Railway suicide attempts are associated with amount of sunlight in recent days

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Short title: Railway suicides and amount of sunlight.

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Abstract

Background: To assess the relationship between hours of sunlight and railway suicide attempts, three and seven days before these attempts.

Methods: All railway suicide attempts causing railway suspensions or delays of 30 min or more between 2002 and 2006. We used a linear probability model to assess this relationship. This study was conducted at Tokyo, Kanagawa, and Osaka prefectures in Japan. Data were collected from the railway delay incident database of the Japanese Railway Technical Research Institute and public weather database of the Japan Meteorological Agency.

Results: About 971 railway suicides attempts occurred between 2002 and 2006 in Tokyo, Kanagawa, and Osaka. Less sunlight in the seven days leading up to the railway suicide attempts was associated with a higher proportion of attempts ($p = 0.0243$). Sunlight over the three days before an attempt had a similar trend ($p = 0.0888$). No difference was found in sunlight hours between the days with (median: 5.6 [IQR: 1.1–8.8]) and without (median: 5.7 [IQR: 1.0–8.9]) railway suicide attempts in the evening. Finally, there was no apparent correlation between the railway suicide attempts and the monthly average sunlight hours of the attempted month or those of a month before.

Limitations: Railway suicides were not the main suicidal methods in Japan,

Conclusions: We observed an increased proportion of railway suicide attempts after several days without sunlight. Light exposure (blue light or bright white light) in trains may be useful in reducing railway suicides, especially when consecutive days without sunshine are forecasted.

Keywords: railway suicide; sunlight; exposure; Japan

Introduction

Psychiatric disorders are widespread and contribute substantially to the total burden of disease on the general population in Japan and the world (Murray et al., 2012) . Many psychiatric disorders, especially depression, lead to an increased risk of suicide. In Japan, the number of suicides increased substantially in the year 1998, and has remained high ever since. In the Tokyo Metropolitan Area, almost half of all train delays in 1998 were caused by suicides (Railway Bureau Ministry of Land, Infrastructure and Transport, 2009). Since 2005, more than 200 railway suicides have been attempted in this area every year (mean = 265, SD = 29.6 suicides per year). The economic cost of railway transport delays due to suicide in Japan was estimated at 89 million yen (1 million USD) per railway suicide attempt (Railway Bureau Ministry of Land, Infrastructure and Transport, 2010). Thus, 23.6 billion yen (265 million USD: 89 million yen/suicide × 265 suicides/year) are lost on average because of railway suicides annually, only in the Tokyo Metropolitan Area (Railway Bureau Ministry of Land, Infrastructure and Transport, 2009, 2010). Thus, railway suicide attempts are not only a severe health problem, but they contribute to substantial economic loss.

Psychiatrists, epidemiologists, and sociologists have debated whether suicide is associated with the weather conditions. However, no specific associations between suicides and meteorological factors have yet been established (Deisenhammer, 2003). Previous studies have focused on seasonality or current weather conditions such as hours of sunlight, cloud cover, precipitation, humidity, wind speed, air pressure (Kordic et al., 2010), and temperature (Kim et al., 2011; Likhvar et al., 2011). However, few studies have focused on recent weather conditions such as sunlight duration several days before the suicidal attempts, instead opting to examine the weather conditions of

the attempted days. In addition, studies have shown that certain methods of suicide may have an association with various meteorological factors (Ajdacic-Gross et al., 2010; Deisenhammer, 2003). Reports suggest that weather factors may be more associated with violent suicides (e.g., hanging, drowning, firearms, jumping from buildings, or being run over by a train) than with non-violent suicides (e.g., poisoning; (Ajdacic-Gross et al., 2010; Deisenhammer, 2003). Suicide methods are now thought to be to some extent associated with the season that they are attempted in (Ajdacic-Gross et al., 2010), and jumping from high places and being run over by a train are thought to have the highest associations with weather factors. Because of this, the lack of clear associations from previous research might be explained in part by their inclusion of multiple methods of suicide into a single analysis. This may have obscured any observable association between suicidal behaviour and weather, if some methods are associated with weather, and some are not.

