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Trends and differences in alcohol-related mortality rates by gender and by prefectures in Japan between 1995 and 2016

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ABSTRACT

Background: This study aimed to identify increases in 100 % alcohol-related death (ARD) and any differences among prefectures between 1995–2016.

Methods: Data from the national death registry on 100 % ARDs between 1995–2016 were extracted. Age-standardized mortality rate (ASMR) of 100 % ARD by year, gender, and gender ratio were calculated. After dividing the period into 1995−2005 and 2006−2016, the ASMRs of 100 % ARDs were calculated by prefecture. Additionally, based on geographical area, municipality size, or annual alcohol sales per adult in each prefecture, prefectures were divided into groups and analysed.

Results: In total, 95,455 deaths were caused by 100 % ARD from 1995–2016. Men's ASMRs of 100 % ARD markedly increased from 4.0 per 100,000 in 1995 to 5.2 between 2010 and 2013, and gradually declined to 5.0 in 2016. Women's ASMRs increased steadily from 0.3 in 1995 to 0.8 in 2016. The gender ratio of ASMRs decreased from 13.3 in 1995 to 6.3 in 2016. The ASMR of one prefecture, which had reduced alcohol tax rates, was higher for both genders. Both men's and women's ASMRs were higher in the prefectures that had higher alcohol sales (6.3 [5.0–7.7] and 0.8 [0.6–1.1], respectively) compared to the prefectures that had lower alcohol sales (4.3 [4.0–4.7] $p < 0.001$ and 0.6 [0.5−0.6] $p = 0.045$, respectively).

Conclusions: The ASMR of 100 % ARD remained high for men and increased for women, and prefecture-level higher alcohol sales and lower tax rates correlated with the higher mortality rate. Increasing prices and taxes and reducing alcohol sales may contribute to a decrease in alcohol-related mortality.

1. Introduction

Alcohol-related deaths (ARD) are preventable. However, more than three million people died worldwide from harmful alcohol use in 2016 (World Health Organization, 2018b). According to trends in alcohol-related deaths in some countries between the 1990s and 2010s, the alcohol-related crude mortality rate decreased in areas and countries where it had been higher before the 1990s but increased in areas where it had been lower before the 1990s (Heale et al., 2002; Shipton et al., 2013; Kraus et al., 2015; Marmet et al., 2016; Ogeil et al., 2016; Piontek and Kraus, 2018). The age-standardized mortality rate (ASMR) is needed to compare annual changes. For the ASMR from alcohol-related disease, an increasing trend was reported in the United States, while in Japan, trends in ARDs have not been revealed (Polednak, 2016; White et al., 2020).

There are two kinds of alcohol-related death: 'ARD' and '100 % ARD'. ARD includes all diseases and accidents related to alcohol, like breast cancer, suicide, and traffic accidents (Rehm et al., 2017). The ASMR of ARD in Japan in 2016 was estimated at 9.1 per 100,000 people (95 % confidence interval: 4.3–14.0) (GBD, 2016). However, ARD needs estimation and is not ideal for monitoring alcohol-related harm. Additionally, deaths partially caused by alcohol are affected by other risk factors, such as tobacco use. Conversely, 100 % ARD indicates diseases fully attributed to alcohol use, which are identified in the International Statistical Classification of Diseases and Related Health Problems, Tenth Edition (ICD-10) (World Health Organization, 2016; Rehm et al., 2017).

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The diseases included in 100 % ARD can be tabulated from the national death registry system, and trends in 100 % ARD can be made for each prefecture. Therefore, we adopted 100 % ARD as an indicator to monitor trends in the effects of alcohol use over time.

From 1950 to the 1990s in Japan, alcohol sales had increased steadily and peaked in 1999, and after that gradually decreased to around 90 % of the peak sales in 2018 (National Tax Agency, 2020). The sales of beer and alcopop accounted for around 25 % of total sales, respectively. The proportions of drinking patterns by gender in 2013 were: current drinkers: 82.9 % in men and 63.3 % in women; hazardous drinkers: 14.4 % in men and 5.7 % in women; and alcohol dependence: 1.9 % in men and 0.2 % in women (Osaki et al., 2016). The prevalence of alcohol dependence is low in comparison with Finland (4.5 %), France (3.3 %), and the United States (7.7 %) (World Health Organization, 2018b). The weakness of a Japanese alcohol policy has been identified (Higuchi et al., 2007). However, based on the World Health Organization's (WHO) publication of 'The Global Strategy to Reduce Harmful Use of Alcohol' in 2010, the Basic Act on Measures against Alcohol-related Harm was enacted in 2014, and a national action plan was launched in Japan (Ministry of Health, Labour and Welfare, 2013). Additionally, prefectures were required to provide their own action plans. For the purposes of developing national and local action plans, information is needed on trends in alcohol-related harm at the national and prefectural levels. However, Japan has not created a monitoring system, such as that in the United States, to track mortality rates related to excessive alcohol use (Polednak, 2016). Therefore, the other purpose of the current study was to reveal correlates by prefectures of 100 % ARD and explore the associated factors. To our knowledge, there is no research that has investigated the associated factors of 100 % ARD by prefecture level in Japan. An ecological study in Great Britain reported that regions with higher alcohol consumption had higher alcohol-related mortality rates (Robinson et al., 2015). The current study investigated whether there is a positive relationship between 100 % ARD and alcohol sales in Japan, as well as the relation between 100 % ARD and geographical area or municipality size.

Additionally, recent population-based studies indicated that increased drinking among women is a public health concern in Japan, where heavy drinking among women was previously less common (Osaki et al., 2016). Therefore, the current study examined the trend of women's 100 % ARD and the ratio of men to women among heavy drinkers and ARDs in order to add further information about women's drinking habits.

2. Material and methods

2.1. Data source

Fig. 1 shows the data extraction flow for the current study. Based on Article 36 of the Statistics Acts in Japan, 24,038,889 death records from 1995 to 2016 were obtained from the Ministry of Health, Labour and Welfare. The data had been anonymised and included the year of death, age of death, prefecture where the deceased lived, and cause of death as identified using ICD-10 codes (World Health Organization, 2016). Excluding data with missing years of death and cases occurring before 1994, 24,033,863 cases between 1995 and 2016 were extracted. Of these, 95,491 cases of 100 % ARDs were identified by ICD-10 codes. After excluding data with missing ages, 95,455 cases were included in this study. Since this study used anonymous data, ethical review was not

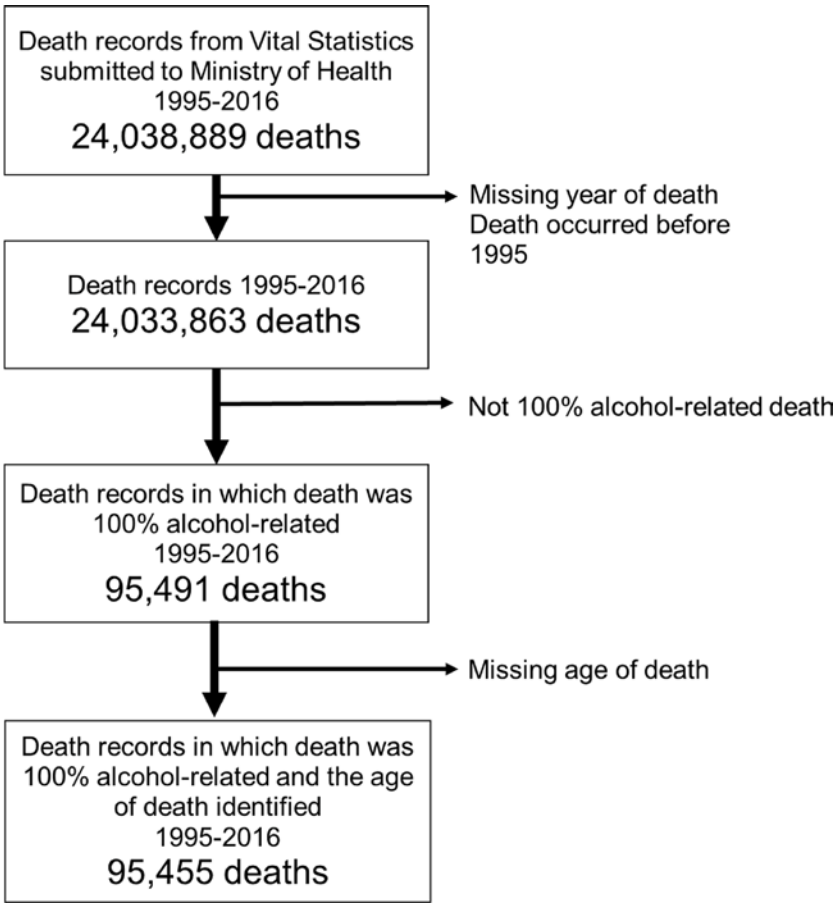

Fig. 1. Flowchart of data cleaning. There were 13 death records with addresses abroad and 356 death records with unknown addresses. Therefore, 95,076 death records were included when the number of deaths by prefecture was calculated.

required.

2.2. 100 % ARD

A 100 % alcohol-related disease was defined as a disease identified in the ICD-10 as alcohol-related, as shown in previous reports (Rehm et al., 2017) (Table S1). Additionally, 100 % ARDs were divided into five categories using ICD-10 codes: category F10, mental and behavioural disorders due to use of alcohol; category G, diseases of the nervous system due to alcohol; category I, alcoholic cardiomyopathy; category K, diseases of the digestive system due to alcohol; and category T, toxic effect of alcohol.

2.3. Recorded alcohol per capita

Annual alcohol consumption recorded per capita (APC; 15 years and older population; in litres of pure alcohol) from 1961 to 2015 was obtained from the WHO Global Information System on Alcohol and Health (GISAH) (World Health Organization, 2015). The original data are from World Drink Trends in 1961–1988 and from the National Tax Agency of Japan in 1989−2018. They are estimated based on sales data.

2.4. Geographical areas, municipality size, alcohol sales per adult in prefectures

Geographical areas were classified into six groups: North Japan (Hokkaido, etc.), Kanto (metropolitan area), Chubu (Nagoya, etc.), Kinki (Osaka, Kyoto, etc.), Chugoku/Shikoku, and Kyusyu (Fukuoka, Okinawa, etc.). According to municipality size, prefectures were divided into three categories: large (more than 2.3 million population during 1995–2015, 15 prefectures), medium (more than 1.26 million population during 1995–2015, 17 prefectures), and small (less than 1.26 million population during 1995–2015, 15 prefectures). Population data for each year were obtained from the Portal Site of Official Statistics of Japan (Ministry of Internal Affairs and Communications, 2008).

Alcohol sales per adult by prefecture were reported in the annual report, 'Booklet of Alcoholic Beverages', published by the National Tax Agency (National Tax Agency, 2005). The alcohol sales reflect the sum of alcoholic beverages sold in a prefecture, irrespective of alcohol concentration. The alcohol sales were divided by the adult population aged 20 and over in the prefecture. Based on the alcohol sales per adult by prefecture in 2005, prefectures were divided into three groups. The 'high sales group' included 12 prefectures with $\geq$ 90 L of alcohol sales per adult. The 'moderate sales group' included 17 prefectures with 80–90 litres of alcohol sales per adult. The 'low sales group' included 17 prefectures with <80 L of alcohol sales per adult. Okinawa, where the liquor tax was reduced, was not included in the list of prefectures in 'Booklet of Alcoholic Beverages', but the alcohol sales per adult was calculated as 91.8 L per adult from the following formula: the total alcohol sales in Okinawa from the regional annual reports divided by Okinawa's population in 2005. Therefore, Okinawa was classified into a 'high sales group' group. Finally, prefectures were divided into three groups: high sales group, moderate sales group, and low sales group.

Since 1972, the liquor manufactured and sold in Okinawa has had a 65 % lower tax rate for traditional sake, 'Awamori', and an 80 % lower rate for beer and other liquors, compared to the tax rate for these products in other prefectures (Cabinet Office, 2017). The alcohol tax reduction for Okinawa was implemented to promote local industry. As a result, the tax on 1.8 L of Awamori with 30 % alcohol content would be 350 yen (US $1 = 111.46 yen, US $3.15) in Okinawa and 540 yen (US $4.84) outside Okinawa. Additionally, the tax on 350 mL of beer would be 61.6 yen (US $0.55) in Okinawa and 77 yen (US $0.69) outside the prefecture.

2.5. Statistical analysis

The crude mortality rate for each year was calculated by dividing the number of deaths for that year by the total population. The ASMR for each year was calculated using the Japanese 1985 model population. The gender ratio was calculated by dividing the ASMR for men by the ASMR for women each year.

The 22-year period from 1995 to 2016 was divided into two periods—1995−2005 and 2006−2016—and the age distribution by causative disease and ASMR by prefecture were calculated for each period. When calculating the ASMR by prefecture, the numerator was the total number of 100 % ARD in the relevant prefecture during the period, and the denominator was the sum of the mid-year population by age group during the period. The rate of change between the two periods was expressed as a percentage by subtracting the 1995−2005 value from the 2006−2016 value, and then dividing by the 1995−2005 value. Kruskal–Wallis tests were used to assess differences between prefecture categories based on geographical areas, municipality sizes, and alcohol sales per prefecture. IBM SPSS 22.0 software was used for statistical analysis.

3. Results

Both men's and women's ASMRs for 100 % ARDs increased from 1995–2016. Fig. 2 shows recorded APC changes since 1961 and ASMRs of 100 % ARDs by gender since 1995. Recorded APC has increased since 1960, peaking at 8.37 L/year per capita in 1993, and falling to 6.86 L/year in 2015. The crude mortality rate for men increased steadily from 4.6 in 1995, and flattened thereafter, reaching 7.4 in 2011 and 7.5 in 2016. The ASMR for men (per 100,000 population) increased from 4.0 in 1995 to 5.2 between 2010 and 2013, and gradually declined to 5.0 in 2016. The crude mortality rate for women increased from 0.4 in 1995 to 1.0 in 2016. The ASMR for women also increased steadily, from 0.3 in 1995 to 0.8 in 2016.

Table 1 shows the number, ASMR, and gender ratio for 100 % ARDs each year. The ASMR for 100 % ARDs was 13.3 times higher for men than for women in 1995; however, the gender ratio gradually decreased, and in 2016 it was only 6.3 times higher for men than women.

