
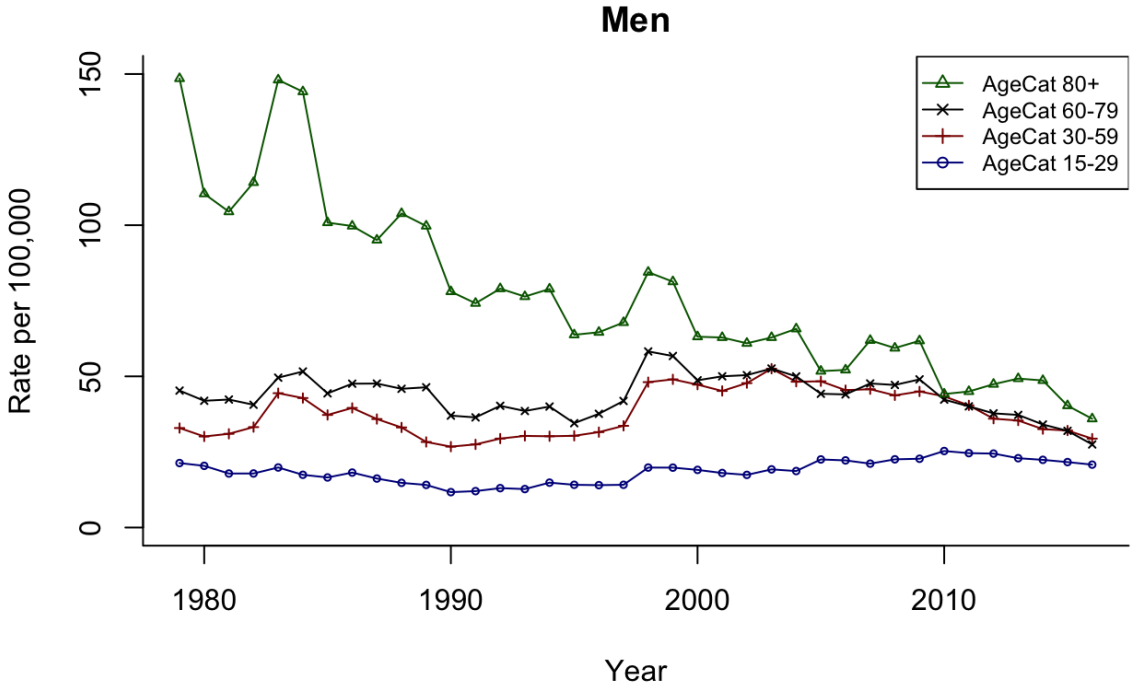


(b)

Figure 3: Trends in age-standardised and crude suicide mortality by top three methods:

(a) men, (b) women

Figure 4 shows the trends in suicide rates by age category for men and women from 1979 to 2016. The suicide trend for people aged 80+ follows a broad downward trend in both sexes. However, among men aged 30–79, suicide rates increased slightly after 1997. These figures clearly show that suicide rates increase with any increase in age, but are decreasing rapidly in the groups with the highest rates. Note that even in the broader age categories shown here, the effect of ageing within the narrower age categories may lead to an appearance of stable rates when they are actually mildly decreasing. Since plots of five-year age groups are too complex to depict, age-specific rates in very narrow categories are not shown.



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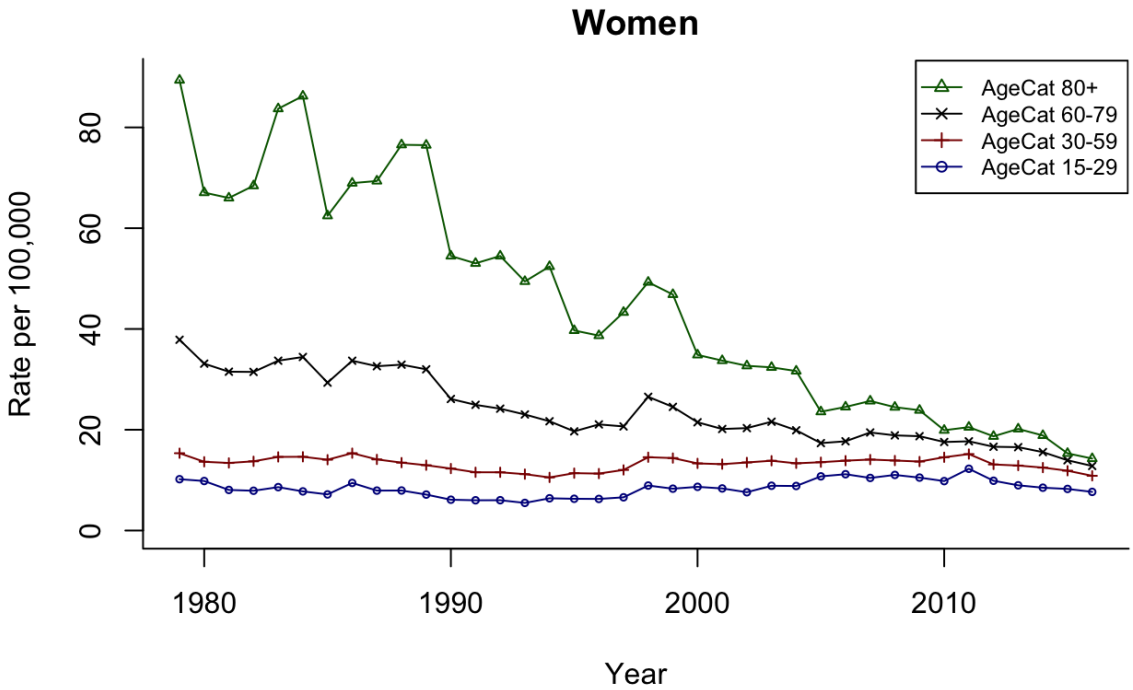
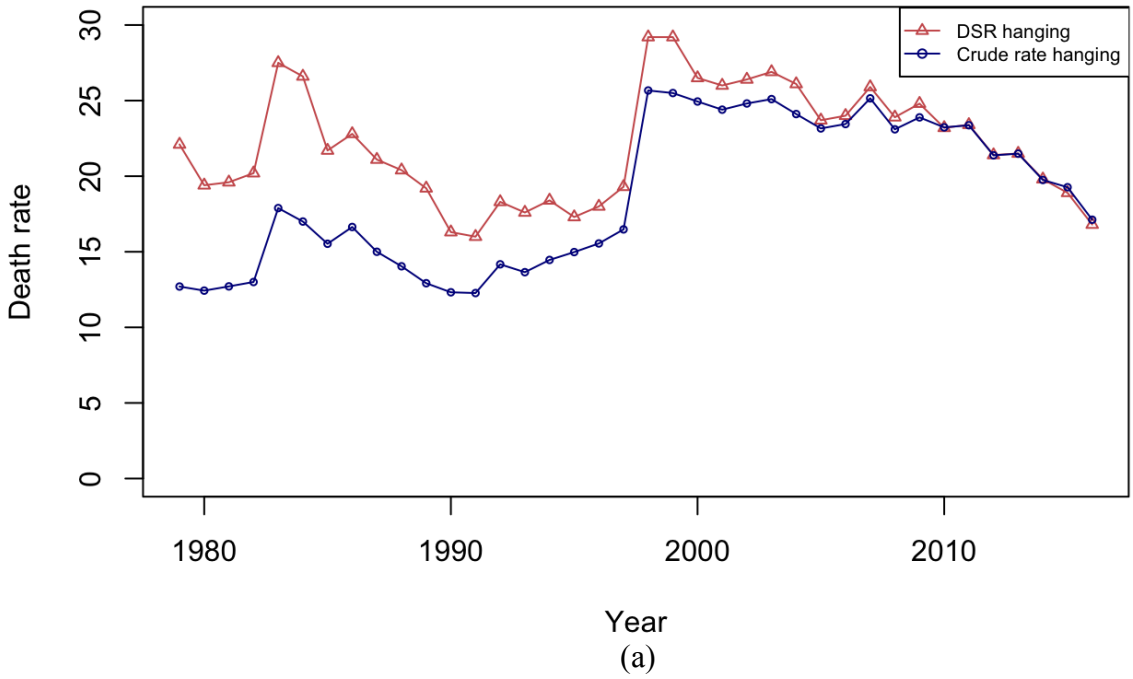