To further illustrate that suicide attempts might be related to weather factors, some forms of depression have been shown to be alleviated by therapies involving bright light. For example, studies have reported that around 10% and 2% of seasonal affective disorder (SAD) patients had suicidal ideas and past suicidal attempts, respectively (Lam et al., 2001), but after at least two weeks of bright light therapy, SAD patients have shown significant reductions in suicidal ideation (Lam et al., 2000). SAD, also known as winter depression, is believed to manifest as a result of the fewer hours of sunlight in winter (American Psychiatric Association, 2000). Bright light therapy has been shown to be the most effective therapy in treating SAD (Konstantinidis and Winkler, 2003; Lam et al., 1999; Partonen and Lonnqvist, 1998). Responses to this therapy generally occur within two to four days, and measurable improvement in SAD symptoms can

often be seen within one week (Konstantinidis and Winkler, 2003; Lam et al., 1999). Thus, the effects of bright light—such as sunshine—on mood may take several days to have maximum benefit. In addition, when bright light therapy is stopped, SAD symptoms typically relapse within about a week (Rosenthal et al., 1985).

Bright light therapy also has beneficial effects for non-seasonal depression, which is the majority of depression cases. A seven-day course of bright light therapy is effective in non-seasonal depression (Even et al., 2008; Yamada et al., 1995). As with SAD treatment, the antidepressant effect of bright light therapy ends after about a week when being used to treat non-seasonal major depressive disorder (Martiny et al., 2006). Thus, bright light exposure that proceeds over several days might affect the moods of both seasonal and non-seasonal depressive subjects days later.

Thus, we hypothesized that the hours of sunlight in the days preceding the suicide attempt, but not those of the actual day of the attempt, may affect suicidal behaviour. In order to test this hypothesis, we decided to confine the suicide method to railway suicide, as there is an accessible database for railway delays in Japan (Railway Technical Research Institute). Thus, using databases to collect information on railway delays and weather in three different prefectures, we analysed the association between railway suicide attempts and duration of sunlight in the past few days.

Methods

Data collection and variables

Data on suicides were taken from the database of the Railway Technical Research Institute (Railway Technical Research Institute). This database contains reports of all the incidents that have caused suspensions in railway services or delays of 30 min or

more, including the time, location, and details of the incidents. We used "suicide" as the key word to search for incidents between 1 January 2002 and 12 December 2006. We chose these dates because the annual number of railway suspensions or delays caused by suicides was similar during this period (Railway Bureau Ministry of Land, Infrastructure and Transport, 2009).

Data on the weather during the studied period were available from the public database of the Japan Meteorological Agency (Japan Meteorological Agency), which reports the hours of sunlight, cloud cover, precipitation, humidity, wind speed, air pressure, temperature, and time of sunset. "Hours of sunlight" were defined as the duration of hours when direct sunlight of 0.12 kw/m^2 or more reached the ground. We measured the number of hours of sunlight three days, seven days, and one month before the suicide attempt, in order to measure the precise range of time it takes for sunlight to have an effect.

Study Areas

Tokyo, Kanagawa, and Osaka prefectures were chosen as the target areas, because the numbers of railway delays caused by suicide were highest in these three prefectures across the whole of Japan. In addition, as these three prefectures are relatively small, we believed that the weather data would be similar across them. Weather data from the Shinjyu-ku area, Yokohama city, and Osaka city were used as representative of those in Tokyo, Kanagawa, and Osaka, respectively.

Statistical analysis

For continuous variables with a normal distribution, we report means and standard

deviations. For not normally distributed variables, we report medians and interquartile ranges (IQR).

The relationship between suicide attempts and hours of sunlight (direct sunlight of 0.12 kw/m^2 or more reaching the ground) during the overlapping three- and seven-day periods before the attempt was analysed using the linear probability model, where suicide attempt was set as a binary variable (1: at least one suicide attempt per day, 0: no suicide attempts), because more than one suicide attempt in the same prefecture was very rare. The hours of sunlight were categorized into the number of days with sunlight for ≥1 h and that for <1 h, because sunlight duration had two peaks in the distribution: one at less than one hour and the other at 8.5 hours (Figure 1). As a sensitivity analysis, we also applied a log-linear model, a logistic regression model, and a Poisson regression model for count data. All reported p-values are two-sided; those under 5% are considered statistically significant without multiplicity adjustments because this study is exploratory research. Statistical analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC).

Ethical considerations

This study protocol was approved by the Kyoto University Graduate School and Faculty of Medicine Ethics Committee.

Results

A total of 2,783 suicides that resulted in railway delays or cancellations were reported between 2002 and 2006 in Japan, 971 of which (34.9%) were reported in Tokyo, Kanagawa, and Osaka. The demographics for these prefectures are presented in Table 1.