In terms of total 100 % ARDs, the ages of death for both men and women were higher between 2006−2016 than 1995−2005, and women were 4–5 years younger than men (on average) at time of death. Table 2 shows descriptive statistics for age of death by cause of 100 % ARD. The average age of death by 100 % ARD was 57.9 (57.7−58.0) years old in 1995−2005 and 61.8 (61.7−61.9) years old in 2006−2016 among men, and 53.2 (52.8−53.6) years old in 1995−2005 and 56.2 (55.9−56.6) years old in 2006−2016 among women. When comparing the number of deaths between 1995−2005 and 2006−2016, the increase in the diseases of the digestive system due to alcohol was greater than the other categories. Deaths attributable to the toxic effect of alcohol increased significantly. For both men and women, the mean age of death was the lowest for the toxic effect of alcohol, followed by the mental and behavioural disorders due to use of alcohol.

The maps of prefectures with ASMR of 100 % ARDs in 2005–2016 by gender are shown in Fig. 3. The numerical value of ASMR of 100 % ARDs by prefecture and by gender are shown in Table S2. Compared to 1995−2005, the ASMR for 100 % ARDs between 2006−2016 was higher for men and women in all prefectures, except for two. For both 1995−2005 and 2006−2016, the prefecture with the highest male and female ASMRs (per 100,000 population) was Okinawa, with 12.8 and 2.0 —more than twice the national average ASMR in Japan. Rates for men were highest in Tokyo after Okinawa, with 8.2 in 2006−2016. Four prefectures geographically located in the central area of Japan and were small or middle municipalities—Ishikawa, Fukui, Gifu, and Mie—had the lowest ASMRs between 2006 and 2016 for both sexes. The ASMRs for women were similar, except for the exceptionally high rates of Okinawa, Tokyo, and Osaka prefectures of 1.1.

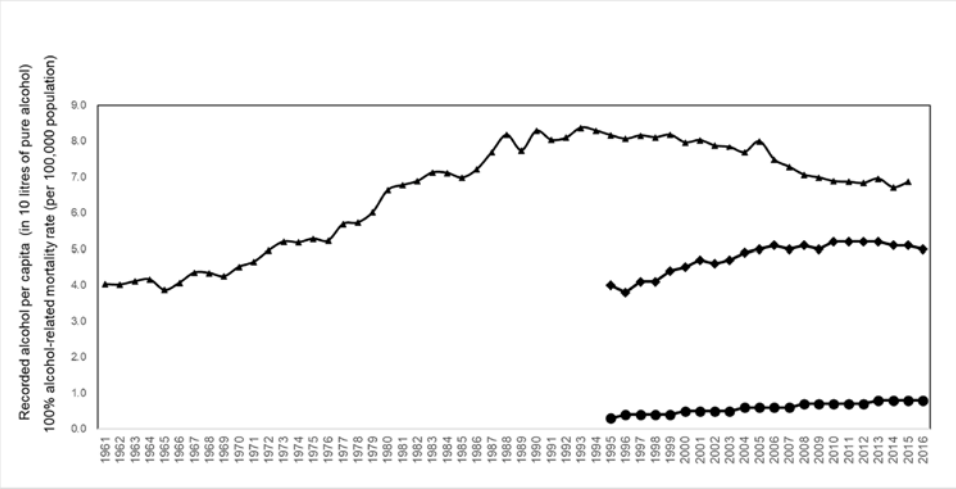

Fig. 2. 100 % alcohol-related mortality rates by gender in Japan.
▲Recorded alcohol per capita ■Men: age-standardized mortality rate ●Women: age-standardized mortality rate.

Table 1
Trends in numbers, age-standardised rates, and men:women ratio of 100 % alcohol-related deaths by gender, 1995–2016.

Year	Men		Women		Men/women ratio of age-adjusted mortality rate(per 100,000 population)
	Number of deaths	Age-standardised mortality rate (per 100,000 population)	Number of deaths	Age-standardised mortality rate (per 100,000 population)	
1995	2816	4.0	244	0.3	13.3
1996	2734	3.8	271	0.4	9.5
1997	2950	4.1	290	0.4	10.3
1998	3022	4.1	267	0.4	10.3
1999	3253	4.4	299	0.4	11.0
2000	3397	4.5	338	0.5	9.0
2001	3578	4.7	342	0.5	9.4
2002	3541	4.6	364	0.5	9.2
2003	3717	4.7	341	0.5	9.4
2004	3875	4.9	407	0.6	8.2
2005	4068	5.0	449	0.6	8.3
2006	4147	5.1	446	0.6	8.5
2007	4147	5.0	483	0.6	8.3
2008	4211	5.1	498	0.7	7.3
2009	4177	5.0	497	0.7	7.1
2010	4447	5.2	537	0.7	7.4
2011	4587	5.2	549	0.7	7.4
2012	4563	5.2	560	0.7	7.4
2013	4623	5.2	613	0.8	6.5
2014	4567	5.1	660	0.8	6.4
2015	4621	5.1	652	0.8	6.4
2016	4624	5.0	673	0.8	6.3

Age-adjusted rate was adjusted by 1985 standard population of Japan.

Alcohol sales per adult and reduced tax rates were related to the higher ASMRs of 100 % ARDs. Fig. 4 shows a boxplot comparing prefectures' ASMRs by geographical area, municipality size, and alcohol sales per adult. Data by geographical area showed men had significantly higher ASMRs for 100 % alcohol-related deaths in Kyushu and Chugoku/Shikoku prefectures ($p = 0.032$); however, women had no significant differences. No differences due to municipality size were noted. In terms of alcohol sales per adult, ASMRs due to deaths from 100 % ARD in both sexes were significantly higher among those from the high sales group. Rates in Okinawa, which was classified into the high sales group, were far higher than the others for both men and women. Results from Kruskal–Wallis tests are shown in Table S3.

Table 2
Age of 100 % alcohol-related deaths.

	Male		Female	
	1995−2005	2006−2016	1995−2005	2006−2016
Total number of 100 % alcohol-related deaths				
Number of deaths	36,951	48,714	3612	6168
Median	58.0	62.0	53.0	56.0
Average age	57.9	61.8	53.2	56.2
95 % CI	(57.7−58.0)	(61.7−61.9)	(52.8−53.6)	(55.9−56.6)
F10: Mental and behavioural disorders due to alcohol use				
Number of deaths	4659	3371	513	285
Median	57.0	64.0	51.0	57.0
Average age	56.6	64.0	51.5	57.7
95 % CI	(56.2−56.9)	(63.6−64.4)	(50.2−52.8)	(56.0−59.4)
G: Nervous system				
Number of deaths	181	226	18	13
Median	62.0	68.0	55.0	64.0
Average age	62.0	68.2	56.0	65.4
95 % CI	(60.7−63.4)	(67.0−68.2)	(48.5−63.5)	(58.9−71.9)
I: Cardiomyopathy				
Number of deaths	813	537	68	53
Median	57.0	62.0	54.0	52.0
Average age	56.7	60.5	53.8	54.4
95 % CI	(56.0−57.5)	(59.4−61.6)	(50.8−56.7)	(50.7−58.0)
K: Alcoholic liver disease and gastritis				
Number of deaths	31,257	43,654	3000	5566
Median	58.0	62.0	53.0	56.0
Average age	58.1	61.8	53.5	56.5
95 % CI	(57.9−58.2)	(61.7−61.9)	(53.1−53.9)	(56.2−56.8)
T: Toxic effect of alcohol				
Number of deaths	41	926	13	251
Median	51.0	53.0	47.0	48.0
Average age	49.6	51.9	46.6	48.5
95 % CI	(44.3−54.9)	(50.9−53.0)	(35.8−57.4)	(46.7−50.3)

95 % CI = 95 % confidence intervals.

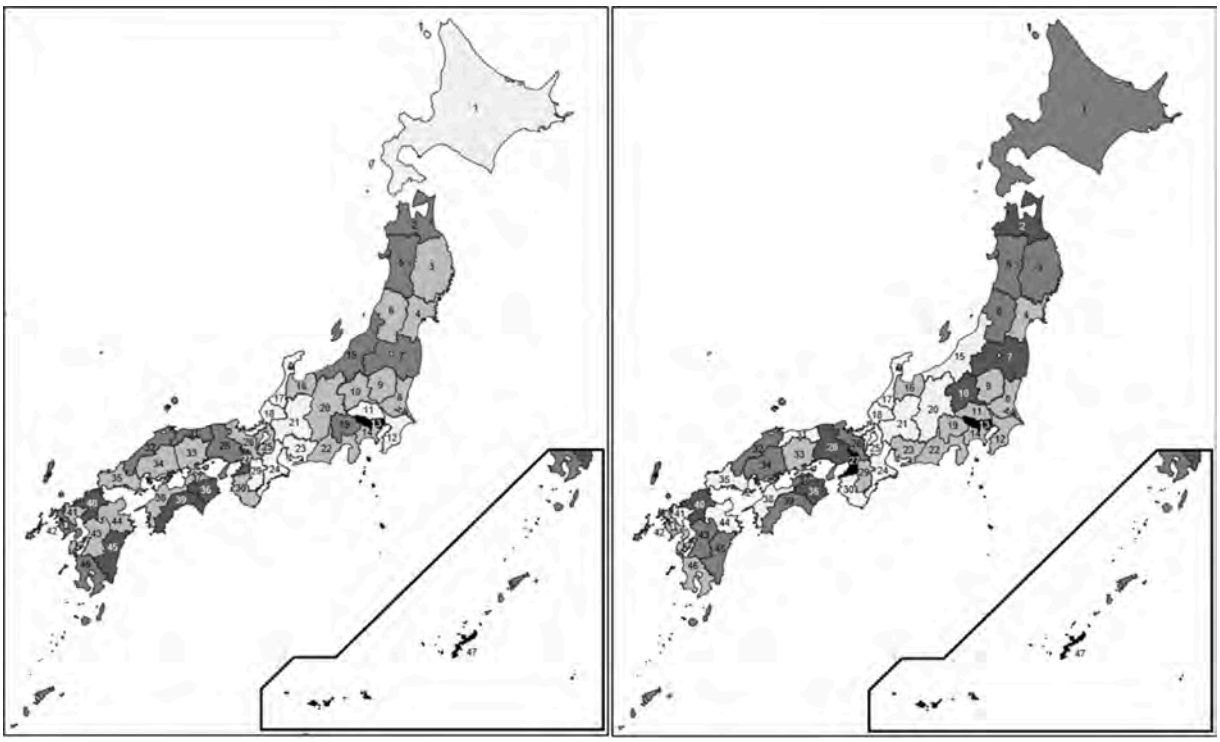

Fig. 3. Age-standardised mortality rates of 100 % alcohol-related deaths for men and women in 2006–2016, in 47 prefectures.
Left is for men and right is for women. The colours for men show age-standardised mortality rate (per 100,000 population); ■(white) <4.0, ■(sky gray) 4.0–4.9, ■(ash gray) 5.0–5.9, ■(gray) 6.0–6.9 ■(black) >7.0. The colours for women show age-standardised mortality rate (per 100,000 population); ■(white) <0.6, ■(sky gray) 0.6, ■(ash gray) 0.7, ■(gray) 0.8–1.0, ■(black) >1.0. The number in the map shows the following prefecture's number; 1. Hokkaido, 2. Aomori, 3. Iwate, 4. Miyagi, 5. Akita, 6. Yamagata, 7. Fukushima, 8. Ibaraki, 9. Tochigi, 10. Gumma, 11. Saitama, 12. Chiba, 13. Tokyo, 14. Kanagawa, 15. Niigata, 16. Toyama, 17. Ishikawa, 18. Fukui, 19. Yamanashi, 20. Nagano, 21. Gifu, 22. Shizuoka, 23. Aichi, 24. Mie, 25. Shiga, 26. Kyoto, 27. Osaka, 28. Hyogo, 29. Nara, 30. Wakayama, 31. Tottori, 32. Shimane, 33. Okayama, 34. Hiroshima, 35. Yamaguchi, 36. Tokushima, 37. Kagawa, 38. Ehime, 39. Kochi, 40. Fukuoka, 41. Saga, 42. Nagasaki, 43. Kumamoto, 44. Oita, 45. Miyazaki, 46. Kagoshima, 47. Okinawa.

4. Discussion

In this study, we analysed the trend of 100 % ARDs in Japan using data from the national death registry. We found that, over the past 22 years, the ASMRs of 100 % ARDs in men levelled off in 2011; however, they gradually increased for women. The average age of women who died from 100 % ARD was five years younger than men. Analysis at the sub-national level showed that prefectural groups with higher alcohol sales per adult had a higher ASMR of 100 % ARDs, and Okinawa, which has a reduced tax rate on liquor, stands out.

4.1. ASMR of 100 % ARD in Japan

In 2016, the ASMR of 100 % ARDs was similar to that of diabetes and traffic accidents in men and higher than that of chronic bronchitis and emphysema in women (Ministry of Internal Affairs and Communications, 2008). In Japan, the recorded APC shown in Fig. 2 peaked in the 1990s and has levelled off, while the total APC, including unrecorded APC, has reportedly increased (World Health Organization, 2015). An increase in alcohol consumption as a whole seems to have influenced the increase in digestive system diseases due to alcohol. According to our results, the increase in 100 % ARDs over the past 22 years was largely attributable to alcohol-related digestive system diseases. In the United States, an increase in alcohol-related mortality rates and alcohol-associated liver disease was reported from 1999 to 2017, especially among middle-aged individuals (White et al., 2020; Moon et al., 2020). Alcohol poisoning has also increased. One factor may be Japanese-style dining bars that offer an all-you-can-drink system called '*Nomihodai*', which motivates young people to increase their alcohol consumption (Kawaida et al., 2018).

4.2. The gender difference in ASMR of 100 % ARD

In Japan, it used to be common that men drank but women rarely drank. However, women have recently developed similar drinking habits, and the decrease in gender differences needs to be observed carefully and the trend needs to be clarified (Osaki et al., 2016). The current results showed that the gender ratio of ASMR of 100 % ARDs is decreasing. In a national population-based survey on drinking conducted every five years since 2003, the number of daily drinkers and risky drinking has decreased in men, but not in women (Osaki et al., 2016). Our finding that 100 % ARDs among women were slowly but consistently increasing reinforces the results from this population-based survey. Additionally, a similar trend was found in the United States (Keyes et al., 2019).