(b)

Figure 4: Trends in suicide mortality by age group: (a) men, (b) women

Hanging, is the most frequently used method of suicide in Japan and also the most lethal. It contributes to a large proportion of the overall suicide rates in Japan, and deserves special investigation. The age-adjusted and crude suicide rates due to hanging for men and women respectively are depicted in Figure 5. The rate of suicide mortality by hanging was higher in men compared to women. In the late 1990s, suicide by hanging increased sharply for both men and women of all age groups. Even for hanging, the trend in the age-standardised suicide rate was decreasing until 1998, when it increased suddenly, and then continued to decline again among men. In the case of women, the rise in age-standardised suicide rates in 1998 slowed down the decreasing trend. Hanging-related suicide in women remained low from the year 2000 onwards.



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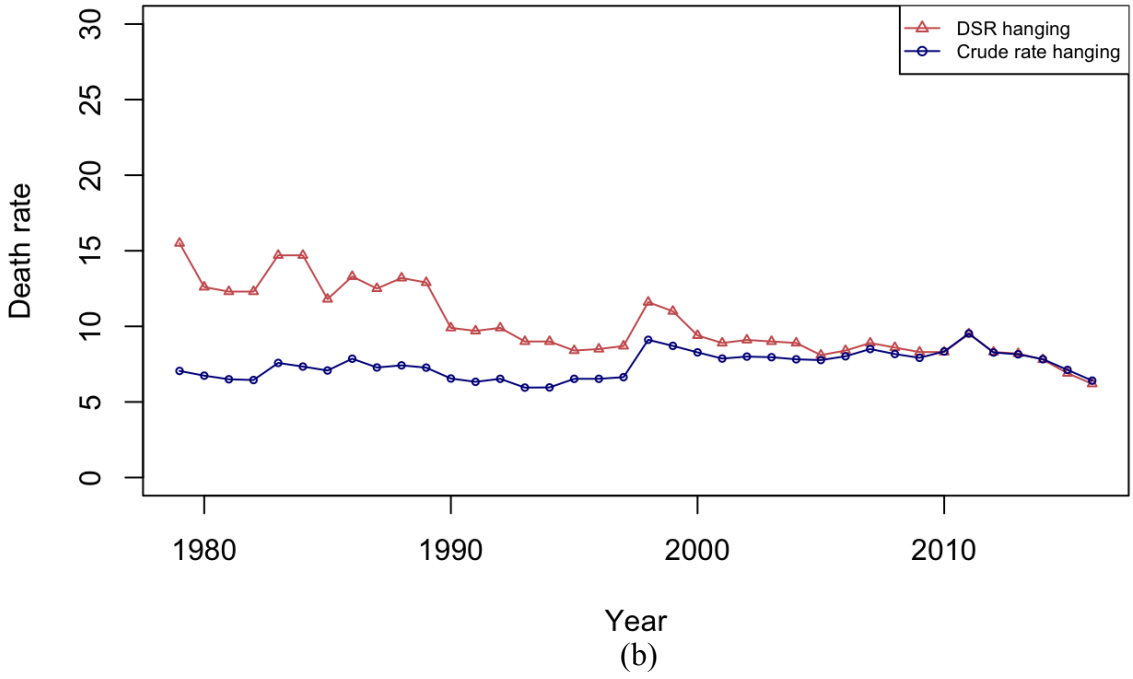


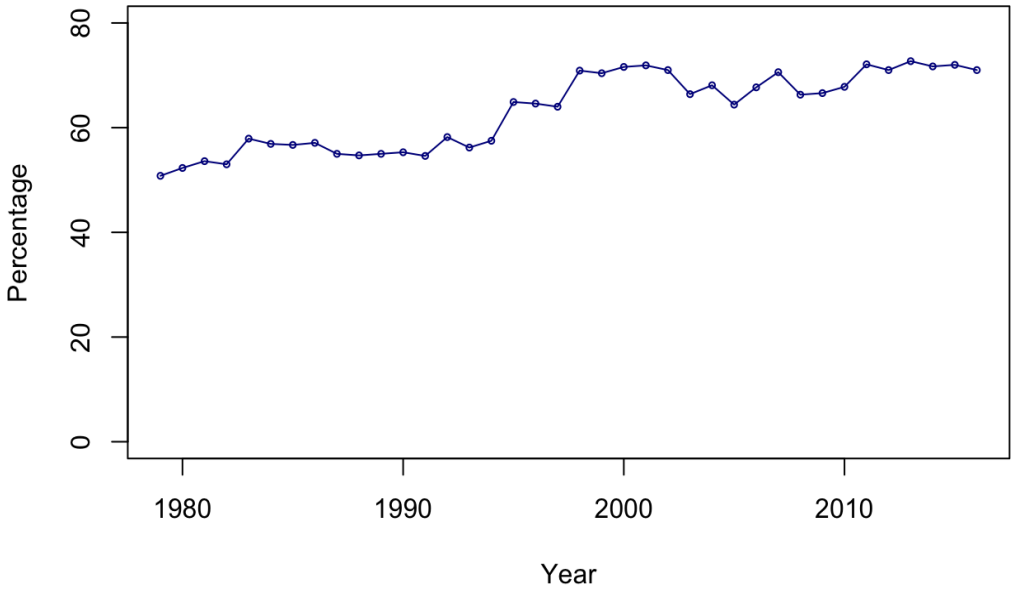
(b)

Figure 5: Crude and standardised suicide rates due to hanging: (a) men, (b) women

The graph of overall suicide trends (Figure 1) closely resembles the graph of suicide by hanging among men and women (Figure 5), indicating that suicide rates in Japan are mostly driven by hanging.