In Tokyo, 19.6% (97/494) railway suicides were attempted underground, and the others were made on surface. More than one railway suicide attempt in the same prefecture was very rare with 91 (1.7%) of the 5478 days in the study period depicting more than one suicide in a given prefecture on the same day (5 years in 3 areas. 365.2 day x 5 years x 3 areas = 5478). Zero, one, two, and three or more railway suicides were attempted in 4600, 787, 89, and 2 of 5478, respectively. In 85.6% (831/971), 13.3% (130/971) and 1.0% (10/971) of the attempts, victims completed suicides, were injured only, and no one was killed or injured, respectively. Of all the victims, 67.2% were male. The average age of the victims was 45.0 (16.9) years (range: 14–91 years; age data was available from only 442 incidents; Table 1). In two incidents, two and three people committed suicide at the same time. The age and gender data from these two incidents were not included in the analysis.

The distribution of hours of sunlight per day in these prefectures had two peaks (Figure 1). The hours of sunlight were also categorized into the number of days with sunlight for ≥1 h and that for <1 h.

Table 2 and Figure 2 show the results of the linear probability models examining the relationship between the proportion (%) of suicide attempts and the number of days with hours of sunlight ≥1 h during the three- and seven-day periods before the attempts, respectively. We found that a greater number of days that had ≥1 h of sunlight tended to be associated fewer suicide attempts. Especially, the relationship between suicide attempts and hours of sunlight in the seven-day period before the attempt (the slope of the linear probability model) was statistically significant ($p = 0.0243$). Even when the average hours of sunlight per day was categorized into five groups of 2.5 h, almost the same results were obtained (Figure 2, Table 2). The number of days with an average of

10 or more hours of sunlight during a seven-day period was so small that we combined the 7.5–10 and 10+ categories together in our analysis.

As a sensitivity analysis, we also applied a log-linear model, a logistic regression model, and a Poisson regression model for count data, which all showed similar relationships between suicide attempts and hours of sunlight..

When we broke down days into individual hours, we found that few suicide attempts occurred between midnight and 9:00. There was little variation between 10:00 and 23:00, but the proportion peaked around 20:00–21:00 (Figure 3A).

We found no association between suicide attempts and hours of sunlight on the attempted days. The hours of sunlight with and without suicides were 6.0 (IQR = 1.4–8.8) and 5.6 (IQR = 0.9–8.9), respectively, which was not significant ($p = 0.24$, t-test). However, this analysis does not account for suicides attempted in the morning, as it includes the hours of sunlight after the attempt was made. To control for this, we analysed the association between evening suicides and sunlight of the same day. The mean (SD) sunset time of the study area was 17:52 (0:52 min). Thus, to analyse the effects of hours of sunlight for the day of the suicide attempt, we included all attempts after 19:00. We found that the hours of sunlight were 5.6 (IQR = 1.1–8.8) and 5.7 (IQR = 1.0–8.9) in days with and without railway suicides after 19:00, respectively.

Finally, we examined whether the relationship between railway suicide attempts and hours of sunlight was observable on a longer time scale. Therefore, we plotted the monthly changes in average hours of sunlight and the proportion of railway suicidal attempts (see Figure 3B), and found that in both February and June, the monthly average sunshine hours (when direct sunlight of 0.12 kw/m2 or more reached the ground) were short and thus, the proportions of railway suicidal attempts were higher,

but not significantly. We also examined whether this relationship was observable when considering the hours of sunlight of the attempted month and one month before (Figures 3C and 3D). However, we found no apparent correlation between railway suicide attempts and monthly average sunlight hours of the attempted months, or for one month before.

Discussion

In this study, we analysed the association between railway suicide attempts and hours of sunlight in three prefectures in Japan. We found that fewer hours of sunlight during the three- or seven-day periods before the railway suicide attempts was more likely to lead to a suicide attempt. However, the hours of sunlight on the day of the suicide attempt were not associated with more attempts. This suggests that suicide attempts by trains are associated with recent, but not current, weather condition.

Some studies on railway suicide found that attempts peak in spring and autumn (Erazo et al., 2005; Radbo et al., 2005), or in summer (Ozdogan et al., 2006), while others did not find such seasonal peaks (Odonnell and Farmer, 1992; van Houwelingen and Beersma, 2001). Overall, the suicide frequency in Japan reportedly has two peaks: a large one in April and a small one in autumn (Nakaji et al., 2004). However, we found no apparent seasonal pattern in our analysis. In addition, railway suicidal attempts showed no apparent correlation with average sunlight hours of the attempted month (Figure 3C) or that of the month before (Figure 3D). This was expected, as according to the results of previous studies on blight light therapy, the effects of sunlight duration on mental health might disappear after several days without such light.