Women have a longer life expectancy than men worldwide; however, our results indicated that women who died by 100 % ARD were approximately five years younger than men (World Health Organization, 2019). Reports of 100 % ARDs in Germany showed the peak age of death was almost identical for men and women, which differed from our findings (Piontek and Kraus, 2018). One of the factors for the younger death age of women might be biological sex differences. Studies show that women are more likely to have alcohol-related problems within a shorter period than men after starting drinking (Erol and Karpyaka, 2015). The other factor would be that women's mean age of drinking is younger than that of men, while the initiation age of drinking is older than men (Osaki et al., 2016). The survey shows that the proportion of the flushing reactioner is similar between men and women, and therefore the influence from the flushing reaction might be less (Osaki et al., 2016). Current results show that the sex differences in age of death were detected not only in chronic diseases like mental and behavioural

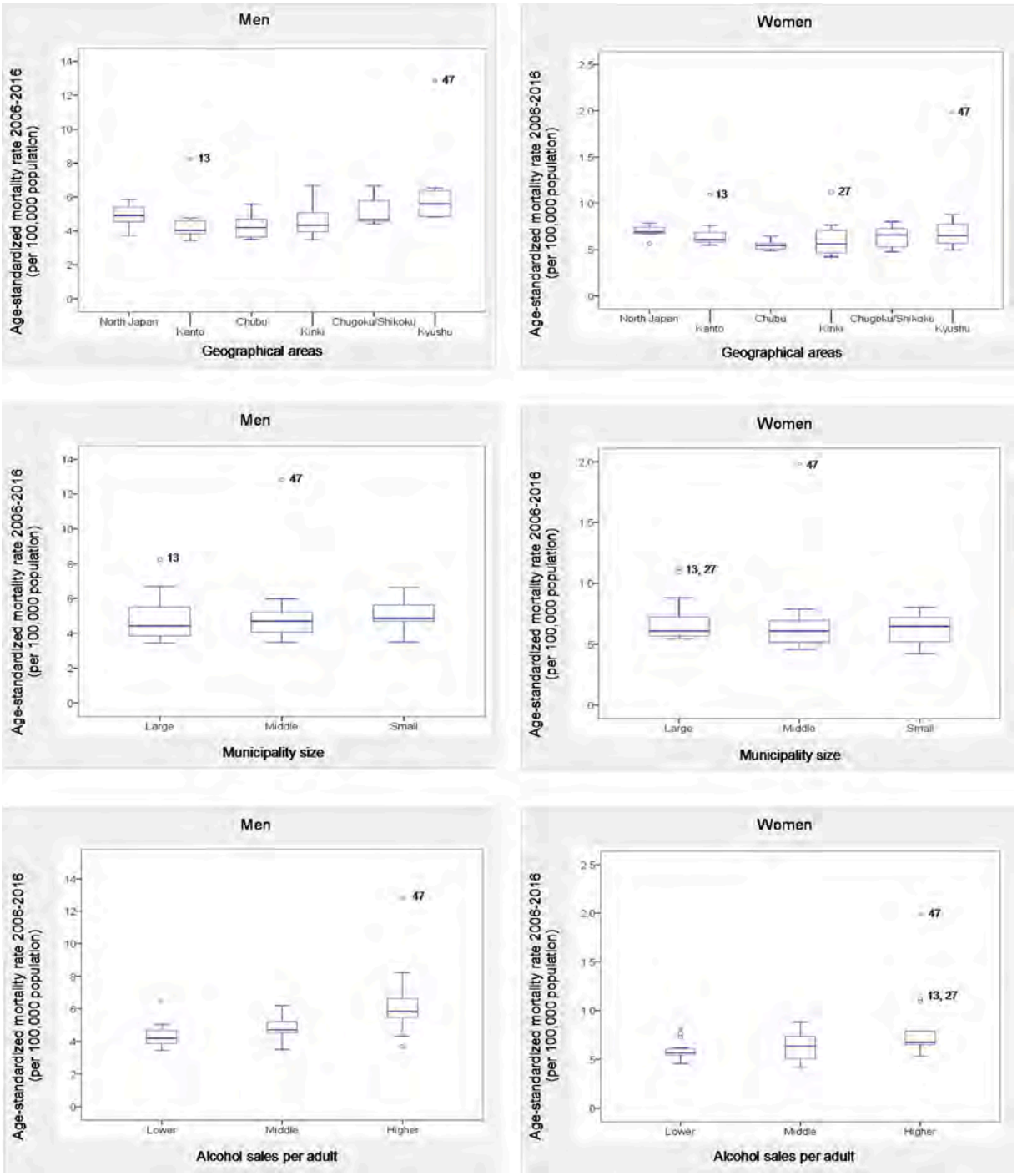

Fig. 4. Comparisons of age-standardised mortality rates for 2006-2016 by geographical area, population size, and annual per capita alcohol consumption.
Regarding municipality size, prefectures were divided into three categories: large (more than 2.3 million population during 1995–2015, 15 prefectures), medium (more than 1.26 million population during 1995–2015, 17 prefectures), and small (less than 1.26 million population during 1995–2015, 15 prefectures).
Regarding alcohol sales per adult by prefecture, prefectures were divided into three categories: lower (prefecture's annual alcohol sales per adult in 2005 was $<$ 80 L, 12 prefectures), middle (prefecture's annual alcohol sales per adult in 2005 was 80–90 litres, 17 prefectures), and higher (prefecture's annual alcohol sales per adult in 2005 was $\geq$ 90 L, 17 prefectures).
The boxplot shows five number summaries: the smallest observation, first quartile, median, third quartile, and sample maximum by category. The circles (○) show the outliers. The numbers in the chart shows the prefecture number: 13: Tokyo, 27: Osaka, 47: Okinawa.

disorders due to alcohol use and alcoholic liver disease, but also in acute diseases like the toxic effect of alcohol. This result shows that both factors are related to the younger age of death of women. It is necessary to provide accurate information showing that women are more susceptible to negative health outcomes related to drinking.

4.3. Geographical areas, municipality size, alcohol sales per adult and ASMR of 100 % ARD

The ASMR of 100 % ARD differs depending on the prefectures. Therefore, for the purpose of exploring the related factors to higher ASMR, the prefectures were classified by geographical area, by

municipality size, and by alcohol sales per adults, and then the associations between each factor and the ASMR were explored. Geographical distribution could also reflect the traditional culture. One of the reasons why a few areas had higher ASMRs for 100 % ARD in men might be that drinking habits had traditionally been built there. Some prefectures in these geographical areas are thriving with brewing traditional Japanese rice wines called *Sake* or traditional Japanese distilled liquors called *Shochu* (National Tax Agency, 2005; National Research Institute of Brewing, 2018). The population of a prefecture could show to some extent whether the prefecture has a large city. Current results found that there was no association between municipality size and ASMRs for 100 % ARD. Every prefecture has urbanareas and therefore the classification by population would not show the reason for differences in ASMRs by prefecture. However, the ASMRs for 100 % ARD in Tokyo and Osaka were higher than the other prefectures except for Okinawa, and the ASMR would be higher in metropolises.

Alcohol sales per adult had been predicted to have a positive association with ASMRs because it is reported that lower outlet numbers and reduced outlet densities and limited hours and days of sale can effectively reduce alcohol sales and problems in other countries (Gruenewald, 2011). The ASMR for 100 % ARD was highest in the prefectural group with the highest alcohol sales per adult, as expected. Our result suggests that reducing alcohol sales can lead to a reduction in 100 % ARD in Japan. The effectiveness of measures to raise taxes and determine unit prices according to alcohol content has been reported (Wagenaar et al., 2010; Zhao et al., 2013; Sharma et al., 2017; O'Donnell et al., 2019). In 2018, the WHO launched SAFER, 'a new initiative and technical package outlining five high-impact strategies that can help governments to reduce the harmful use of alcohol and related health, social and economic consequences', as a strategy to reduce harmful alcohol use by 10 % by 2025 (World Health Organization, 2018a). In Japan, 'A' (advance and enforce drunk-driving countermeasures) has been legislated, and 'F' (facilitate access to screening, brief interventions, and treatment) is currently being strengthened. However, the current efforts for 'S' (strengthen restrictions on alcohol availability), 'E' (enforce bans or comprehensive restrictions on alcohol advertising, sponsorship, and promotion), and 'R' (raise prices on alcohol through excise taxes and pricing policies) are not enough. In order to lower ASMRs of 100 % ARD, it would probably be effective to work on improving alcohol taxation and pricing policies.

The ASMRs of 100 % ARD in Okinawa for both genders were by far the highest among all 47 prefectures. Nevertheless, a previous study revealed that premature adult mortality rates from 1970 to 2005 were much lower in Okinawa than in other prefectures (Suzuki et al., 2012). The Okinawa Prefecture is the southwestern-most part of Japan, consisting of 57 islands of various sizes. Okinawa is unique within Japan because of its location and the island's culture and history (Institute for International Cooperation Japan International Cooperation Agency, 2000). The direct reason for the highest ASMR of 100 % ARD in Okinawa would be the proportion of current drinkers, heavy drinkers, and binge drinkers (Okinawa prefecture, 2016; Mori and Fukuda, 2020). Okinawa is considered to be the first place where the *Shochu* had been brought from southeast Asia, and each of Okinawa's islands has a unique drinking culture (National Research Institute of Brewing, 2018; nippon.com, 2020). These factors might be related to the highest ASMR of 100 % ARD occurring in Okinawa. Additionally, there is a difference in alcohol policy between Okinawa and the other prefectures. Of Japan's 47 prefectures, only Okinawa has had a reduced tax rate on liquors since 1972 (Cabinet Office, 2017). Okinawa's traditional *Shochu*, Awamori, which has a high alcohol concentration, was designed to have a lower tax rate in order to promote local industry. Compared to Japan's other 46 prefectures, liquor in Okinawa is available at a lower price, suggesting this might be the other factor for the high ASMR of 100 % ARD. One effective way to reduce Okinawa's ASMR of 100 % ARD would be to revise the reduced tax rates.

4.4. Limitations

One limitation of this study is that it did not include data on less than 100 % ARDs, such as cancer. According to a previous report on alcohol-related cancer deaths in 2005, there are about five times more alcohol-contributed cancer deaths (approximately 20,000) than 100 % ARDs (Inoue et al., 2012). However, only the detailed drinking rates in Japan after the year 2003 can be obtained (Osaki et al., 2016; Zaitsu et al., 2020; National Institute of Health and Nutrition, 2013). Additionally, the survey for detailed drinking rates was conducted every five years. It is necessary to conduct the survey more frequently for the yearly changes of all ARD to be monitored.

Second, there is a limitation regarding the accuracy of causes of death in the national death registry system. The national death registry system is based on a death or autopsy certificate made by a physician at the time of death. Thus, cause of death is listed at the doctor's discretion. In medical education, students perform exercises to determine cause of death as described on death certificates, guaranteeing quality to some extent. However, when a possible cause of death other than alcohol also exists, a cause other than a 100 % ARD may be provided. For example, in an analysis of individuals who drowned in the bathtub, blood ethanol was detected in 146 out of 357 people. Of those, acute ethanol intoxication was recorded on the death certificate of seven individuals, while the cause of death listed for most of them was drowning (Suzuki et al., 2015). Thus, 100 % ARDs are likely to be underestimated.

In conclusion, the current study suggested that in Japan, ASMR of 100 % ARD among men stayed high and increased among women. According to prefecture-level analysis, per capita alcohol sales were positively associated with ASMRs of 100 % ARD. Strengthening alcohol-control policy is necessary to reduce ARDs in Japan. In particular, the prefecture with the highest mortality rates should reconsider its reduced alcohol tax system.

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Contributors

All authors have materially participated in the research or article preparation. SH planned the survey and received the funding. AK and YO designed the survey. AK, BP, and TO contributed in analyzing and interpreting the data and writing the report. YK, MF, and YO contributed in analyzing and interpreting the data.

All authors approved the final manuscript before submission.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

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Gender differences in dietary behaviors among Japanese adolescents

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ABSTRACT

Unhealthy dietary behaviors in adolescence are an important public health problem. Gender differences in dietary behaviors have already appeared during adolescence. However, few studies have assessed a variety of adolescent dietary behaviors in Japan. We aimed to clarify gender differences in unhealthy dietary behaviors among Japanese adolescents. The participants consisted of 84,988 participants from seventh to 12th grades. Unhealthy dietary behaviors were defined according to the National Health and Nutrition Survey. Multivariable logistic regression was used to analyze a nationally representative sample of Japanese adolescents from the 2014 to 2015 Lifestyle Survey. The effective response rate was 51.4%. The prevalence of unhealthy dietary behaviors (skipping breakfast, snacking, eating out, skipping meals, eating alone at dinner, and subjectively poor diet quality) among boys and girls was 14.2% versus 12.4%, 19.6% versus 14.1%, 10.6% versus 7.0%, 7.9% versus 5.6%, 13.3% versus 12.1%, and 12.3% versus 15.8%, respectively. Compared with boys, girls were more negatively associated with skipping breakfast [OR = 0.76 (95% CI 0.73–0.79)], snacking [OR = 0.67 (95% CI 0.65–0.70)], eating out [OR = 0.62 (95% CI 0.59–0.66)], skipping meals [OR = 0.61 (95% CI 0.58–0.65)], and eating alone at dinner [OR = 0.79 (95% CI 0.76–0.83)]. However, girls were more positively associated with subjectively poor diet quality [OR = 1.19 (95% CI 1.14.1.24)]. The findings suggest that gender differences existed in dietary behaviors. Gender differences in dietary behaviors suggest opportunities for tailoring interventions related to dietary education in schools.

1. Introduction

Adolescence is an important period for physical and psychological development. Dietary behaviors once established in adolescence tend to continue throughout life (Wahl, 1999). Unhealthy dietary behaviors during adolescence can result in nutritional deficiency and delayed growth and may also have a negative effect on performance in school (Kim et al., 2016). Adolescent unhealthy dietary behaviors are associated with other health-related behaviors (Neumark-Sztainer et al., 1997). For example, skipping breakfast has been linked to insomnia (Kaneita et al., 2006). Frequent snacking is a risk factor for poor dietary behaviors, and is related to lifestyle behaviors (Larson et al., 2016). In Korean high school students, distress not only increased instant food and snack intake, but also the frequency of eating out (Hong and Kim, 2014). Skipping meals is an unhealthy method to promote weight loss and a potential risk factor for eating disorders (Neumark-Sztainer et al., 2012). Shared meals may protect against nutritional-related health problems, including obesity, other unhealthy dietary behaviors, and eating disorders (Fulkerson et al., 2014). A cross-sectional study targeting Australian adolescents showed that poor diet quality was associated with depression (Jacka et al., 2010). Furthermore, unhealthy dietary behaviors increase the risk of obesity and non-communicable diseases (Amine et al., 2002; Story et al., 2000). Therefore, unhealthy dietary behaviors in adolescence have been suggested as an important public health issue (Moreno et al., 2014). It is necessary to develop strategies to promote healthier dietary behaviors.