3.1.1 Proportion of suicide deaths due to hanging

Figure 6 shows the proportion of all suicide deaths that were due to hanging, by gender, over the time period. It clearly shows that hanging was the most commonly used method to commit suicide. It consistently contributed to more than 50% of the suicide deaths from 1979 until 2016 among both men and women, and the proportion has been growing over time.



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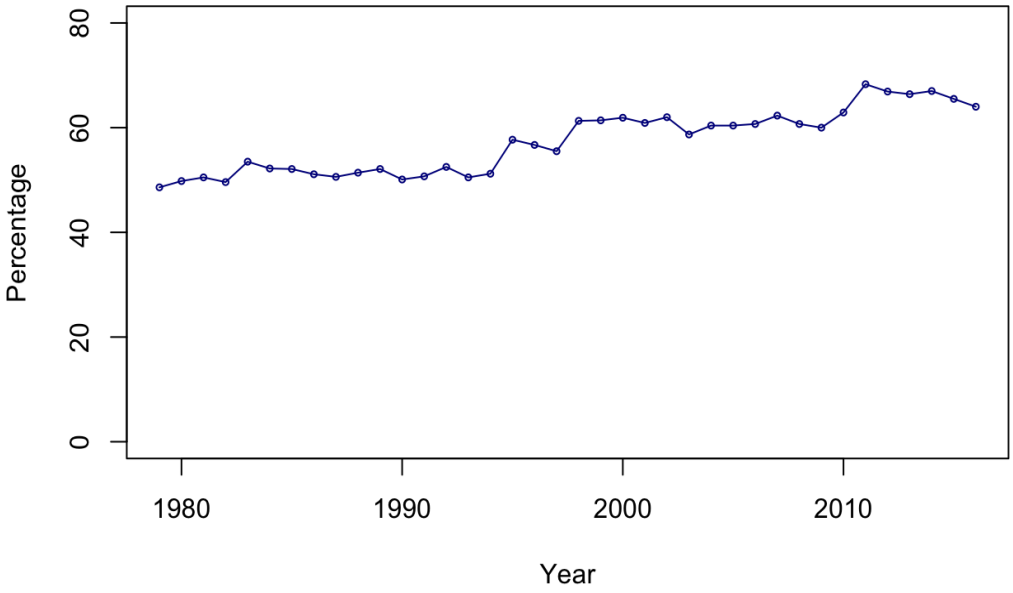

(b)

Figure 6: Proportion of suicide due to hanging for (a) men, (b) women

Table 3 shows the results of a linear regression of the proportion of deaths that are due to hanging, including a term for the 1998 increase. There was an annual 1.3% statistically significant increase in the odds that a suicide death would be due to hanging for both sexes.

Table 3: Odds ratio of proportion of suicide deaths due to hanging by sex, 1979–2016

Variables	Odds Ratio	95% CI	*p*-Value
Men			
Year	1.013	(1.006–1.021)	<0.01
1998 increase	1.367	(1.163–1.608)	<0.01
Women			
Year	1.013	(1.008–1.018)	<0.01
1998 increase	1.219	(1.092–1.359)	<0.01

Note: CI = Confidence Interval.

In 1998, when there was a sharp increase in the crude and standardised suicide rates and rates due to hanging, there was a statistically significant increase in the odds that a death would be due to hanging, by 36.7% among men and 21.9% among women (table 3).

3.2 Trends in and factors affecting suicide mortality

Full results of the Poisson regression analysis of suicide by age and suicide categories, separately by sex are shown in table 4. For simplicity, the reference categories in the interaction terms are collapsed to a single category (labelled "Reference levels") to avoid complexity in the table. This shows that suicide rates increased with increase in age. Moreover, mortality due to hanging was particularly high in the older age groups. The four-way interaction for men shows that gas and poisoning showed a reduction in trend after 1998 that was even greater than the reduction in the trend in hanging. The step/age category interaction shows the very large increase in hanging in older men (aged 30–79) after 1998 compared to before. This is the key driver of the size of the step after 1998.

Table 4: Poisson regression analysis of suicide by age and suicide categories, 1979 – 2016, by sex

	Men		
Variable	**Rate ratio**	**P-value**	**95% CI**
Year	0.989	0.000	0.986 - 0.991
Suicide Category			
Hanging	Ref		
Gas	0.616	0.000	0.586 - 0.647
Drowning	0.090	0.000	0.081 - 0.099
Poisoning	0.123	0.000	0.113 - 0.135
Other	0.700	0.000	0.671 - 0.730
Suicide Category / Year Interaction			
Hanging	Ref		
Gas	0.911	0.000	0.906 - 0.917
Drowning	0.972	0.000	0.962 - 0.982
Poisoning	0.961	0.000	0.952 - 0.970
Other	0.999	0.591	0.995 - 1.003
Age Category			
age 15 - 29	Ref		
age 30 - 59	2.356	0.000	2.286 - 2.428
age 60 - 79	4.221	0.000	4.082 - 4.364
age 80+	13.012	0.000	12.433 - 13.618
Age Category / Year interaction			
age 15 - 29	Ref		

age 30 - 59	1.010	0.000	1.007 - 1.013
age 60 - 79	0.998	0.202	0.995 - 1.001
age 80+	0.972	0.000	0.968 - 0.976
Suicide Category / Age Category interaction			
Reference levels	Ref		
Gas / age 30 - 59	0.489	0.000	0.462 - 0.518
Gas / age 60 - 79	0.060	0.000	0.054 - 0.067
Gas / age 80+	0.025	0.000	0.018 - 0.036
Drowning / age 30 - 59	0.828	0.001	0.741 - 0.926
Drowning / age 60 - 79	0.721	0.000	0.634 - 0.820
Drowning / age 80+	0.882	0.165	0.739 - 1.053
Poisoning / age 30 - 59	1.236	0.000	1.123 - 1.359
Poisoning / age 60 - 79	0.903	0.062	0.811 - 1.005
Poisoning / age 80+	0.411	0.000	0.343 - 0.493
Other / age 30 - 59	0.554	0.000	0.527 - 0.581
Other / age 60 - 79	0.243	0.000	0.227 - 0.259
Other / age 80+	0.247	0.000	0.222 - 0.275
Suicide Category / Age Category / Year interaction			
Reference levels	Ref		
Gas / age 30 - 59	1.052	0.000	1.045 – 1.058
Gas / age 60 – 79	1.109	0.000	1.098 – 1.121
Gas / age 80+	1.023	0.230	0.986 – 1.062
Drowning / age 30 - 59	1.018	0.002	1.007 – 1.030