The results of this study suggest that railway suicides are more probable following

periods with less sunlight; this provides valuable information on predicting and preventing attempts at suicide. Previous studies have shown that reducing public access to the tracks and improving surveillance by station staff were two major methods of preventing railway suicide attempts (Clarke and Poyner, 1994; Krysinska and De Leo, 2008). Thus, station staff should increase surveillance after several consecutive days without sunshine or perhaps even place bright lights in trains or around the stations on days when suicides are more likely to occur. Similarly, recent studies also suggest that blue wavelengths are responsible for the effectiveness of bright light therapy on SAD(Odonnell and Farmer, 1992; van Houwelingen and Beersma, 2001), although some studies have implicated the role of specific neurotransmitters such as serotonin, which are affected by the sunlight (Lambert et al., 2002). This is because retinal cells utilize an opsin/vitamin A-based photopigment called melanopsin, which is maximally sensitive to the blue range of the light spectrum (Hankins et al., 2008; Meesters et al., 2011). Blue light presented at 750 lux for 30 min has been reported to have similar effects on SAD as bright white light at 10,000 lux for the same duration (Meesters et al., 2011). However, llittle information is available about light dose responses for depression, especially about blue light. And what time of the day is best is still not clear (Pail et al., 2011).

According to the Japanese transportation census (Ministry of Land, Infrastructure, Transport and Tourism, 2009), passengers in Japanese railways stay, on average, for more than 30 min in trains when using them. Thus, shining blue light at 750 lux in trains after several consecutive days without sunshine might be another option for decreasing railway suicide attempts. Most areas in railway stations, including concourses and waiting rooms, were kept 500 lux or more (Japanese Standards Associations, 2010).

Railway Rolling Stocks were kept 200 lux or more (Japanese Standards Associations, 1992). Usually, inside of passenger cars was kept at least 450 lux.

Visible light of short wavelength (blue light) may cause a photochemical injury to the retina, called blue-light hazard. This blue light hazard may come from the interaction of blue light with molecules constituting the retina or accumulating in the retina with age or in pathological conditions. Studies indicating a blue light hazard within the intensity range of natural light to the retina are based on animal experiments(Organisciak and Vaughan, 2010; van Norren and Gorgels, 2011). The relevance of these experimental data for human pathological conditions is not very clear. In general, the probability that artificial lighting for visibility purposes induces any acute pathologic conditions is low, since the levels of maximum exposure are normally much lower than those where such effects are known to occur in healthy people and certainly much lower than in typical summer daylight (>100,000 lux)(SCENIHR, 2012).

This study had several limitations that must be addressed. First, the main purpose of utilizing the railway database was to gather information about the railway incidents. However, because data for this database were gathered as part of routine surveillance by the Railway Technical Research Institute, and not to get information on railway suicide victims, we had limited information about the victims, such as their ages and genders, but no other pertinent information such as medical history. Second, although the railway database reported all railway delays of 30 minutes or greater as well as cancellations, the suicide attempts that did not result in such delays or cancellations were not included here. However, as 85% and 15% of the victims of railway suicide attempts in Japan were killed or injured, respectively (Railway Bureau Ministry of Land, Infrastructure

and Transport, 2010), we believe that most attempts would have resulted in delays and cancellations, and were thus included in the database. Third, the variation in hours of sunlight among areas and victims should be carefully considered in future research to evaluate the impact of sunlight on suicide attempts more precisely (Nitta et al., 2010). The macro meteorological values of different regions might not be accurately representative of the local microenvironment where the acts took place. However, in this study, we chose three of the five smallest prefectures out of the 47 prefectures in Japan as target locations. This might minimize the effects that small variations in weather situation could have between sites of suicide attempts on our results. Fourth, we included only one of many suicide attempts in this analysis. More than 30,000 Japanese commit suicide annually (Cabinet Office, 2011), with only 556.6 railway suicides per year were attempted in Japan during the studied periods. Future studies should look at the impact of sunlight on other suicide methods. Recent research has suggested that specific suicide methods may have differing associations with metrological factors (Ajdacic-Gross et al., 2003; Rasanen et al., 2002). Finally, it may be that certain people are more vulnerable to fewer hours of sunlight than others. Studies have shown that the prevalence of Japanese people who are more sensitive to changes in seasons (higher seasonality) and who have SAD are around 10.1–16.5% (Okawa et al., 1996) and 0–4.6% (Imai et al., 2003), respectively. Future studies should examine how such factors influence the relationship between hours of sunlight and suicide.

Conclusions

To the best of our knowledge, this is the first report analysing the association between railway suicides and recent sunshine. We believe that our results may be useful

for decreasing railway suicide attempts by encouraging railway staff to use certain resources more efficiently. This could include increasing light exposure (bright white or blue light) in railway platforms or in trains when consecutive days without sunshine are forecasted, or to increase railway surveillance after consecutive days without sunshine.