Gender differences in dietary behaviors have already appeared during adolescence (Reynolds et al., 1999). For example, adolescent boys eat faster than adolescent girls in Korea (Jeong et al., 2014). Furthermore, compared with boys, girls tend to give consideration to their food choices (Rolls et al., 1991). The incidence of obesity continues to increase worldwide among children and is particularly high in

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developed countries (Ng et al., 2014). In Japan, while obesity is increasing among boys, leanness is increasing among girls (Ministry of Education, Culture, Sports, Science and Technology, 2018). Adolescent girls' leanness may lead to future osteoporosis (Rigotti et al., 1991) and delivery of a low-birthweight infant (Ronnenberg et al., 2003). Compared with other countries, Japan shows a specific trend. Thus, it is important to study dietary behaviors in adolescence by gender.

However, few studies have comprehensively assessed adolescent dietary behaviors by gender in Japan. Furthermore, most previous studies were conducted in the U.S. and other Western countries. To address these issues, we conducted a large-scale survey of adolescents' lifestyles throughout Japan. Based on previous reports (Reynolds et al., 1999; Rolls et al., 1991), we hypothesized that boys tend to adopt unhealthy dietary behaviors to a greater extent than girls. In this study, we aimed to investigate gender differences in unhealthy dietary behaviors among Japanese adolescents.

2. Methods

2.1. Participants

Of the 10,547 junior and 4807 senior high schools registered in Japan in May 2013, 140 junior (selection rate: 1.3%) and 124 senior (selection rate: 2.6%) high schools were sampled. We used a stratified, single-stage cluster-sampling method to divide Japan into regional blocks and randomly selected schools from each block. To avoid any sampling bias, stratified sampling was performed with regional blocks as the strata. All the students in the sampled schools were the study participants. The sample size was determined by the response rate and confidence intervals based on the variance of the results obtained from a previous study (Osaki and Minowa, 1996).

In the Japanese education system, children enter elementary school at the age of 6 years and leave after 6 years of study. They then enter junior high school for 3 years of study, followed by a further 3 years in senior high school. Education is mandatory in junior high school. In this study, the first to third years of junior high school are called the 7th to 9th grades, and the first to third years of senior high school is called the 10th to 12th grades.

2.2. Survey procedure

We sent a letter to the principal of each selected school for cooperation in the survey, along with the same number of questionnaires and envelopes as the number of students enrolled at the school. Schools, where the principals had agreed to the survey and had received questionnaires and envelopes, also required each class teacher to inform the students and ensure the protection of the privacy of the respondents. Teachers explained to the students about confidentiality and voluntary participation, and delivered the completed questionnaires in the sealed envelopes back to our department. The survey was conducted from October 2014 to January 2015. This study was approved by the research members' institutional Ethical committee.

2.3. Measures

The major sections of the questionnaire were (1) personal data, (2) dietary behaviors, (3) lifestyle, and (4) mental health status. Personal data included gender, school grade, and type of school.

2.3.1. Dietary behaviors

To ensure reliability of the dietary behaviors, we used the questions of the 2007 National Health and Nutrition Survey (NHNS) established by the Ministry of Health, Labor and Welfare (Ikeda et al., 2015). The unhealthy dietary behaviors in the present study were based on definitions used in previous studies (Otsuka et al., 2019; Videon and Manning, 2003; Wijtzes et al., 2015):

1) Skipping breakfast

How often did you eat breakfast during the previous month? (1. Almost every day, 2. Sometimes, 3. Seldom). Skipping breakfast was defined when answered as "Sometimes" or "Seldom."

2) Snacking

How many times per day did you snack during the previous month? (1. Over 14 times/week, 2. 7–13 times/week, 3. 2–6 times/week, 4. under once/week, 5. None). Snacking was defined when answered as "Over 14 times/week."

3) Eating out

How many times per day did you eat out during the previous month? (1. Over 14 times/week, 2. 7–13 times/week, 3. 2–6 times/week, 4. under once/week, 5. None). Eating out was defined when answered as "Over 14 times/week" or "7–13 times/week."

4) Skipping meals

How many times per day did you skip a meal during the previous month? (1. Over 7 times/week, 2. 4–6 times/week, 3. 2–3 times/week, 4. under once/week, 5. None). Skipping meals was defined when answered as "Over 7 times/week" or "4–6 times/week."

5) Eating alone at dinner

When you ate dinner at home during the previous month, who did you eat with? (1. All the family, 2. Some of the family, 3. Alone, 4. Other). Lack of family dinner was defined when answered as "Alone."

6) Subjectively poor diet quality

How was the quality of meals at home during the previous month? (1. Very good, 2. Good, 3. Bad, 4, Very bad). Subjectively poor diet quality was defined when answered as "Bad" or "Very bad."

2.3.2. Covariates

To determine the following covariates, we referred to factors associated with dietary behaviors in previous studies (Fulkerson et al., 2014; Jacka et al., 2010; Kaneita et al., 2006; Kim et al., 2010; Larson et al., 2016; Neumark-Sztainer et al., 1997). The lifestyle questionnaire assessed current smoking, current alcohol drinking, participation in club activities, exercise habits, more than 5 h of internet usage on weekdays, insomnia symptoms, and interest in being healthy. The covariate of internet usage time was derived from a previous study in which Japanese adolescents using $\geq$5 h of internet on weekdays were categorized as "high-risk" group for problematic internet use (Mihara et al., 2016). Internet addiction in adolescents can negatively affect dietary behaviors (Kim et al., 2010). Insomnia is defined when there is presence of one or more of the following symptoms: difficulty in initiating sleep, difficulty in maintaining sleep, and early morning awakening (Kaneita et al., 2006). Mental health status was assessed using selected items from the 12-item General Health Questionnaire (GHQ-12) (Doi et al., 2003; Goldberg et al., 1976). In this study, we used the assessments for "depression and anxiety" and "decrease in positive feeling" from the GHQ-12. One question from each of the two factors was selected for this study. Students who answered affirmatively to either question were classified as having poor mental health (Suzuki et al., 2011).

2.4. Data analysis

First, we calculated the demographic characteristics of the analyzed participants and the 95% confidence intervals. Next, we calculated the prevalence and the 95% confidence interval of each unhealthy dietary behavior by gender and school grade and compared gender differences using the chi-squared test. Finally, to examine the gender differences in unhealthy dietary behaviors, multiple logistic regression analyses were performed. School grade, drinking alcohol, smoking, extracurricular activities, interest in being healthy, exercise habits, insomnia, mental health status, and 5-or-more hours of internet use on weekdays were used as the covariates. We set the level of significance at $P < 0.01$. All analyses were performed using SPSS version 17.0.

Table 1
Demographic characteristics of analyzed participants (%).

	Boys N = 41,225	%	95%CI	Girls N = 43,763	%	95%CI
Grade						
Grade 7	5467	13.3	12.9–13.6	5061	11.6	11.3–11.9
Grade 8	5426	13.2	12.8–13.5	5055	11.6	11.3–11.9
Grade 9	5320	12.9	12.6–13.2	5145	11.8	11.5–12.1
Grade 10	9058	22.0	21.6–22.4	9990	22.8	22.4–23.2
Grade 11	8348	20.3	19.9–20.6	9390	21.5	21.1–21.8
Grade 12	7606	18.5	18.1–18.8	9122	20.8	20.5–21.2
Drinking alcohol	3516	8.5	8.3–8.8	3298	7.5	7.3–7.8
Smoking	1101	2.7	2.5–2.8	469	1.1	1.0–1.2
Club activity	28,220	71.5	71.1–72.0	28,469	66.7	66.2–67.1
Excise habit	20,745	52.4	51.9–52.9	13,365	31.2	30.8–31.6
Insomnia	8762	21.3	20.9–21.7	8666	21.0	20.6–21.4
Poor mental health	5002	13.3	13.0–13.6	7500	17.2	16.9–17.6
Interest in being healthy	22,897	55.9	55.4–56.4	26,477	60.8	60.3–61.3
Using the Internet hour > 5 h in weekdays	5022	12.4	12.1–12.7	5651	13.1	12.8–13.4

3. Results

This study enrolled 165,269 students who randomly selected junior and senior high schools. The total number of respondents was 85,931. Overall, 943 questionnaires were excluded because gender was not specified or the responses were inconsistent. Data from the remaining 84,988 questionnaires were analyzed. The effective response rate was 51.4%.

Table 1 shows the demographic characteristics of the participants by gender. The proportion of boys was higher in grades 7–9 and that of girls was higher in grades 10–12. Regarding drinking alcohol, smoking, club activities, and exercise habits, the proportion of boys was significantly higher than that of girls. Regarding poor mental health, interested in being healthy, and heavy Internet users during the weekday, the proportion of girls was significantly higher than that of boys.

Fig. 1 shows the prevalence of unhealthy dietary behaviors by gender and school grade. The prevalence of skipping breakfast was significantly lower among girls than among boys (12.7%: 95%CI 12.4–13.0 vs. 14.9%: 95%CI 14.6–15.2, $\chi^2 = 83.65$, $p < .001$). The tendency to skip breakfast increased among boys and girls with higher grades (Fig. 1A). The prevalence of snacking among girls was significantly lower than that among boys (14.6%: 95%CI 14.3–15.0 vs.

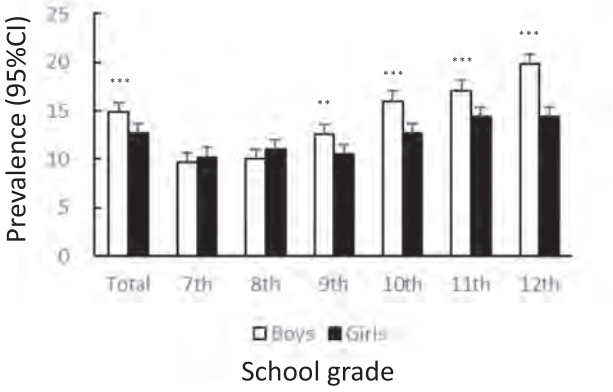
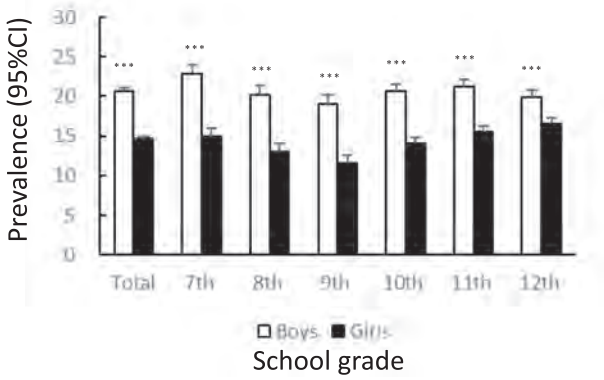


Fig. 1. Prevalence of unhealthy dietary behaviors among Japanese adolescents by gender and school grade.



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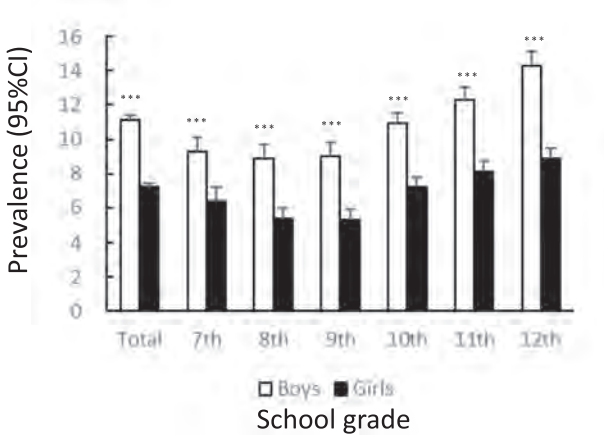

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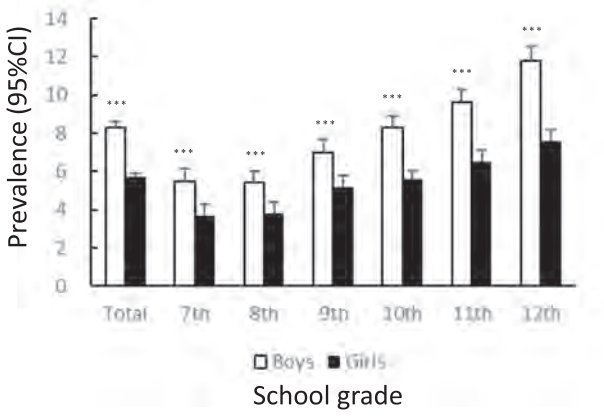
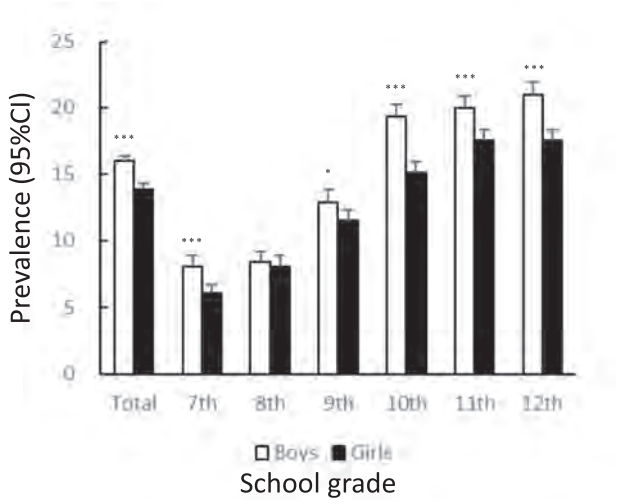


Fig. 1. (*continued*)

20.6%: 95%CI 20.2–21.0, $\chi^2 = 521.4$, $p < .001$). In both boys and girls, this percentage declined after the 7th grade, bottomed out in the 9th grade, and then rose again (Fig. 1B). The prevalence of eating out was significantly lower among girls than among boys (7.2%: 95%CI 6.9–7.4 vs. 11.1%: 95%CI 10.8–11.4, $\chi^2 = 372.8$, $p < .001$). In boys and girls, the higher the grade, from 10th to 12th, the higher the prevalence of eating out (Fig. 1C). The prevalence of skipping meals was significantly lower among girls than among boys (5.7%: 95%CI 5.5–6.0 vs. 8.3%: 95%CI 8.0–8.6, $\chi^2 = 205.0$, $p < .001$). In boys and girls, the higher the grade in schools, the higher the prevalence of skipping meals (Fig. 1D). The prevalence of eating alone at dinner was significantly lower among girls than among boys (13.9%: 95%CI 13.6–14.3 vs. 16.0%: 95%CI 15.7–16.3, $\chi^2 = 73.96$, $p < .001$). The prevalence



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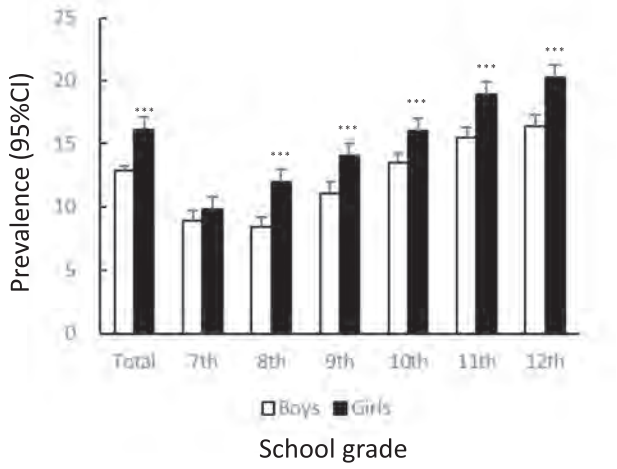

Fig. 1. (*continued*)

tended to increase with higher grades in both boys and girls (Fig. 1E). The prevalence of subjectively poor diet quality was significantly higher among girls than among boys (16.1%: 95%CI 15.7–16.5 vs. 12.9%: 95%CI 12.6–13.2, χ^2 = 175.1, p < .001). The prevalence tended to increase with higher grades in both boys and girls.