Drowning / age 60 – 79	1.010	0.136	0.997 – 1.023
Drowning / age 80+	0.986	0.121	0.968 – 1.004
Poisoning / age 30 - 59	1.003	0.541	0.993 – 1.013
Poisoning / age 60 – 79	1.039	0.000	1.028 – 1.050
Poisoning / age 80+	1.065	0.000	1.047 – 1.083
Other / age 30 - 59	0.996	0.095	0.991 – 1.001
Other / age 60 – 79	1.016	0.000	1.010 – 1.022
Other / age 80+	0.985	0.004	0.975 – 0.995
1998 Step	1.127	0.000	1.054 – 1.204
Step / Year interaction			
Before 1998	Ref		
After 1998	1.024	0.000	1.021 -1.027
Suicide Category / Step interaction			
Hanging / After 1998	Ref		
Gas / After 1998	0.074	0.000	0.063 - 0.086
Drowning / After 1998	0.618	0.019	0.413 - 0.924
Poisoning / After 1998	1.524	0.009	1.108 - 2.094
Other / After 1998	1.133	0.053	0.999 - 1.285
Suicide Category / 1998 Step / Year interaction			
Hanging / After 1998	Ref		
Gas / After 1998	1.165	0.000	1.156 - 1.174
Drowning / After 1998	0.997	0.773	0.980 - 1.015
Poisoning / After 1998	0.981	0.012	0.967 - 0.996

Other / After 1998	0.970	0.000	0.964 - 0.976
Age Category / 1998 Step interaction			
age 15 – 29 / After 1998	Ref		
age 30 - 59 / After 1998	2.688	0.000	2.500 - 2.890
age 60 - 79 / After 1998	2.004	0.000	1.854 - 2.166
age 80+ / After 1998	0.978	0.682	0.878 -1.089
Age Category / 1998 Step / Year interaction			
age 15 – 29 / After 1998	Ref		
age 30 - 59 / After 1998	0.954	0.000	0.950 - 0.957
age 60 - 79 / After 1998	0.961	0.000	0.957 - 0.965
age 80+ / After 1998	0.983	0.000	0.978 - 0.988
Suicide Category / Age Category / 1998 Step interaction			
Reference levels	Ref		
Gas / age 30 - 59 / After 1998	4.292	0.000	3.632 - 5.073
Gas / age 60 - 79 / After 1998	17.655	0.000	14.022 - 22.229
Gas / age 80+ / After 1998	2.595	0.027	1.114 - 6.046
Drowning / age 30 - 59 / After 1998	1.870	0.005	1.209 - 2.893
Drowning / age 60 - 79 / After 1998	0.938	0.784	0.595 - 1.480
Drowning / age 80+ / After 1998	0.860	0.636	0.462 - 1.603
Poisoning / age 30 - 59 / After 1998	0.401	0.000	0.283 - 0.568
Poisoning / age 60 - 79 / After 1998	1.225	0.280	0.848 - 1.770
Poisoning / age 80+ / After 1998	1.409	0.169	0.864 - 2.298
Other / age 30 - 59 / After 1998	0.692	0.000	0.600 - 0.799

Other / age 60 - 79 / After 1998	0.966	0.684	0.819 - 1.140
Other / age 80+ / After 1998	0.781	0.090	0.587 - 1.039
Suicide Category / Age Category / 1998 Step / Year interaction			
Reference levels	Ref		
Gas / age 30 - 59 / After 1998	0.924	0.000	0.916 - 0.932
Gas / age 60 - 79 / After 1998	0.861	0.000	0.850 - 0.872
Gas / age 80+ / After 1998	0.966	0.135	0.923 - 1.011
Drowning / age 30 - 59 / After 1998	0.971	0.003	0.953 - 0.990
Drowning / age 60 - 79 / After 1998	1.019	0.078	0.998 - 1.040
Drowning / age 80+ / After 1998	1.033	0.021	1.005 - 1.063
Poisoning / age 30 - 59 / After 1998	1.022	0.008	1.006 - 1.039
Poisoning / age 60 - 79 / After 1998	0.962	0.000	0.945 - 0.978
Poisoning / age 80+ / After 1998	0.970	0.012	0.948 - 0.994
Other / age 30 - 59 / After 1998	1.022	0.000	1.016 - 1.029
Other / age 60 - 79 / After 1998	1.011	0.009	1.003 - 1.019
Other / age 80+ / After 1998	1.037	0.000	1.023 - 1.052
Constant	0.000	0.000	0.000 - 0.000
Population offset	1 (offset)		

	Women		
Variables	**IRR**	**P-value**	**95% CI**
Year	0.989	0.000	0.984 - 0.993
Suicide Category			
Hanging	Ref		
Gas	0.896	0.009	0.826 - 0.973

Drowning	0.300	0.000	0.269 - 0.336
Poisoning	0.346	0.000	0.312 - 0.383
Other	1.373	0.000	1.287 - 1.465
Suicide Category / Year interaction			
Hanging	Ref		
Gas	0.875	0.000	0.866 - 0.885
Drowning	0.940	0.000	0.928 - 0.951
Poisoning	0.961	0.000	0.950 - 0.971
Other	1.008	0.011	1.002 - 1.014
Age Category			
age 15 - 29	Ref		
age 30 - 59	2.651	0.000	2.512 - 2.798
age 60 - 79	9.864	0.000	9.348 - 10.408
age 80+	25.381	0.000	23.889 - 26.966
Age Category / Year interaction			
age 15 - 29	Ref		
age 30 - 59	0.999	0.792	0.994 - 1.005
age 60 - 79	0.977	0.000	0.972 - 0.982
age 80+	0.973	0.000	0.968 - 0.979
Suicide Category / Age Category interaction			
Reference levels	Ref		
Gas / age 30 - 59	0.281	0.000	0.255 - 0.310
Gas / age 60 - 79	0.044	0.000	0.038 - 0.052
Gas / age 80+	0.012	0.000	0.008 - 0.018