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Figure Legends

Figure 1. Distribution of daily sunlight hours.

Distribution of hours of sunlight per day in Tokyo, Kanagawa, and Osaka from 2002 to 2006.

"Hours of sunlight" were defined as the direct sunlight of 0.12 kw/m^2 or more reached the ground. Numbers of days with "hours of sunlight" of 0-0.5, 0.5-1.5, 1.5-2.5,…., and 12.5 or more were plotted, respectively.

The total number of observations was 5,478 (5 years in 3 areas. 365.2 day x 5 years x 3 areas = 5478).

Figure 2. Proportion of railway suicide attempts and hours of sunlight during the three-day (left) and seven-day (right) periods before the attempts.

Daily proportion (%) of railway suicide attempts (more than one attempts = 1, no attempt = 0) were plotted against the number of days with ≥1 h of sunlight (direct sunlight of 0.12 kw/m^2 or more reached the ground) in a three-day period (A) and seven-day period (B). Daily proportion of railway suicide attempts were plotted against average hours of sunlight in three (C), and seven (D) day period, respectively. Categories of 7.5–10, and ≥10 h in the seven-day period were combined, because numbers in these categories were small. Mean and 95% confidence interval (CI) were plotted with solid lines and vertical lines, respectively. The fitted values of the estimated linear probability model were plotted with dotted lines. The relationship between suicide attempts and hours of the sunlight in the seven-day period before the attempt (the slope of the linear probability model) was statistically significant ($p = 0.0243$ and $p = 0.0383$).

Figure 3. Distribution of railway suicide attempts.

A: Time distribution of railway suicide attempts between 2002 and 2006 in Tokyo, Kanagawa, and Osaka, Japan. The numbers were plotted in two-hour increments.

B: Proportions of railway suicidal attempts (more than one attempts = 1, no attempt = 0) and hours of sunlight (direct sunlight of 0.12 kw/m^2 or more reached the ground) per day were averaged for each month, and then plotted in solid and dotted lines, respectively.

C and D: The monthly proportions (%) of railway suicidal attempts plotted against average sunlight hours of the attempted month (C) and one month before (D).

Table 1. Characteristics of analysed prefectures

	Tokyo	Kanagawa	Osaka	Total
Characteristics				
Area, km^2	2,188	2,416	1,898	6,502
Population	13,157,000	9,050,000	8,859,000	31,066,000
Latitude, °N	35.66	35.45	34.68	
Longitude, °E	139.74	139.65	135.48	
Hours of sunlight				
Median	5.4	5.9	5.7	5.7
IQR	0.5–8.8	0.8–9.1	1.9–8.7	1.0–8.8
Sunset time				
Median	17:49	17:50	18:06	17:55
IQR	16:57–18:36	16:58–18:36	17:16–18:51	17:04–18:41
Railway suicide attempts				
Number	494	215	262	971
Age (y)	44.5 ± 17.1	46.0 ± 16.4	N/A	45.0 ± 16.9
Male (%)	69.8	57.6	69.7	67.2
Delayed or cancelled				
Median (n)	52	59	33	47
IQR (n)	23–90	24.5–98.5	16–61	20–87
Maximum delay				
Median (min_	47	40	54	47
IQR (min)	38–60	26.5–55	40–69	37–61

Note: The number of railway suicide attempts were highest in Tokyo, Kanagawa, and Osaka prefectures in Japan between 2002 and 2006 (34.9% of railway suicides).
190, 78, and 261 reports lacked age data and 61, 43, and 44 reports lacked sex data in Tokyo, Kanagawa, and Osaka, respectively. Three reports in Kanagawa did not have data on maximum railway delay duration and number of trains delayed by these incidents.
IQR = Interquartile range.

Table 2. Results of the linear probability regression model on the association between number of suicide attempts and hours of sunlight in three- and seven-day periods

	Period (d)	Intercept	Slope (P value)
Number of days with ≥1 h of sunlight	3	18.3	-1.0 (0.0888)
	7	20.0	-0.8 (0.0243)
Average hours of sunlight	3	17.5	-0.9 (0.0558)
	7	18.0	-1.2 (0.0383)

Note: The numbers of days with ≥1 h of sunlight (direct sunlight of 0.12 kw/m^2 or more reached the ground) were categorized as 0, 1, 2, and 3 in the three-day period, and 0–7 in the seven-day period. Average hours of sunlight were categorized as 0–2.5, 2.5–5, 5–7.5, 7.5–10, and ≥10 h in the three-day period, and 0–2.5, 2.5–5, 5–7.5, and ≥7.5 h in the seven-day period. Categories of 7.5–10, and ≥10 h were combined in the seven-day period, because numbers in these categories were small. The relationship between suicide attempts (% of days with railway suicidal attempts) and hours of the sunlight in the seven-day period before the attempt (the slope of the linear

probability model) was statistically significant.