Table 2 shows the logistic regression results for the gender differences in unhealthy dietary behaviors among Japanese adolescents. After adjusting for covariates, girls compared to boys were more negatively associated with skipping breakfast [AOR = 0.76 (95% CI 0.73–0.79)], snacking [AOR = 0.67 (95% CI 0.65–0.70)], eating out [AOR = 0.62 (95% CI 0.59–0.66)], skipping meals [AOR = 0.61 (95% CI 0.58–0.65)], and eating alone at dinner [AOR = 0.79 (95% CI 0.76–0.83)]. On the contrary, girls were more positively associated with subjectively poor diet quality [AOR = 1.19 (95% CI 1.14.1.24)].

4. Discussion

This is the first study to examine gender differences in unhealthy dietary behaviors among Japanese adolescents. The results suggest that gender differences in dietary behaviors appear to be partly related to their beliefs regarding healthy eating. This study had two strengths: 1) a nationwide survey and 2) an extremely large sample. Many studies have examined a few unhealthy dietary behaviors, such as skipping breakfast. However, we found almost no similar studies examining the prevalence of a variety of dietary behaviors. Furthermore, few studies have been conducted on adolescents' dietary behaviors in Asia. Therefore, this study makes an important contribution to health education.

Overall, the present study indicated that girls tended to adopt regular dietary behaviors as compared to boys, but they seemed dissatisfied with the quality of their diet. This is partially consistent with previous studies (Reynolds et al., 1999; Rolls et al., 1991). Reasons for different dietary behaviors can be found in nutrition knowledge and attitude. Girls have more nutrition knowledge than boys and are extremely self-conscious about their bodies (Pirouznia, 2001; Rampersaud et al., 2005). In contrast, girls showed lower intake of essential vitamins and minerals and lesser ingestion fruits and vegetables as compared to boys (Johnson et al., 1994). Boys tended to have meals that were higher in total fat and saturated fat as compared to girls (Munoz et al., 1997). Thus, boys and girls showed a significant difference in their dietary behaviors. In future studies, it is necessary to identify these differences.

Previous studies on skipping breakfast and meals have shown inconsistent gender differences (Oba et al., 2016; Smetanina et al., 2015; Smith et al., 2017; Vereecken et al., 2009). In Western countries, girls skip breakfast and other meals more frequently than boys (Smith et al., 2017; Vereecken et al., 2009). However, similar to the present study, another cross-sectional study among Japanese adolescents reported that there is a significant association between skipping meals and male gender (Oba et al. 2016). Although the reason for this gender difference is not known, more boys reported frequent snacking and eating out as compared to girls, and the gender distribution could explain it. Despite the low frequency of skipping meals among adolescent girls, the prevalence of lean women in their 20 s is very high (21.7%) as compared to

Table 2
Logistic regression results for the gender differences about unhealthy dietary behaviors among Japanese adolescents.

	Girls compared with boys					
Unhealthy dietary behaviors	Crude OR	95%CI	p-value	Adjusted OR	95%CI	p-value
Skipping breakfast	0.83	0.80–0.86	< 0.001	0.76	0.73–0.79	< 0.001
Snacking	0.66	0.63–0.68	< 0.001	0.67	0.65–0.70	< 0.001
Eating out	0.62	0.59–0.65	< 0.001	0.62	0.59–0.66	< 0.001
Skipping meals	0.67	0.64–0.71	< 0.001	0.61	0.58–0.65	< 0.001
Eating alone at dinner	0.85	0.81–0.88	< 0.001	0.79	0.76–0.83	< 0.001
Subjectively poor diet quality	1.30	1.25–1.35	< 0.001	1.19	1.14–1.24	< 0.001

Participants with missing data were excluded from the analysis.
Adjusted for grade, club activity, exercising habit, mental health, long time internet user, alcohol drinking, smoking, and interest in being healthy at multiple logistic regression.
P value was calculated using the multiple logistic regression analysis.
"Skipping Breakfast" was calculated as the sum of "Seldom and Sometimes". "Snacking" was defined as "Over 14 times/week". Eating out was defined as "Over 14 times/week and 7–13 times/week". Skipping meals was defined as the sum of percentage "Over 7 times/week and 4–6 times/week". Eating dinner at alone was defined as "Alone". Subjectively poor diet quality was defined as the sum of "Very bad and Bad".
AOR: adjusted odds ratio; CI: confidence interval;

lean men (9.1%) (Ministry of Health, Labour and Welfare, 2017). Thus, it is suggested that Japanese young girls are more worried about their weight than the boys are. Girls are known to present more body image distortion as compared to boys (Smolak, 2004). Moreover, girls are more likely to sense themselves as overweight when in fact they are average or even underweight, while many boys are likely to be concerned about being overweight when they are actually obese. Skipping meals is often used as a weight-loss method (Neumark-Sztainer et al., 2012). The present study showed that Japanese girls might not skip meals, but instead reduce the amount of food and worsen the quality of their food, for e.g., cut down intake of carbohydrates. In future studies, the question of how they feel about their own weight and the nutrition or energy from meals should be addressed.

We found significant differences in the prevalence of snacking by gender. Adolescent boys snacked more often perhaps because adolescent boys have voracious appetites, which might result in hunger and the need to eat during break times while undergoing club activities. Interestingly, the gap between boys and girls with respect to snacking diminished as the grade increased. A cross-sectional study in Poland youth reported that women snack more frequently on sweets, biscuits, nuts, and seeds, whereas men tend to snack on salty snacks, add sugar to beverages, and add salt to dishes (Zaborowicz et al., 2016). Participants with insufficient nutritional knowledge snack more frequently on salty snacks rather than fruit (Zaborowicz et al., 2016). Thus, age and gender may affect snacking behaviors. Snacking is generally considered a factor in the development of overweight and obesity in childhood (Nicklas et al., 2003). These results suggest the necessity of a multidimensional survey with respect to adolescents' age and gender for healthy snacking behavior.

Regarding the frequency of family dinners, consistent with previous studies, we found that boys ate alone at dinner less often than girls (Goldfield et al., 2011; Shirasawa et al., 2018). One explanation for this is that boys often eat fast food after school and club activities; thus, they have fewer opportunities for family dinners. Previous studies have reported that family meal times may act as a protective factor against nutritional health-related problems encountered during adolescence, including unhealthy dietary behaviors (Hammons and Fiese, 2011). Another explanation is that the schedule of the cram school may affect family dinners. Because of adolescents' cram school sessions and their parents' jobs, the number of times a Japanese family eats a meal together has reduced (Kojima, 2011). Therefore, our findings suggest that health educators need to promote the importance of family dinners and the risks related to eating alone.

In contrast to the above results, we found that the prevalence of subjectively poor diet quality was higher among girls. Studies have reported that girls tend to hold stronger diet-related beliefs than boys (Davy et al., 2006; Wardle et al., 2004). Thus, girls may underestimate the quality of their diet, while boys may overestimate them. Although girls regularly eat meals, the result also suggests that girls may be restricted to the amount of meals. Future research is needed to use objective indicators such as the Diet Quality Index (Vyncke et al., 2013).

The results of the current study also suggested that some dietary behaviors such as skipping breakfast, eating out, eating alone, subjective poor diet quality were likely to have an interaction between gender and school grade which meant age. The findings in the current study support in line with the several previous studies which show that pubertal status may affect on skipping meals and snacks (Lee and Lee, 2013; Nu et al., 1996). Another explanation for that is that high school students (grade10-12) tend to eat in accordance with their own daily rhythms, thus dietary behaviors are easily disturbed. Therefore, our findings suggest that health educators need to change the content of education in dietary behaviors depending on the grade

This study had several limitations. First because it was a cross-sectional study, the cause and effect relationships for each dietary behavior, or how these may have changed over time, could not be determined. For example, poor mental health status could affect dietary and other behaviors more when compared to healthy mental status (Brausch and Gutierrez, 2009). In the present study, we could use only two items from GHQ-12 for mental health due to limited space in the questionnaire. To focus more on the adolescents' mental health status in future surveys, all GHQ items may need to be included for accurate measurement. Second, data for the study were collected via a self-administered questionnaire. Using a validated method to assess meal balance over the previous 24 h, for example, would have provided strong evidence that could have been used in the study. Third, no data were obtained on participants' weights or socio-economic factors, such as family income or the educational levels of the participants' parents. Future research should include socio-economic factors and their actual and ideal weights. Fourth, about 40% of non-responses existed, because minors aged < 20 years in Japan are prohibited by law from smoking and drinking alcohol. Therefore, schools and students tend to be non-cooperative in responding to questions on their smoking and drinking status. However, the present survey response rate had some acceptability (Johnson and Wislar, 2012).

5. Conclusion

The current study found that dietary behaviors differed between genders, and these differences varied among junior and senior high school. Future research should examine factors in the home environment, such as socioeconomic status (SES) and use of electronic devices during meals. Our results highlight the importance of developing gender-specific prevention strategies. Integrating strategies in health education in schools could contribute to improving adolescent health. Interventions should focus on healthy eating behaviors and improving food quality. It would be advisable to focus on developing healthy eating habits in boys, and education in girls regarding the necessary nutrients and proper energy intake. Schools need to not only teach the importance of proper dietary behaviors, but also support modeling and reinforcing healthy dietary behaviors. Adolescents have easy access to high fat and high sugar food and beverage products around school. Hence, schools need to create a supportive and integrated nutrition environment.

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CRediT authorship contribution statement

Yuichiro Otsuka: Formal analysis, Data curation, Writing - original draft. **Yoshitaka Kaneita:** Project administration, Writing - review & editing. **Osamu Itani:** Software, Supervision, Visualization. **Maki Jike:** Investigation, Methodology. **Yoneatsu Osaki:** Formal analysis, Funding acquisition. **Susumu Higuchi:** Project administration, Resources. **Hideyuki Kanda:** Conceptualization, Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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PLOS ONE

RESEARCH ARTICLE

Skipping breakfast, poor sleep quality, and Internet usage and their relation with unhappiness in Japanese adolescents

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Abstract

Subjective happiness is often regarded as a major life goal. Although Japan is an economically powerful country, the level of subjective well-being reported among Japanese adolescents is lower than in other countries. We aimed to investigate the lifestyle factors related to unhappiness in Japanese adolescents. We collected data through the 2017–2018 Lifestyle Survey of Adolescents, a nationally representative cross-sectional study enrolled in randomly selected junior and senior high schools throughout Japan. We assessed the prevalence of subjective unhappiness in junior and senior high school students according to school life factors and daily lifestyle habits. A multivariable logistic regression analysis was used to examine the associations between these factors and unhappiness. A total of 64,329 students were included in the sample (mean age 15.7 years, 53.9% boys). The average prevalence of unhappiness was 10.2%. The logistic regression analyses indicated that unhappiness was strongly associated with being male and with engaging in unhealthy lifestyle behaviors such as not having breakfast, poor sleep quality, and some problematic Internet usage. Although the prevalence of unhappiness was significantly higher among current smokers and alcohol drinkers, these behaviors were not associated with unhappiness in the multivariable logistic regression analysis. Unhappiness among Japanese adolescents appears to be strongly related to how they spend their daily life. We therefore consider it desirable for school officials to educate students on the importance of happiness and lifestyle factors conducive to happiness.

Introduction

Subjective happiness has received increasing attention from academics and policymakers around the world as a global measure of subjective well-being [1, 2]. In the psychometric

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literature, subjective well-being consists of evaluative and affective elements [3]; evaluative well-being reflects individuals' judgments about the quality and virtue of their lives [4], while affective well-being reflects positive emotions and moods such as happiness, joy, excitement, and cheerfulness, as well as avoidance of pain and depression [5]. Although there are many examples of people who have achieved meaning and fulfillment in life without enjoyment, the different types of subjective well-being are on average positively correlated [6]. Thus, many regard subjective happiness as a major life goal [1] with numerous positive effects on physical and mental health, including improved cardiovascular function [7], improved sleep quality [8], an increased survival rate [9], and increased quality of life [10].