Drowning / age 30 - 59	0.894	0.072	0.791 - 1.010
Drowning / age 60 - 79	0.743	0.000	0.657 - 0.841
Drowning / age 80+	0.747	0.000	0.649 - 0.860
Poisoning / age 30 - 59	0.823	0.001	0.734 - 0.922
Poisoning / age 60 - 79	0.364	0.000	0.323 - 0.410
Poisoning / age 80+	0.140	0.000	0.117 - 0.168
Other / age 30 - 59	0.364	0.000	0.338 - 0.392
Other / age 60 - 79	0.110	0.000	0.101 - 0.120
Other / age 80+	0.068	0.000	0.059 - 0.078
Suicide Category / Age Category / Year interaction			
Reference levels	Ref		
Gas / age 30 - 59	1.047	0.000	1.034 - 1.060
Gas / age 60 - 79	1.045	0.000	1.026 - 1.065
Gas / age 80+	1.049	0.040	1.002 - 1.099
Drowning / age 30 - 59	1.051	0.000	1.037 - 1.065
Drowning / age 60 - 79	1.046	0.000	1.032 1.060
Drowning / age 80+	1.041	0.000	1.025 - 1.056
Poisoning / age 30 - 59	1.010	0.105	0.998 - 1.022
Poisoning / age 60 - 79	1.060	0.000	1.047 - 1.073
Poisoning / age 80+	1.086	0.000	1.068 - 1.104
Other / age 30 - 59	1.009	0.013	1.002 - 1.016
Other / age 60 - 79	1.021	0.000	1.013 - 1.029
Other / age 80+	0.999	0.849	0.987 - 1.011

1998 step	1.243	0.000	1.111 - 1.391
1998 Step / Year interaction			
Before 1998	Ref		
After 1998	1.027	0.000	1.021 - 1.033
Suicide Category / 1998 Step interaction			
Hanging / After 1998	Ref		
Gas / After 1998	0.028	0.000	0.021 - 0.038
Drowning / After 1998	0.481	0.003	0.296 - 0.783
Poisoning / After 1998	0.771	0.090	0.571 - 1.041
Other / After 1998	1.490	0.000	1.251 - 1.775
Suicide Category / 1998 Step / Year interaction			
Hanging / After 1998	Ref		
Gas / After 1998	1.223	0.000	1.206 - 1.240
Drowning / After 1998	1.020	0.070	0.998 - 1.042
Poisoning / After 1998	1.017	0.023	1.002 - 1.033
Other / After 1998	0.948	0.000	0.940 - 0.956
Age Category / 1998 Step interaction			
age 15 – 29 / After 1998	Ref		
age 30 - 59 / After 1998	0.899	0.097	0.792 - 1.020
age 60 - 79 / After 1998	0.860	0.020	0.758 - 0.976
age 80+ / After 1998	1.243	0.003	1.077 - 1.434
Age Category / 1998 Step / Year interaction			

age 15 – 29 / After 1998	Ref		
age 30 - 59 / After 1998	0.986	0.000	0.980 - 0.993
age 60 - 79 / After 1998	0.983	0.000	0.976 - 0.989
age 80+ / After 1998	0.956	0.000	0.949 - 0.963
Suicide Category / Age Category / 1998			
Step interaction			
Reference levels	Ref		
Gas / age 30 - 59 / After 1998	6.526	0.000	4.647 - 9.165
Gas / age 60 - 79 / After 1998	6.715	0.000	4.160 - 10.838
Gas / age 80+ / After 1998	3.842	0.034	1.108 - 13.324
Drowning / age 30 - 59 / After 1998	4.517	0.000	2.685 - 7.599
Drowning / age 60 - 79 / After 1998	1.482	0.135	0.884 - 2.485
Drowning / age 80+ / After 1998	1.639	0.086	0.932 - 2.885
Poisoning / age 30 - 59 / After 1998	0.953	0.787	0.673 - 1.350
Poisoning / age 60 - 79 / After 1998	3.549	0.000	2.474 - 5.092
Poisoning / age 80+ / After 1998	3.172	0.000	2.016 - 4.993
Other / age 30 - 59 / After 1998	1.077	0.471	0.880 - 1.319
Other / age 60 - 79 / After 1998	0.930	0.522	0.744 - 1.162
Other / age 80+ / After 1998	0.609	0.004	0.434 - 0.854
Suicide Category / Age Category / 1998			
Step / Year interaction			
Reference levels	Ref		
Gas / age 30 - 59 / After 1998	0.926	0.000	0.911 - 0.942
Gas / age 60 - 79 / After 1998	0.934	0.000	0.911 - 0.956
Gas / age 80+ / After 1998	0.945	0.063	0.889 - 1.003

Drowning / age 30 - 59 / After 1998	0.928	0.000	0.906 - 0.949
Drowning / age 60 - 79 / After 1998	0.987	0.256	0.965 - 1.010
Drowning / age 80+ / After 1998	0.980	0.106	0.955 - 1.004
Poisoning / age 30 - 59 / After 1998	0.988	0.157	0.971 - 1.005
Poisoning / age 60 - 79 / After 1998	0.915	0.000	0.899 - 0.931
Poisoning / age 80+ / After 1998	0.926	0.000	0.905 - 0.947
Other / age 30 - 59 / After 1998	1.015	0.004	1.005 - 1.025
Other / age 60 - 79 / After 1998	1.027	0.000	1.016 - 1.038
Other / age 80+ / After 1998	1.055	0.000	1.038 - 1.073
Constant*	0.000	0.000	0.000 - 0.000
Population offset	1 (offset)		

Note: CI = Confidence Interval

*The constant in this model is the rate in 15-29-year olds, in 1979, who died by hanging. The rate is less than 1 per 1000 and so is 0 to three decimal places in these tables.

Table 5 summarizes the suicide trends before and after 1998, with coefficients presented as rate ratios. Among men, suicide by hanging was increasing for the 15–29 age group after 1998, while it was decreasing for all the other age groups. Suicide by gas was increasing in most male age groups after 1998, and this increase was large compared to all the other suicide categories. For women, suicide by hanging was increasing slightly after 1998 in all the groups except for those aged above 80. However, the annual trend in suicide by gas among women was increasing steadily after 1998. Table 5 shows that rates of hanging-related suicide were declining in older age groups before 1998, and continued to decline after 1998.