Figure 1

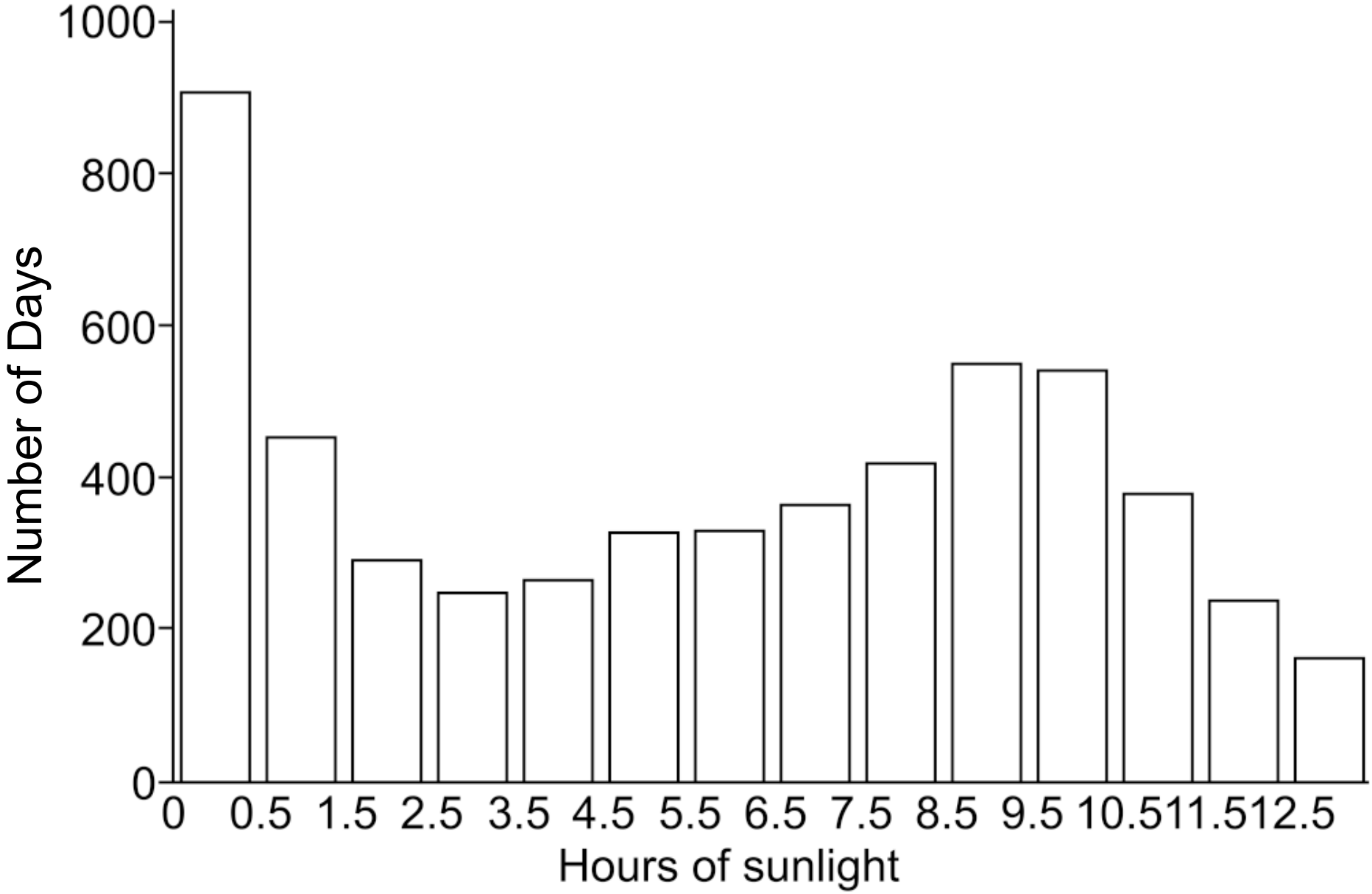

1000
800
600
400
200
0
Number of Days
0
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
Hours of sunlight