However, the above findings pertain to adults only; few studies have targeted adolescents. Adolescence is a period of rapid physical and psychological change intrinsically linked to adulthood [8]—indeed, happiness in adolescence is associated with happiness in adulthood. Furthermore, happiness in childhood is related to social and coping skills (which predict subjective happiness) in adulthood [11]. Happiness in adolescence is also associated with lifestyle behaviors such as physical activity, eating habits, smoking, and alcohol use [12–14]. For instance, a cross-sectional survey in Hong Kong targeted 45,857 secondary school students and found that students who reported fewer than two days of exercise per week were up to 32% more likely to be unhappy than those who reported three to seven days of exercise. Further, the risk of unhappiness increased with the number of days of drinking, and current and former smokers were more likely to be unhappy than those who never smoked [13]. Subjective happiness is also negatively related to problematic Internet usage [15–17]. A cross-sectional study of 56,086 adolescents in Taiwan showed that adolescents who reported being unhappy had a higher risk of Internet addiction—1.54 times higher in boys and 1.88 times higher in girls—than adolescents who were happy [16]. A study in Chile targeting 3461 students 17 to 24 years old reported that eating lunch, fruits, and vegetables every day increased the likelihood of being classified as "very happy" [14]. Thus, happy adolescents are less likely to engage in a variety of harmful and unhealthy behaviors, including smoking, drinking, unhealthy eating, and problematic Internet usage. Increasing adolescents' subjective happiness might improve their social adaptability and quality of life later on [18, 19]. Therefore, the positive impacts of subjective happiness can benefit health through indirect relationships with health promotion activities.

A study targeting 540,000 fifteen-year old students found that the happiness levels of Japanese students was ranked 42 out of 47 countries and regions (including Organisation for Economic Co-operation and Development [OECD] countries and partner nations) [20]. As such, it is important to implement strategies aimed at improving Japanese youths' overall happiness, which requires consideration of the factors related to happiness, such as gender [14] and environmental factors, including school support structures, communication between parents and children, and academic load [21]. Teachers and policymakers would find it challenging to improve parent-child relationships as a method of increasing adolescents' happiness. Though change is not an immediate process, addressing lifestyle behaviors and the school environment while attempting to address parent-child relationship quality might result in more immediate benefits than solely focusing on a single factor.

No studies have actually investigated the associations between lifestyle factors and unhappiness in Japanese adolescents. In 2000, the Government of Japan formulated a comprehensive health policy, Health Japan21, and set daily lifestyle goals such as increasing breakfast intake and reducing drinking and smoking in minors [22]. Internet addiction has also become a serious public health issue, and its effects are particularly detrimental to young people, who are in the process of growing both mentally and socially [23]. Targeting lifestyle factors allows us to orient adolescents toward future happiness by improving the conditions of not-yet-happy

adolescents. Although there have been previous reports on "unhappiness at school" in a nationwide survey [24], we were interested in the "feeling that school is not fun" (based on the Japanese wording of the questionnaires) rather than unhappiness. In actuality, numerous extracurricular activities and aspects of adolescent lifestyle occur outside of school; therefore, increasing the range of variables is needed, including not only school life, but also daily life behaviors to accurately evaluate unhappiness in adolescents. Identifying the factors associated with subjective unhappiness among adolescents is a step toward addressing unhappiness in adolescents and thereby improving individuals' future physical and mental health. Therefore, we conducted a large-scale survey on how different lifestyle factors among adolescents throughout Japan are associated with unhappiness. Based on previous research, we hypothesized that adolescents' levels of unhappiness would be associated with daily behaviors, such as Internet usage; whether they participate in school extracurricular activities, sleep quality, eating behavior; and gender. Daily activities facilitate group intervention education in schools, and considering which behaviors are associated with adolescents can inform future surveys and policies on lifestyle interventions to improve happiness.

Materials and methods

Participants

We collected data via the 2017–2018 Lifestyle Survey of Adolescents. Of the 10,235 junior and 4,907 senior high schools registered in Japan in May 2017, we sampled 98 junior (selection rate: 0.96%) and 86 senior (selection rate: 1.75%) high schools using a stratified, single-stage cluster-sampling method, which involved dividing Japan into regional blocks and randomly selecting schools from each block. We used this method to limit sampling bias. All students in the sampled schools were included. The sample size was determined using the response rates and confidence intervals based on variance of results obtained from a previous study [25]. Replies were obtained from 48 junior high schools (school response rate: 49.0%) and 55 senior high schools (school response rate: 64.0%; total school response rate: 56.0%) and enrolled 118,303 students in the study. A total of 64,417 individuals responded. We excluded 88 questionnaires lacking gender information or with inconsistent responses. Consequently, 64,329 questionnaires were analyzed (effective response rate = 54.4%). The age range was 12–19 years (mean = 15.7±1.7 years).

Survey procedure

We sent a letter to the principals of selected schools requesting their cooperation, along with questionnaire forms and envelopes for enrolled students. In participating schools, we had class teachers inform students of the study, including its confidentiality and voluntary participation, and assure them that their privacy would be protected. There was an option to withdraw from the study or refuse to complete the questionnaire. Teachers delivered the completed questionnaires in the sealed envelopes back to our office. The survey was administered between December 2017 and February 2018.

Measures

The questionnaire assessed (1) personal data, (2) lifestyle behaviors, (3) school life, and (4) subjective happiness. Personal data included school type (junior high school or senior high school), gender, age, and school grade.

For lifestyle behaviors, we assessed frequency of having breakfast ("every day," "sometimes," or "seldom"), drinking and smoking status, subjective sleep quality ("very good,"

"good," "bad," or "very bad), and Internet usage. As for eating breakfast, respondents who selected "every day" were included in the "yes" category and those who selected "sometimes" or "never" were collapsed into the "no" category for analysis [26]. Participants were defined current smokers if they answered that they had smoked one cigarette per day or more in the past month. Similarly, we defined those who responded that they had drunk alcohol one day or more in the past month as being current drinkers [26]. For subjective sleep quality, participants who responded with "bad" or "very bad" were considered to have poor subjective sleep quality [26]. To assess Internet usage, we used the 8-item version of the Young Diagnostic Questionnaire for Internet Addiction (YDQ) [27]. Each item is rated dichotomously ("yes" or "no").

As for school life, participation in extracurricular activities ("active participation," "passive participation," or "no participation") and future direction were asked. To evaluate future plan, we used the following question. "What is your plan for your future life course?" Participants selected one of seven items: "high school," "vocational school," "college," "university," "postgraduate school," "taking a job after leaving the current school," and "not decided yet." Those who selected "university" or "postgraduate school" were grouped as students who intended to go to university; otherwise, they were grouped as students who did not intend to go to university or those who had not yet decided [26].

Subjective happiness was measured using a single item: "In general, how would you describe your happiness?" Participants responded on a visual analogue scale. Participants were instructed to (a) focus on their global estimation and general feelings, (b) take note that 0 is the minimum and 10 is the maximum, and (c) select the number that best described their feelings. This single scale has good concurrent, convergent, and divergent validity [28]. Single-item happiness measures have been used widely throughout the world [29, 30]. We defined participants with a score of 3 or less (10th percentile score) as being unhappy [31], because it is quite plausible that data on lower levels of happiness scores (that is, unhappiness) could help to identify groups or problems that are potential priorities for policy interventions. Thus, subjective unhappiness was dichotomously scored (unhappy = 1, other = 0).

Data analysis

First, we examined participants' characteristics by school type. Second, we calculated the prevalence and 95% confidence intervals (95% CI) of unhappiness by school grade. Third, we examined the prevalence of unhappiness by lifestyle behaviors and items of Young Diagnostic Questionnaire for Internet Addiction, according to gender and school type, by using the χ^2 test. Finally, we analyzed a multivariable logistic regression, calculating the adjusted odds ratios (ORs) of each factor and its 95% CI for subjective unhappiness. The covariates in the logistic regression analysis included basic demographic characteristics (gender and school grade), lifestyle behaviors (having breakfast, drinking alcohol, smoking status, sleep quality, and Internet usage), and school life (extracurricular activities and intending to study at university). To determine covariates, we referred to factors associated with happiness in previous studies [14, 15, 17, 24]; these behaviors are factors of high interest to national policies as well as teachers and parents as intervention goals. The statistical level of significance was $p<0.01$. Statistical analyses were performed with Stata 15.1.

Ethics statement

In the Ethical Guidelines for Epidemiological Studies jointly announced by the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology of Japan, personal information is defined as follows: information of a living individual,

and the name, birthday, and other descriptions included in that information that can be used to identify a specific individual. We used questionnaires devoid of all such information to prevent participant identification and to safeguard their privacy. We obtained written informed consent from all participants. Limited to junior high school students, informed consent was obtained from each child's parent or guardian. According to the Ministry of Health, Labor and Welfare's epidemiology ethical guidelines, researchers are not required to obtain parental approval in a non-invasive survey of high school students. This study was approved by the ethical review board of the Tottori University School of Medicine.

Results

Table 1 shows the participant demographics by school type. The prevalence of subjective unhappiness was 9.3% and 10.2% in junior and senior high school students, respectively. Students in junior and senior high schools who wished to go to university accounted for 61.2% and 55.5%, while 65.3% and 51.8% actively participated in extracurricular activities, respectively. Most junior and senior high school students ate breakfast daily (85.9% and 81.5%,

Table 1. Characteristics of the analyzed participants.

		Junior high school		Senior high school	
		n	%	n	%
Gender					
	Boys	11,179	50.3	23,403	55.8
	Girls	11,036	49.7	18,534	44.2
Grade					
	Grade 7 and 10	7,384	33.4	14,201	34.0
	Grade 8 and 11	7,329	33.1	14,212	34.0
	Grade 9 and 12	7,415	33.5	13,404	32.0
Subjective happiness					
	Unhappy	2,057	9.3	4,264	10.2
	Neither	7,558	34.0	16,718	39.9
	Happy	11,872	53.4	19,680	46.9
	Unknown	728	3.3	1,275	3.0
Having breakfast					
	Every day	19,079	85.9	34,183	81.5
	Sometimes	1,627	7.3	4,052	9.7
	Seldom	887	4.0	2,603	6.2
	Unknown	622	2.8	1,099	2.6
Participating in extracurricular activities					
	No	3,896	17.5	13,227	31.6
	Active	14,502	65.3	21,740	51.8
	Passive	3,103	14.0	5,796	13.8
	Unknown	714	3.2	1,174	2.8
Present smoking					
	No	21,971	98.9	40,998	97.8
	Yes	244	1.1	939	2.2
Present alcohol use					
	No	21,580	97.1	38,986	93.0
	Yes	635	2.9	2,951	7.0

(*Continued*)

Table 1. (Continued)

		Junior high school		Senior high school	
		n	%	n	%
Subjective sleep quality					
	Good	14,937	67.2	24,063	57.4
	Bad	6,559	29.5	16,633	39.7
	Unknown	719	3.3	1,241	2.9
Intending to study at university					
	Yes	13,587	61.2	23,262	55.5
	No	4,253	19.1	14,241	34.0
	Not yet decided	3,704	16.7	3,322	7.9
	Unknown	671	3.0	1,112	2.7
Internet Addiction Diagnostic Questionnaire					
	Preoccupied with the Internet	10,981	49.7	23,359	56.0
	Need to use the Internet with increasing amounts of time to achieve satisfaction	2,430	11.0	5,109	12.2
	Repeatedly made unsuccessful efforts to control, cut back, or stop Internet use	8,169	37.0	16,232	38.9
	Restless, moody, depressed, or irritable when attempting to cut down or stop Internet use	4,382	19.8	8,509	20.4
	Stay online longer than originally intended	9,196	41.6	22,999	55.1
	Jeopardized or risked the loss of significant relationship, school, educational or club activity because of the Internet	1,586	7.2	3,871	9.3
	Lied to family members, therapist, or others to conceal the extent of involvement with the Internet	3,212	14.5	6,900	16.5
	Use the Internet as a way of escaping from problems or of relieving a dysphoric mood	4,003	18.1	11,658	27.9

Internet Addiction Diagnostic Questionnaire by Young's Diagnostic Questionnaire showed that participants answered "yes".

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respectively), while 29.5% and 39.7% had poor sleep quality. About half of adolescents reported being preoccupied with the Internet and regularly stayed online longer than they originally intended.

Table 2 shows the prevalence of unhappiness by school grade. The average prevalence was 10.2%. The prevalence increased with higher grade, while has leveled off since Grade 10.

Table 2. Prevalence of subjective unhappiness by school grade.

	Total number	Prevalence of subjective unhappiness (%)	95% CI		p-value
Grade 7	7,384	9.0	8.3	9.7	0.003
Grade 8	7,329	9.5	8.9	10.2	($\chi^2(5) = 17.8$)
Grade 9	7,415	10.1	9.4	10.8	
Grade 10	14,201	10.5	10.0	11.0	
Grade 11	14,212	10.5	10.0	11.0	
Grade 12	13,404	10.5	9.9	11.0	
Total	63,945	10.2	9.9	10.4	

Participants with missing data were excluded from the analysis.

P-value was calculated with chi-square test by grade.

Unhappiness was defined as a score of 3 or less on an 11-point scale.

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Fig 1 shows the prevalence of subjective unhappiness in lifestyle behaviors and school life by each school type and gender. Among junior and high school students, factors that had significantly a higher prevalence of subjective unhappiness were having breakfast sometimes/seldom, passive participation in extracurricular activities, present smoking, present alcohol use, poor sleep quality, and not yet having decided to study at university. These variables showed no significant differences by gender among both school levels.

Tables 3 and 4 show the prevalence of subjective unhappiness in items by each school type and gender. In all YDQ items, the prevalence of unhappiness among those who answered "Yes" was higher than that among those who answered "No." In particular, items with a large difference in the prevalence of unhappiness were "Need to use the Internet with increasing amounts of time to achieve satisfaction," "Restless, moody, depressed, or irritable when attempting to cut down or stop Internet use," "Jeopardized or risked the loss of significant relationship, school, educational or club activity because of the Internet," and "Use the Internet as a way of escaping from problems or of relieving a dysphoric mood."