Table 5: Suicide trends before and after 1998

Suicide Category	Before 1998		After 1998	
	IRR	95% CI	IRR	95% CI
		Men		
Age 15–29				
Hanging	0.989	(0.986–0.991)	1.012	(1.010–1.015)
Gas	0.901	(0.897–0.906)	1.075	(1.070–1.080)
Drowning	0.961	(0.951–0.970)	0.981	(0.967–0.995)
Poisoning	0.950	(0.942–0.959)	0.955	(0.944–0.966)
Others	0.988	(0.985–0.991)	0.981	(0.977–0.985)
Age 30–59				
Hanging	0.998	(0.997–1.000)	0.975	(0.974–0.976)
Gas	0.957	(0.954–0.959)	1.005	(1.003–1.007)
Drowning	0.988	(0.983–0.992)	0.935	(0.929–0.940)
Poisoning	0.962	(0.959–0.966)	0.942	(0.938–0.947)
Others	0.993	(0.991–0.995)	0.962	(0.960–0.964)
Age 60–79				
Hanging	0.987	(0.985–0.988)	0.971	(0.970–0.972)
Gas	0.998	(0.989–1.006)	0.984	(0.979–0.989)
Drowning	0.968	(0.961–0.975)	0.968	(0.961–0.974)
Poisoning	0.985	(0.980–0.990)	0.915	(0.909–0.921)
Others	1.001	(0.997–1.005)	0.966	(0.963–0.969)
Age 80+				
Hanging	0.961	(0.958–0.964)	0.967	(0.965–0.970)

Gas	0.896	(0.864–0.930)	1.015	(0.990–1.041)
Drowning	0.921	(0.907–0.934)	0.955	(0.940–0.970)
Poisoning	0.984	(0.970–0.997)	0.943	(0.932–0.954)
Others	0.946	(0.938–0.954)	0.958	(0.951–0.965)
Women				
Age 15–29				
Hanging	0.989	(0.984–0.993)	1.015	(1.012–1.019)
Gas	0.865	(0.857–0.873)	1.087	(1.077–1.096)
Drowning	0.929	(0.918–0.940)	0.973	(0.957–0.990)
Poisoning	0.950	(0.941–0.959)	0.993	(0.983–1.002)
Others	0.996	(0.993–1.000)	0.971	(0.966–0.975)
Age 30–59				
Hanging	0.988	(0.986–0.990)	1.001	(0.999–1.003)
Gas	0.905	(0.899–0.911)	1.038	(1.033 –1.043)
Drowning	0.976	(0.971–0.980)	0.935	(0.929–0.941)
Poisoning	0.959	(0.954–0.963)	0.976	(0.971–0.982)
Others	1.005	(1.002–1.008)	0.979	(0.977–0.982)
Age 60–79				
Hanging	0.965	(0.963–0.967)	0.974	(0.973–0.976)
Gas	0.883	(0.870–0.897)	1.017	(1.005–1.030)
Drowning	0.949	(0.944–0.953)	0.964	(0.959–0.969)
Poisoning	0.983	(0.978–0.988)	0.924	(0.918–0.930)
Others	0.993	(0.989–0.998)	0.976	(0.972–0.980)
Age 80+				
Hanging	0.962	(0.959–0.965)	0.944	(0.942–0.947)

Gas	0.884	(0.845–0.924)	1.002	(0.965–1.040)
Drowning	0.941	(0.934–0.948)	0.923	(0.914–0.931)
Poisoning	1.004	(0.992–1.016)	0.928	(0.918–0.938)
Others	0.969	(0.959–0.979)	0.952	(0.943–0.960)

Note: IRR = Incidence rate ratio; CI = Confidence interval

Table 6 shows the level change in suicide that occurred in 1998 by age and suicide method. For men, suicide by hanging increased drastically among the 30–59 and 60–79 age groups. Similarly, suicide by gas rose among the age group 30–59, while it declined in large percentages among the 15–29 and above-80 age groups. Suicide by poisoning among men increased significantly in 1998. In women, the change in level of hanging suicide was high in the oldest age group.

Table 6: Level change in suicide at 1998

Suicide Category	Rate ratio	95% CI	Percent change	95% CI
		Men		
Age 15–29				
Hanging	1.154	(1.083–1.229)	15.4	(8.3–22.9)
Gas	0.099	(0.087–0.113)	−90.1	(-91.3– -88.7)
Drowning	0.711	(0.485–1.042)	−28.9	(-51.5– -4.2)
Poisoning	1.725	(1.279–2.325)	72.5	(27.9–132.5)
Others	1.268	(1.144–1.405)	26.8	(14.4–40.5)
Age 30–59				
Hanging	2.957	(2.875–3.042)	195.7	(187.5–204.2)
Gas	1.004	(0.945–1.067)	0.4	(-5.5–6.7)
Drowning	3.310	(2.826–3.877)	231.0	(182.6–287.7)
Poisoning	1.811	(1.583–2.072)	81.1	(58.3–107.2)
Others	2.301	(2.170–2.439)	130.1	(117.0–143.9)
Age 60–79				
Hanging	2.221	(2.136–2.309)	122.1	(113.6–130.9)
Gas	2.891	(2.463–3.393)	189.1	(146.3–239.3)
Drowning	1.308	(1.071–1.597)	30.8	(7.1–59.7)
Poisoning	3.911	(3.289–4.650)	291.1	(228.9–365.0)
Others	2.384	(2.167–2.622)	138.4	(116.7–162.2)
Age 80+				
Hanging	1.109	(1.021–1.203)	10.9	(2.1–20.3)

Gas	0.238	(0.108–0.526)	−76.2	(-89.2– -47.4)
Drowning	0.607	(0.388–0.951)	−39.3	(-61.2– -4.9)
Poisoning	2.267	(1.604–3.204)	126.7	(60.4–220.4)
Others	0.987	(0.783–1.245)	−1.3	(-21.7– -24.5)
		Women		
Age 15–29				
Hanging	1.277	(1.146–1.422)	27.7	(14.6–42.2)
Gas	0.044	(0.034–0.058)	−95.6	(-96.6– -94.2)
Drowning	0.627	(0.397–0.988)	−37.3	(-60.3– -1.2)
Poisoning	1.002	(0.767–1.308)	0.2	(-23.3–30.8)
Others	1.804	(1.586–2.052)	80.4	(58.6–105.2)
Age 30–59				
Hanging	1.132	(1.071–1.196)	13.2	(7.1–19.5)
Gas	0.237	(0.203–0.277)	−76.3	(-79.7– -72.3)
Drowning	2.327	(1.970–2.747)	132.7	(97.0–174.7)
Poisoning	0.836	(0.713–0.980)	−16.4	(-28.7– -2.0)
Others	1.748	(1.613–1.894)	74.8	(61.3–89.4)
Age 60–79				
Hanging	1.079	(1.021–1.140)	7.9	(2.1–14.0)
Gas	0.235	(0.164–0.336)	−76.5	(-83.6– -66.4)
Drowning	0.775	(0.663–0.905)	−22.5	(-33.7– -9.5)
Poisoning	2.750	(2.288–3.304)	175.0	(128.8–230.4)
Others	1.456	(1.292–1.642)	45.6	(29.2–64.2)
Age 80+				
Hanging	1.517	(1.394–1.650)	51.7	(39.4–65.0)

Gas	0.191	(0.060–0.608)	−80.9	(-94.0– -39.2)
Drowning	1.195	(0.920–1.552)	19.5	(-8.0–55.2)
Poisoning	3.494	(2.552–4.783)	249.4	(155.2–378.3)
Others	1.376	(1.056–1.794)	37.6	(5.6–79.4)

Note: CI = Confidence Interval.