Figure 2

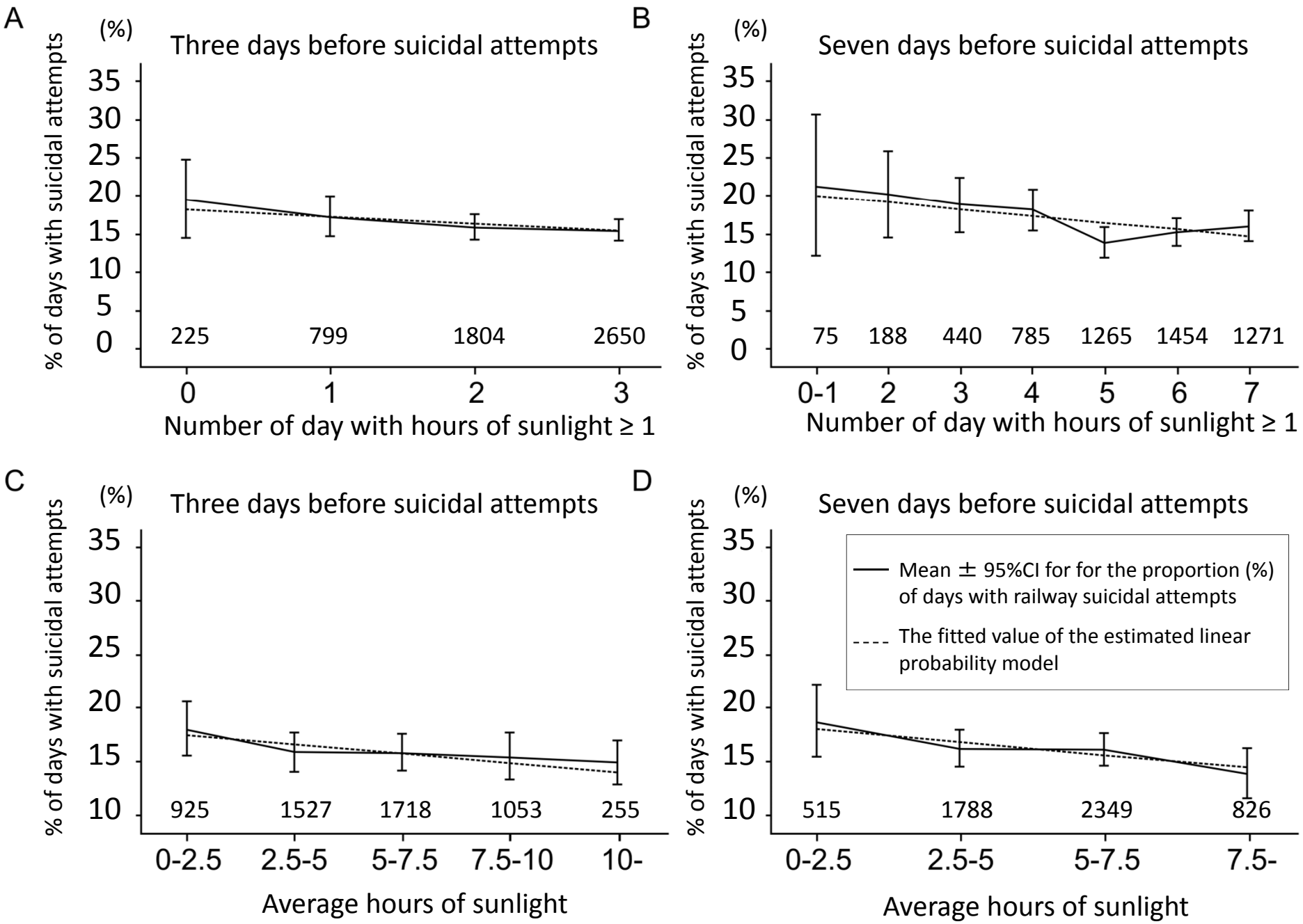
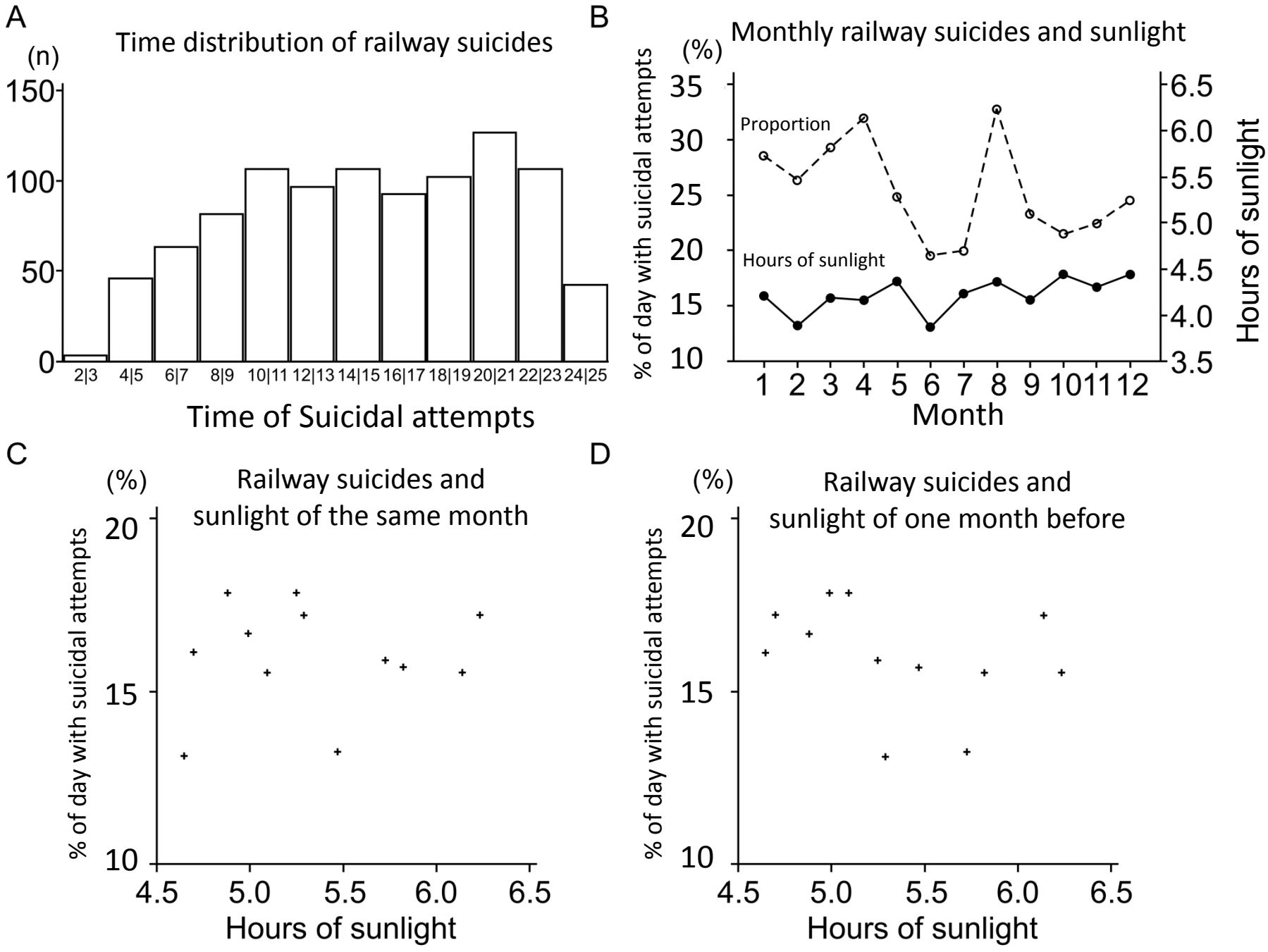