Table 5 shows the crude and adjusted ORs (AORs) and 95% CIs for the association between unhappiness and each of the explanatory variables. In this multivariable logistic regression model, the AUC was 0.724 and the pseudo-R squared was 0.093. The analysis revealed higher

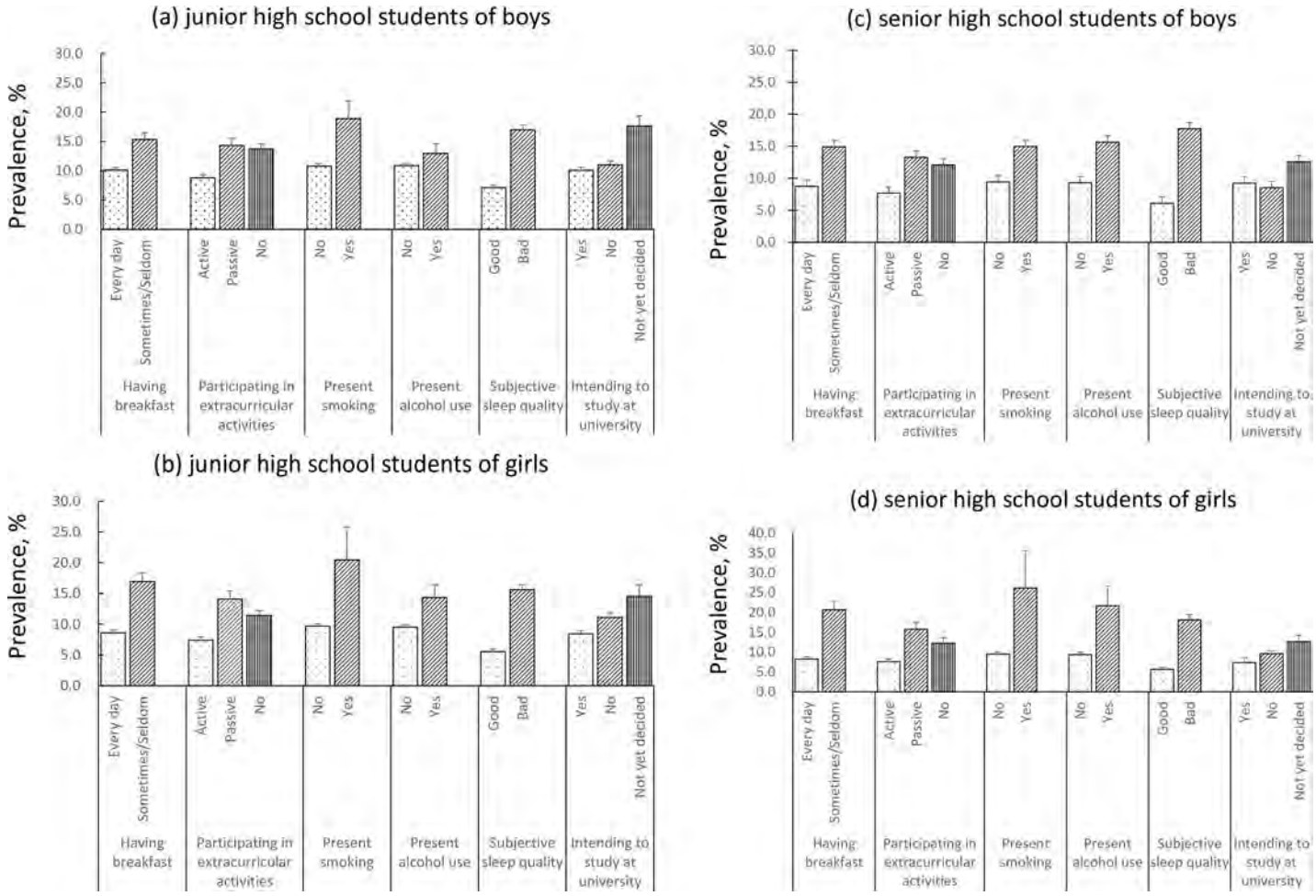

Fig 1. The prevalence of subjective unhappiness in Japanese adolescents by each life style factor. (a) junior high school students of boys (b) junior high school students of girls (c) senior high school students of boys (d) senior high school students of girls.

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Table 3. The prevalence of subjective unhappiness in junior high school students by components of internet addiction.

	Boys						Girls					
	n	%	95% CI			p-value	n	%	95% CI			p-value
Preoccupied with the Internet												
No	417	7.9	7.2	-	8.7	< 0.001	389	7.1	6.5	-	7.9	< 0.001
Yes	585	11.0	10.2	-	11.9		654	12.3	11.4	-	13.2	
Need to use the Internet with increasing amounts of time to achieve satisfaction												
No	772	8.3	7.7	-	8.8	< 0.001	800	8.2	7.6	-	8.7	< 0.001
Yes	232	18.0	16.0	-	20.3		247	23.7	21.1	-	26.4	
Repeatedly made unsuccessful efforts to control, cut back, or stop Internet use												
No	603	8.6	8.0	-	9.3	< 0.001	537	8.3	7.7	-	9.0	< 0.001
Yes	398	11.1	10.1	-	12.1		507	11.7	10.8	-	12.7	
Restless, moody, depressed, or irritable when attempting to cut down or stop Internet use												
No	665	7.7	7.1	-	8.3	< 0.001	656	7.7	7.1	-	8.2	< 0.001
Yes	336	17.2	15.6	-	19.0		393	17.2	15.7	-	18.9	
Stay online longer than originally intended												
No	530	8.2	7.5	-	8.9	< 0.001	463	7.7	7.1	-	8.4	< 0.001
Yes	471	11.4	10.5	-	12.4		579	12.1	11.2	-	13.1	
Jeopardized or risked the loss of significant relationship, school, educational or club activity because of the Internet												
No	861	8.7	8.2	-	9.3	< 0.001	887	8.9	8.3	-	9.4	< 0.001
Yes	136	19.6	16.7	-	22.7		162	19.4	16.8	-	22.2	
Have you lied to family members, therapist, or others to conceal the extent of involvement with the Internet												
No	783	8.5	7.9	-	9.1	< 0.001	763	8.4	7.8	-	9.0	< 0.001
Yes	219	15.9	14.0	-	17.9		287	16.7	15.0	-	18.5	
Use the Internet as a way of escaping from problems or of relieving a dysphoric mood												
No	667	7.3	6.8	-	7.9	< 0.001	537	6.4	5.9	-	7.0	< 0.001
Yes	334	22.9	20.7	-	25.1		508	21.1	19.4	-	22.8	

Participants with missing data were excluded from the analysis. P-values were calculated by chi-square test for all factors.

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odds of unhappiness among individuals with poor sleep quality (AOR 2.41; 95% CI 2.28–2.55); those with passive participation in extracurricular activities (AOR 1.12; 95% CI 1.04–1.22); those who used the Internet as a way of escaping from problems or of relieving a dysphoric mood (AOR 2.44; 95% CI 2.29–2.61)); those with the need to use the Internet increasingly to achieve satisfaction (AOR 1.55; 95% CI 1.43–1.67); those who were restless, moody, depressed, or irritable when attempting to cut down or stop Internet use (AOR 1.32; 95% CI 1.23–1.42); and those who had jeopardized or risked the loss of significant relationships or school, educational, or club activities because of the Internet (AOR 1.35; 95% CI 1.24–1.47). Conversely, lower odds of unhappiness were found for girls (AOR 0.80; 95% CI 0.71–0.79), individuals who ate breakfast daily (AOR 0.75; 95% CI 0.70–0.81), individuals intending to study at university (AOR 0.87; 95% CI 0.73–0.83), and, interestingly, those preoccupied with the Internet (AOR 0.88; 95% CI 0.82–0.93), those who repeatedly made unsuccessful efforts to control, cut back, or stop Internet use (AOR 0.88; 95% CI 0.83–0.94), and those who stayed online longer than originally intended (AOR 0.85; 95% CI 0.79–0.90). School grades, smoking, and drinking status were not significant related factors.

Table 4. The prevalence of subjective unhappiness in senior high school students by components of internet addiction.

	Boys						Girls					
	n	%	95% CI			p-value	n	%	95% CI			p-value
Preoccupied with the Internet												
No	979	9.6	9.0	-	10.2	< 0.001	571	7.5	7.0	-	8.2	< 0.001
Yes	1,485	12.2	11.6	-	12.8		1,212	11.5	10.9	-	12.1	
Need to use the Internet with increasing amounts of time to achieve satisfaction												
No	1,898	9.8	9.3	-	10.2	< 0.001	1,379	8.5	8.1	-	9.0	< 0.001
Yes	573	19.0	17.7	-	20.5		401	20.7	18.9	-	22.6	
Repeatedly made unsuccessful efforts to control, cut back, or stop Internet use												
No	1,495	10.1	9.6	-	10.6	< 0.001	886	8.9	8.4	-	9.5	< 0.001
Yes	977	12.9	12.1	-	13.6		894	10.9	10.2	-	11.6	
Restless, moody, depressed, or irritable when attempting to cut down or stop Internet use												
No	1,732	9.4	9.0	-	9.9	< 0.001	1,120	8.1	7.6	-	8.5	< 0.001
Yes	728	18.4	17.2	-	19.6		676	15.6	14.4	-	16.6	
Stay online longer than originally intended												
No	1,093	9.8	9.2	-	10.3	< 0.001	596	8.5	7.8	-	9.1	< 0.001
Yes	1,369	12.2	11.6	-	12.9		1,192	10.7	10.1	-	11.3	
Jeopardized or risked the loss of significant relationship, school, educational or club activity because of the Internet												
No	2,065	10.1	9.7	-	10.5	< 0.001	1,421	8.7	8.3	-	9.2	< 0.001
Yes	401	20.7	18.9	-	22.6		360	19.8	18.0	-	21.7	
Have you lied to family members, therapist, or others to conceal the extent of involvement with the Internet												
No	1,855	9.8	9.4	-	10.2	< 0.001	1,312	8.8	8.3	-	9.3	< 0.001
Yes	614	17.8	16.5	-	19.1		473	14.6	13.4	-	15.9	
Use the Internet as a way of escaping from problems or of relieving a dysphoric mood												
No	1,434	8.2	7.8	-	8.6	< 0.001	690	5.9	5.5	-	6.3	< 0.001
Yes	1,022	20.9	19.8	-	22.1		1,099	17.0	16.1	-	18.0	

Participants with missing data were excluded from the analysis. P-values were calculated by chi-square test for all factors.

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Discussion

This is the first nationally representative study to examine the association between subjective unhappiness and daily lifestyle factors such as having breakfast, extracurricular activity, sleep, and Internet usage in Japanese adolescents. The results demonstrated that unhappiness was significantly positively associated with passive participation or lack of participation in extracurricular activities, poor sleep quality, and some aspects of problematic Internet usage. On the other hand, unhappiness was significantly negatively associated with being a girl, eating breakfast daily, intending to study at university, and a few problematic Internet usage patterns. The results were nearly identical with previous research in other countries and confirmed our hypothesis except the lack of effects on class grades. These findings provide important evidence on the ways that lifestyle interventions could improve overall happiness in adolescents in Japan.

We found that there were unhappier boys than girls in Japan. Gender differences in subjective happiness and well-being have been reported in both Western and Asian countries [14]. Male Chinese adolescents had 1.05-fold greater odds of being unhappy than did their female counterparts [13]. This difference might be attributed to women having higher resilience than men [32]. However, an Australian study reported that no gender differences in subjective well-

Table 5. Logistic regression results: Variables associating unhappiness in Japanese adolescents.

	N	Crude OR	95%CI		p-value	AOR	p-value		
Gender									
Boys	32,119	1.00				1.00			
Girls	28,276	0.92	0.87	0.97	0.002	0.80	0.76	0.85	<0.001
Grade									
Grade 7	6,814	1.00							
Grade 8	6,893	1.07	0.95	1.19	0.267	0.98	0.87	1.11	0.801
Grade 9	6,997	1.14	1.02	1.27	0.023	0.97	0.86	1.09	0.612
Grade 10	13,496	1.18	1.07	1.30	0.001	0.95	0.86	1.06	0.393
Grade 11	13,458	1.18	1.07	1.30	0.001	0.92	0.83	1.03	0.140
Grade 12	12,737	1.18	1.07	1.31	0.001	0.90	0.81	1.01	0.081
Having breakfast									
Sometimes/seldom	8,808	1.00				1.00			
Everyday	51,587	0.51	0.48	0.54	<0.001	0.75	0.70	0.81	<0.001
Participating in extracurricular activities									
No	17,036	1.00				1.00			
Active	36,061	0.61	0.57	0.64	<0.001	0.76	0.71	0.81	<0.001
Passive	8,862	1.20	1.12	1.29	<0.001	1.12	1.04	1.22	0.005
Present smoking									
No	59,366	1.00				1.00			
Yes	1,029	2.15	1.85	2.51	<0.001	1.21	1.01	1.46	0.038
Present drinking									
No	57,120	1.00				1.00			
Yes	3,275	1.52	1.38	1.68	<0.001	0.99	0.88	1.11	0.890
Subjective sleep quality									
good	37,831	1.00				1.00			
bad	22,564	3.05	2.89	3.22	<0.001	2.41	2.28	2.55	<0.001
Intending to study at university									
No	27,647	1.00				1.00			
Yes	27,452	0.90	0.85	0.95	<0.001	0.87	0.82	0.93	<0.001
Not yet decided	6,967	1.49	1.38	1.61	<0.001	1.30	1.19	1.41	<0.001
Internet Addiction Diagnostic Questionnaire									
Preoccupied with the Internet	34,340	1.01	0.94	1.07	0.881	0.88	0.82	0.93	<0.001
Need to use the Internet with increasing amounts of time to achieve satisfaction	7,539	1.01	0.95	1.08	0.746	1.55	1.43	1.67	<0.001
Repeatedly made unsuccessful efforts to control, cut back, or stop Internet use	24,401	0.75	0.70	0.81	<0.001	0.88	0.83	0.94	<0.001
Restless, moody, depressed, or irritable when attempting to cut down or stop Internet use	12,891	1.65	1.52	1.78	<0.001	1.32	1.23	1.42	<0.001
Stay online longer than originally intended	32,195	1.08	1.02	1.15	0.013	0.85	0.79	0.90	<0.001
Jeopardized or risked the loss of significant relationship, school, educational or club activity because of the Internet	5,457	1.22	1.15	1.29	<0.001	1.35	1.24	1.47	<0.001
Lied to family members, therapist, or others to conceal the extent of involvement with the Internet	10,112	0.95	0.89	1.02	0.185	1.06	0.98	1.14	0.119
Use the Internet as a way of escaping from problems or of relieving a dysphoric mood	15,661	1.50	1.38	1.63	<0.001	2.44	2.29	2.61	<0.001

Abbreviations: AOR = adjusted odds ratio, CI = confidence interval.

Unhappiness: Students who selected from 0 to 3 point scales about happiness.