Table 6 shows that, despite these large increases in non-hanging-related suicides in 1998, the large increase in hanging in those aged 30–79 dominated the overall profile of suicide in Japan, so that after 1998, the proportion of suicides due to hanging was greater than 60% in both men and women (Figure 6).

3.3 Decomposition of suicide rates

Table 7 shows the relative contributions of changes in population proportion and age-specific suicide rates to the suicide trends in Japan from 1980 to 2015. Difference rate is the difference between rate-standardised rates in 1980 and 2015, which is the age-effect. On the other hand, rate-effect is the difference in the age-standardised rates. Similarly, total difference is the overall difference in crude rates of 1980 and 2015 which also corresponds to the sum of difference in rate-standardised rates and difference in age-standardised rates.

Table 7 shows that, from 1980 to 2015, the overall crude suicide rate increased by 0.7 per 100,000. Among men, it increased by 4.1 per 100,000 while among women it decreased 2.4 per 100,000. For overall crude suicide rates and also among men, a major proportion of this increase is driven by ageing. Changes in the population proportion from 1980 to 2015 accounted for 51.6 per cent of the increase in baseline crude suicide rate by hanging among

men. This had a considerable effect on the overall increase in the suicide rate. Similarly, ageing had an impact on crude suicide rate by gas among men.

Table 7: Decomposition of suicide rates in Japan in 1980 and 2015

Category	**Crude rate 1980**	**Crude rate 2015**	**Total difference (effect)**	**Difference Rate** $I(\bar{a}) - I(\bar{A})$	**Difference Age** $R(\bar{t}) - R(\bar{T})$	**Age effect (%)**	**Rate effect (%)**
Overall	17.9	18.6	0.7	6.6	-5.9	36.9	-33.0
Sex							
Men	22.7	26.7	4.1	7.8	-3.8	34.4	-16.7
Women	13.2	10.9	-2.4	5.8	-8.2	43.9	-62.1
Men							
Suicide category							
Hanging	12.4	19.3	6.8	6.4	0.5	51.6	4.0
Gas	2.9	2.8	-0.1	-0.1	0.0	-3.4	0.0
Drowning	1.0	0.5	-0.5	0.4	-0.9	40.0	-90.0
Poisoning	1.2	0.5	-0.7	0.3	-1.0	25.0	-83.3
Other	5.1	3.6	-1.5	0.9	-2.3	17.6	-45.1

	Women						
Suicide category							
Hanging	6.7	7.1	0.4	4.4	-4.0	65.7	-59.7
Gas	1.2	0.6	-0.6	-0.1	-0.5	-8.3	-41.7
Drowning	1.7	0.5	-1.2	0.9	-2.1	52.9	-123.5
Poisoning	1.1	0.5	-0.6	0.2	-0.8	18.2	-72.7
Other	2.6	2.2	-0.4	0.4	-0.8	15.4	-30.8

Likewise, among women, the increase in crude rates of suicide by hanging was mostly driven by ageing. Age-specific suicide rates were the driving factor for reduction in crude suicide rates as well as rates of suicide by drowning, poisoning and other methods among women (table 7).

4 DISCUSSION

I analysed the trends in suicide by age and suicide category 18 years before and after 1998 separately for men and women. Age-adjusted directly standardised suicide rates were computed to analyse the overall trends, and compared with crude rates. Linear combinations of the time trend were calculated separately by combinations of age, sex, year and 1998 increase using Poisson regression in order to estimate the change in suicide rates separately for age and suicide category. We also conducted linear regression of the trend in the proportion of all suicides that were due to hanging. Crude suicide rates in 1980 and 2015 were decomposed to find the effect of change in population proportion and age-specific rates.

This study found broad changes in the trends in suicide after adjusting for age. The age-adjusted suicide trend was decreasing in Japan both before and after 1998. The apparent sudden increase in 1998 did not appear to have any effect on this downward trend. This shows that the apparent high rates of suicide observed in previous studies are a consequence of ageing. Hanging was the most commonly used method to commit suicide among both men and women throughout the study period. Although the non-hanging-related suicide rate increased in 1998, the large increase in hanging among people aged 30–79 dominated the overall increase. Furthermore, while a large increase in overall suicide rates occurred in 1998, it was almost entirely driven by a large increase in rates of hanging, suggesting causal factors in addition to the economic crisis of the 1990s. After 1998, the proportion of suicides due to hanging remained above 60% throughout the study period, and continued to increase. The

sudden increase in hanging at this time suggests a social contagion or some other cultural effect, and more research is needed in order to understand what factors affected suicide at this time in Japan. When the crude suicide rates were decomposed, it was found that ageing had a major contribution in increasing the crude suicide rates overall, as well as among men. It also had a huge effect on increase in crude suicide rates by hanging among men and women.

This is the first study to our knowledge to analyse Japanese suicide data by adjusting for age separately by gender and method, and measure the level change in suicide in 1998 using Poisson regression analysis. Although previous studies have analysed method-specific suicide trends [10], some of these studies did not adjust for ageing or model separately by sex. Other studies used join-point analysis to identify the increased rates in 1998 and the large contribution to this increase due to hanging, but had a limited range of data in the pre-1998 comparison period, and did not perform a difference-in-difference analysis [10], [31]. Our study helps understand the contribution of age-standardised method-specific data to the sharp shifts in the national suicide rates. Previous studies have identified a sudden increase in suicide rates in 1998 and a long-term stable rate of suicide, suggesting that economic stress may be responsible for the 1998 increase [32], [33]. Factors such as work-related stress, family or partner issues, and economic stress are known to be major risk factors for suicide in Japan [34]. However, our results show that suicide rates have been declining despite the stable presence of these risk factors over the past 30 years, and suggest that recent government prevention efforts have been effective. The only significant increase we observed over the past 30 years was the sudden increase in rates in 1998. It has been previously shown