A
(%)
Three days before suicidal attempts
% of days with suicidal attempts
35
30
25
20
15
10
5
0
225
799
1804
2650
0
1
2
3
Number of day with hours of sunlight ≥ 1
B
(%)
Seven days before suicidal attempts
% of days with suicidal attempts
35
30
25
20
15
10
5
0
75
188
440
785
1265
1454
1271
0-1
2
3
4
5
6
7
Number of day with hours of sunlight ≥ 1
C
(%)
Three days before suicidal attempts
% of days with suicidal attempts
35
30
25
20
15
10
925
1527
1718
1053
255
0-2.5
2.5-5
5-7.5
7.5-10
10-
Average hours of sunlight
D
(%)
Seven days before suicidal attempts
% of days with suicidal attempts
35
30
25
20
15
10
515
1788
2349
826
0-2.5
2.5-5
5-7.5
7.5-
Average hours of sunlight
Mean ± 95%CI for for the proportion (%) of days with railway suicidal attempts
The fitted value of the estimated linear probability model

Figure 3


A
Time distribution of railway suicides
(n)
150
100
50
0
2|3
4|5
6|7
8|9
10|11
12|13
14|15
16|17
18|19
20|21
22|23
24|25
Time of Suicidal attempts
B
Monthly railway suicides and sunlight
(%)
% of day with suicidal attempts
Proportion
Hours of sunlight
Hours of sunlight
Month
C
Railway suicides and sunlight of the same month
(%)
% of day with suicidal attempts
Hours of sunlight
D
Railway suicides and sunlight of one month before
(%)
% of day with suicidal attempts
Hours of sunlight