that the largest increase in 1998 compared with the three-year average between 1995–1997 was observed among older men who were unemployed, self-employed, or in managerial positions [34]. However, our study has shown that after adjusting for the ageing of the Japanese population over this period, suicide rates are declining, and the 1998 increase was most likely due to sudden increases in only one method of suicide: hanging among middle-aged men. This suggests that while economic factors may be a baseline factor they are not solely responsible for the increase in suicide. There could be social and cultural factors underlying the 1998 rise that may reflect changes in method. As an example, suicide-related internet use such as suicide bulletin board systems in Japan first began to occur in the mid-1990s, with people gathering on suicide-related bulletin board systems (BBSs) at this time [35]. The use of these BBSs is known to have an adverse effect on the mental health of young and middle-aged people [36], [37]. The growth of these BBSs and other media depictions of suicide at this time may have had some causative effect on suicide rates, indicating a cultural change or cultural contagion that exacerbates the socioeconomic cause. In addition to the growth of suicide-related BBSs, the publication of bestselling guides to suicide that ranked certain methods [38] indicate a cultural phenomenon of increased attention to suicide during this period, and this change in the popular awareness of suicide—and of particular methods—may have some association with the large increase in hanging that was observed at this time. More research is needed on the specific cultural drivers of suicide in Japan before definitive conclusions can be drawn about the causes of the late-1990s suicide peak, but it is possible

that the timing of this increase and the large increase in hanging may indicate that this phenomenon was not limited to economic changes at this time.

We found that a major proportion of increase in crude suicide rates overall as well as among men was due to the change in the population structure of Japan over the years. As Japan's elderly population grows the number of suicide deaths among the elderly will increase even as the rate decreases, maintaining the burden of suicide in the population even as suicide prevention strategies begin to have some effect. While older adults (80+ years) account for 8.5% of the total population, they account for 10.1% of the suicide deaths in 2016. Previous research has shown that fatality rates are higher among elderly suicide attempters, and also elderly women are likely to attempt suicide again [39]. Risk of mental illness, such as psychotic and anxiety disorders increases with age and is associated with increased risk of suicide among the elderly [40]. A recent report from the world population prospects predicts that the proportion of elderly people aged 65 years and above in Japan will increase from the current 28% to 38% by 2050 [41]. This growing burden will have serious implications for long-term elderly care. It will also further increase Japan's suicide burden with the increase in total number of suicide deaths among the elderly. Lethal methods like hanging are a popular method of choice among the elderly, and this could increase the potential fatality rate of suicide attempts among this population, especially if current long-term trends in the proportion of suicides due to hanging continue. The Japanese National Institute of Population and Social Security Research expects that a significant proportion of ageing will occur in the metropolitan area which currently have the most number of working-age populations [42]. The number of elderly people living alone

is expected to rise by 17% to 22.42 million by 2020 [42]. This places them at greater risk of committing suicide while reducing their chances of being rescued due to their isolation. In order to reduce the risk suicide prevention strategies should be targeted to the elderly. With the longevity of Japanese, incidences of suicide increases. The increase in overall suicide rate in Japan is mainly influenced by the increase in hanging among a large number of elderly populations suggesting that prevention efforts need to be focused on hanging among people aged 65 years and above, which could help in further reducing suicide rates at a higher pace.

A common approach for reducing suicide is limiting the access to the commonly used methods [43]. Previous works have shown that restriction of firearms [44], [45], pesticides [46], and domestic gas [47] led to decreases in method-specific suicide rates. However, this approach is not suitable for suicides by hanging, as the ligature that is commonly used is easily available. Nonetheless, there are studies suggesting that restriction to access does not reduce suicide rates, but instead stimulates the individual to shift to alternative methods of suicide [48]–[52]. Among the various factors that contribute to the choice of a suicide method, the social acceptability of the method as well as the cultures, traditions, and values attached to it play a major role as well [53], [54]. In other high-income Asian countries, the pattern of suicide methods is different to that of Japan; for example, jumping from a height is the most common cause of death in Singapore [55]. This may be due to differences in the built environment between these communities, or due to cultural and religious factors affecting the choice of method, for example due to a desire to avoid disfigurement of the body, or due to different suicide prevention strategies already in place in different countries.

As the proportion of suicide due to hanging has been changing over time in Japan, further research on the cultural and social factors affecting suicide is important, especially in relation to hanging.

4.1 Limitations

This study has several limitations. Age, gender and suicide method were the only covariates that were used for confounder adjustment. Analysis was not done by using prefecture level data, thus we were not able to obtain detailed information on the role of hanging and ageing in the change in level. Transition in the ICD version from ICD-9 to ICD-10 over the period studied [56] could have impacted estimates of suicide arising from changes in disease coding. The reliability of suicide statistics could underestimate total reported suicide deaths [57], which may have had an effect on our results, although its extent could not be evaluated due to an absence of evidence. It is possible that there exists correlation between timepoints in this type of analysis. However, we could not consider a time series analysis to adjust for this correlation due to the availability of limited data points. We also did not consider an age–period–cohort model, which might further explain the role of hanging in the overall increase in suicide during the past 38 years [58].

4.2 Recommendations

Correctly understanding the changing trends in age structure of Japan and identifying its effect on the method specific, is crucial for preventing suicide effectively in the future. Nonetheless, the broad downward trend in age-specific suicide rates in this study suggests

that current efforts and suicide prevention strategies seem to be working. Suicide prevention measures such as installation of train platform screen doors and blue lights on train platforms in Japan have been effective in significantly reducing the number of suicide by this means by more than 75 %, without direct implementation of means restriction [59], [60]. However, further interventions in the 30–79 age group are necessary in order to make further gains in reducing the suicide mortality. Public health planners should consider method specific actions for suicide methods with growing appeal such as hanging by identifying the social drivers of this method in particular (including, potentially, internet-based media supporting suicides, group suicides, and other social contagions) and acting to counter them. The government should consider media guidelines similar to those introduced in Australia, which restrict the reporting of suicide and give particular advice about how to report suicide, including the provision of details about suicide help lines in all reports of suicide. In the Japanese context, these guidelines should extend beyond news reports to a new code of conduct for the representation of suicide in movies, popular television, and manga. Hanging is the most difficult suicide method to prevent, but by taking these actions, the government can reverse the apparently inexorable growth of this method.

4.3 Conclusion

The increasing rates of suicide in Japan reflect the super-ageing Japanese society, although the suicide trend is declining in all of the most-affected age groups. The majority of the suicide deaths in the past 38 years were driven by hanging, and the proportion has been

growing over time. With the progress that has been made in the prevention of suicide, rates are declining. Increased attention on finding effective intervention strategies that are particularly aimed at hanging and in people aged 30–79 could work to further drive these rates down, and enable Japan to maintain the progress that it has made in fighting this tragic and preventable cause of death over the past 30 years.

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