Participants for whom data were missing were excluded from the analyses.

All the items included in this table were input as covariates in this multivariable logistic model.

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being were found among high school students [33]. Our present study has unequal ratios between male and female samples and should be standardized in future studies. Thus, the gender difference in adolescent happiness remains unclear. Adolescence is a period of profound change (e.g., hormonal balance, cultural and social influences), which future studies should examine. Liu also reported that, as boys get older, their happiness falls significantly; girls, however, are unaffected [34], which coincides with our findings. No prior studies were available to investigate whether this difference lasts into adulthood. Longitudinal research is needed to examine changes in subjective happiness over time in males and females.

Our raw data showed that students' grade in school was associated with unhappiness. However, our multivariate logistic regression analysis found no association between grade level and unhappiness. Research on adolescents in China [13], Chile [14], and Europe/North America [35] reported that the risk of unhappiness increased with age. Thus, we predicted that as students move up in grade, their proneness to unhappiness would increase (due to the added burden of cram schools, after-school activities, longer commuting hours, and less free time). One reason for the discrepancy in our results could be that some of the explanatory variables were confounders between class grades. A second reason may be related to the Japanese education system, which has students prepare for academic entrance exams in grades 9 and 12. Thus, students are under constant academic pressure. Furthermore, even when the academic pressure lessens, students engage in extracurricular activities; thus, they have little free time regardless.

Not eating breakfast regularly was associated with an increased risk of unhappiness. A cross-sectional study of Chilean university students similarly revealed that happiness was positively associated with regularly eating breakfast [14]. Possibly, breakfast consumption helps maintain normal weight status in adolescents [36]. Given that obesity has a negative effect on subjective happiness [37], eating breakfast might be related to subjective happiness via weight management.

Surprisingly, a passive attitude toward extracurricular activities had a stronger correlation with unhappiness than did no participation at all. Extracurricular activities often involve interaction with individuals with similar objectives and interests [38]. Students with passive attitudes might be unable to commit to these objectives and interests, thus making them feel more isolated within a group. Most Japanese junior and senior high school students are obligated to participate in extracurricular activities. They are often extremely busy with extracurricular activities, which typically occur from early morning until late at night, and frequently on weekends. Therefore, students are unlikely to feel happy if they are not interested in these activities. Given this result, educators need to change the way students participate in extracurricular activities.

The hope to study at university in the future was associated with a decreased risk of unhappiness. We might attribute to this to the fact that individuals who advance to university-level education set goals for themselves, achieve relatively good grades [39], or have a positive home environment [11], all of which may make them more unlikely to become unhappy.

These two factors (participation in extracurricular activities and intend to study at university) seem to be related to freedom of choice. Those who are passively participating are supposed to escape from their activities. However, they are considered to be in a situation where they are forced to participate because they are bound by the relationships between their neighbors and the rules of the school. Therefore, students who participate passively in extracurricular activities have a higher odds ratio of unhappiness than students who do not participate. In addition, it can be seen that the reason for not intending to study at university is that the options for the future are narrowed, such as having to work due to economic circumstances or having no interest in study. Just as discretion is one of the key work engagement factors for

workers [40], freedom of choice may be a related factor of happiness. Future research requires a longitudinal study of how self-determination is related to happiness.

Interestingly enough, the multivariable logistic regression results showed there were no statistical associations of drinking alcohol and smoking with unhappiness. Both negative correlations between smoking and happiness [13, 41] and no correlation [14, 42] have been found in previous longitudinal studies. Thus, we cannot conclude definitively whether a correlation exists or not. Similarly, there are no consistent findings on the correlation between drinking alcohol and happiness [13, 14, 42]. A notable difference between this study and past ones is that the prevalence of smoking and drinking among Japanese junior and senior high school students is decreasing [43, 44]; currently, these prevalence rates are extremely low, and the population of drinkers was not stratified in this study. Furthermore, in Japan, it is illegal for people below 20 years of age to smoke and drink alcohol; therefore, students often refuse to respond to questions on smoking and drinking.

In particular, poor sleep quality was associated with higher risk for unhappiness. A longitudinal study of adults found a J-shaped relationship between happiness and sleep duration [45], indicating that subjective unhappiness decreased with sleep duration. This finding suggested that getting enough sleep was associated with increased happiness. However, few studies have examined the correlation between sleep and happiness among adolescents. Roberts et al. reported that those with insomnia have 3.27-fold higher odds of identifying themselves as unhappy compared to those who do not have insomnia [46]. In contrast, a cross-sectional study of 750 Americans aged 14–15 years revealed that happiness had a significant correlation with daily activities such as studying, communicating with friends on screens, and spending time with family, but not with sleep deprivation [47]. Further research on the relationship between sleeping disorders and happiness is required.

In line with previous research [15–17], we thought that all Internet-dependent items would be positively related factors of unhappiness in adolescence. Surprisingly, our findings showed that a few components of Internet addiction were negatively correlated with unhappiness. These results may suggest that the Internet brings both happiness and unhappiness to adolescents. Similarly, a European pooled cross-sectional dataset showed that Internet usage has been found to correlate positively with well-being [48]. A study of Chinese adolescents revealed that excessive Internet usage provides temporary enjoyment, but ultimately suppresses long-term well-being [17]. A nationally representative yearly survey in the United States showed that American adolescents found that limiting time spent in electronic communication is associated with the greatest happiness levels [49].

Our data did show, however, that the destruction of relationships through Internet use was associated with unhappiness. SNSs like Facebook can generate negative feelings (e.g., jealousy) [50]; constant access to friends' profiles provides people with more in-depth information on others than ever before, but it may cause jealousy and decrease subjective happiness if individuals see friends interacting with ideal figures or role models. Our data also showed that Internet use for the purpose of escape and feeling anxious or depressed by using Internet were associated with unhappiness. Indeed, subjective happiness might be reduced by social isolation, as real relationships become diluted through prolonged Internet use. Adolescents are prone to problematic Internet usage because of their underdeveloped emotional regulation and self-control [51]. Internet addiction does not help adolescents establish interpersonal relationships in the real world. Therefore, given that we live in an Internet-connected world, schools and families need to instruct students on methods of proper Internet usage to maintain adolescents' happiness.

This study has several limitations. First, because this was a cross-sectional study, we cannot determine the causal relationships for each factor, or how these might change over time. Thus,

future studies should use a longitudinal design. Second, we could not collect data from students who were absent from school on the survey day as well as school dropouts. The prevalence of unhappiness might be even higher among absentees and dropouts when compared to those in attendance on the day of the study. Similarly, the data of the explanatory variables might have been affected by the exclusion of these individuals. Third, no data were obtained on participants' weight or socioeconomic factors, such as family income or parents' educational levels. Some studies have highlighted the importance of socioeconomic status for subjective happiness [52], whereas others have found no relation between social class and subjective happiness [53]. Thus, future research should include socioeconomic factors. Fourth, the response rate in this study was 56.0%; thus, approximately 44% of the students did not participate. There may be two reasons for the non-responsiveness. The first reason is that people below 20 years old in Japan are prohibited by law from smoking and drinking alcohol. Therefore, schools and students tend to be non-cooperative in responding to a survey that includes questions on smoking and drinking alcohol. The second reason is the epidemiological survey in Japan required the consent of parents in junior high school students, which can be difficult to obtain. Finally, in this study the effect size, an essential component when evaluating the strength of a statistical claim, was rather small. However, a small effect size can be of great practical value. This is especially true if a treatment is relatively cheap, easy to perform, politically viable, and can be used on a large scale, thereby affecting a large number of individuals [54]. In addition to that practical value, this study had three main strengths: 1) it is a nationwide survey; 2) it has an extremely large sample; and 3) it has a survey response rate over 50%, which was high for this type of epidemiological study. These strengths provide increased credibility in our results by minimizing the impact of potential random errors from self-reporting, especially among adolescents.

Conclusions

This large-scale Japanese adolescent study showed that unhappiness was strongly associated with being male, engaging in unhealthy lifestyle behaviors (e.g., not having breakfast, poor sleep quality), and worrisome Internet usage patterns. Given that our study showed that passive participants in extracurricular activities were less happy, education officials should consider whether to require such activities. Teachers and parents should emphasize the importance of sleep and ensure that adolescents are able to get the sleep they need. Further, schools and families should instruct students in how to use the Internet and provide limits to Internet use. Our findings can help inform future government policies and help teachers and parents promote good quality of life among adolescents.

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RESEARCH ARTICLE Open Access

Changes in smoking behavior among victims after the great East Japan earthquake and tsunami

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Abstract

Background: In areas affected by the tsunami of the great East Japan Earthquake, smoking behavior may have deteriorated due to high stress and drastic changes in living environment. Surveys were conducted to reveal changes in smoking behaviors among victims.

Methods: A population-based random-sample home-visit interview survey of victims in Iwate and Miyagi Prefectures affected by the tsunami disaster was conducted in 2012 (n = 1978), while a population-based nationwide survey was conducted in 2013 (n = 1082). A panel survey in 2014 was conducted with respondents of the 2012 survey (n = 930). Multiple logistic regression analysis was performed to reveal factors related to smoking status after the disaster.

Results: There was high smoking prevalence of both sexes in the tsunami disaster area (current smoking rate in coastal area, 50.0% for male, 21.4% for female; inland area, 34.7% for male, 7.6% for female). Low prevalence of male quitters was observed (quitter rate in coastal area, 20.8% for male, 8.0% for female; inland area, 23.4% for male, 5.5% for female). The prevalence of nicotine-dependent people assessed by FTND (Fagerström Test for Nicotine Dependence) in the coastal area was also higher than in the inland area or other areas of Japan. Smoking behavior among victims worsened after the disaster and did not improve 3 years from the disaster. Post-disaster factors related to smoking were living in coastal area, complete destruction of house, and living in temporary housing.

Conclusions: Smoking prevalence and the level of nicotine dependence of tsunami victims were still high even 3 years after the disaster. It is important to emphasize measures for smoking control in the disaster areas for an extended time period.

Keywords: Natural disaster, Smoking, Tsunami, Nicotine dependence, Great East Japan earthquake

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Introduction

The great East Japan Earthquake was a magnitude 9.0–9.1 (Mw) undersea megathrust earthquake off the coast of Japan that occurred on March 11, 2011. It was the most powerful earthquake ever recorded in Japan. The earthquake triggered powerful tsunami waves that may have reached heights of up to 40.5 m (133 ft), and which, in the Sendai area, traveled up to 10 km inland. The tsunami swept the Japanese mainland and killed many people, mainly through drowning, though blunt trauma also caused many deaths. The latest report from the Japanese National Police Agency confirmed 15,897 deaths, 6157 injured cases, and 2533 missing cases across twenty prefectures (as of March 8, 2019) [1], and the number of refugees was approximately 347 thousand at its peak in 2012. A 2019 report indicated that approximately 52,000 people were still living away from their homes in temporary housing [2]. The National Police Agency report listed 121,990 buildings as "totally collapsed," with a further 282,900 buildings "half collapsed" and another 730,044 buildings "partially damaged" [1]. The earthquake and tsunami also caused extensive, severe infrastructural damage in north-eastern Japan. In the 65 years since the end of World War II, this has been the toughest crisis faced by Japan.

In the disaster area, many people were forced to live long term as evacuees in environments different from those of conventional life, such as temporary housing or rental houses. How health-related lifestyle changed after the disaster is important to understand in order to protect the health of the victims. Some reports have indicated that the smoking behavior of victims has changed after natural and human-made disasters: the September 11, 2001, attacks [3–5]; Hurricane Katrina, in 2005 [6, 7]; bushfires around Canberra, in 2003 [8]; and the Enschede fireworks disaster in the Netherlands, in 2000 [9]. However, there are few reports about smoking behavior after an earthquake or tsunami. Some articles on smoking behavior after a New Zealand earthquake have been published [10], and one article reported decreased smoking prevalence among victims in Fukushima Prefecture after the great East Japan Earthquake [11]. However, no article describing smoking behavior among victims in tsunami-damaged parts of Miyagi and Iwate Prefectures has been found. We conducted a survey to identify changes in smoking behavior of victims after the disaster in Miyagi and Iwate Prefectures. The current study hypothesis was that the smoking status of people in the tsunami-damaged area had worsened after the disaster and that had improved subsequently. The study provides findings that stress the importance of improvising measures for smoking control in disaster areas in the long term to reduce future health hazard.

Materials and methods

A population-based random-sample home-visit interview survey of victims in Iwate and Miyagi Prefectures affected by the tsunami disaster was conducted in 2012 (n = 1978). In order to compare with the results of the 2012 survey, we conducted a nationwide survey in 2013 except for the three affected prefectures using the same questionnaire (n = 1082). A panel survey in 2014 was conducted with respondents of the 2012 survey (n = 930). The outline of this study was shown in Fig. 1.

Participants

Participants of the present survey were survivors living in the disaster area. This study includes an interview survey conducted in the disaster area in 2012, a panel survey in the disaster area 2 years later and a nationwide survey excluding the disaster area in 2013. The survey in the tsunami disaster area was conducted in the Iwate and Miyagi Prefectures. Fukushima Prefecture was excluded from the survey area, because conducting home visits to administer the interview survey was still difficult at that time, and many people were still living as refugees, distant from their registered addresses. A municipality that had a coastline at the boundary was defined as a coastal area. A municipality that did not have a coastline at the boundary was defined as an inland area. Sendai City of Miyagi Prefecture, which has a large population, defined a ward with coastline at the boundary as a coastal area and a ward without the coastline as an inland area.

Procedures

We randomly selected 1800 people from the coastal area and 1800 people from the inland area in the Iwate and Miyagi Prefectures using the resident resisters of local municipalities. Trained investigators requested them for their cooperation and visited participants who had consented to an interview. We entrusted a survey company called the Shin Joho Center to carry out the sample selections and home visit interview surveys. The survey company requested the sampling of residents to the municipalities, and the investigators visited municipal offices and randomly selected residents from the Basic Resident Register. Investigators were 49 well-trained employees of the survey company living in Miyagi and Iwate Prefectures.

The number of respondents was 1006 for the coastal area (56% of response rate and 58% of actual response rate excluded by moving, address unknown, and long-time absent) and 972 for the inland area (54% of response rate, 59% of actual response rate). The survey period was November to December 2012.

We then conducted a national survey on smoking behavior to compare with the findings from the disaster area; hence, the national survey excluded the three

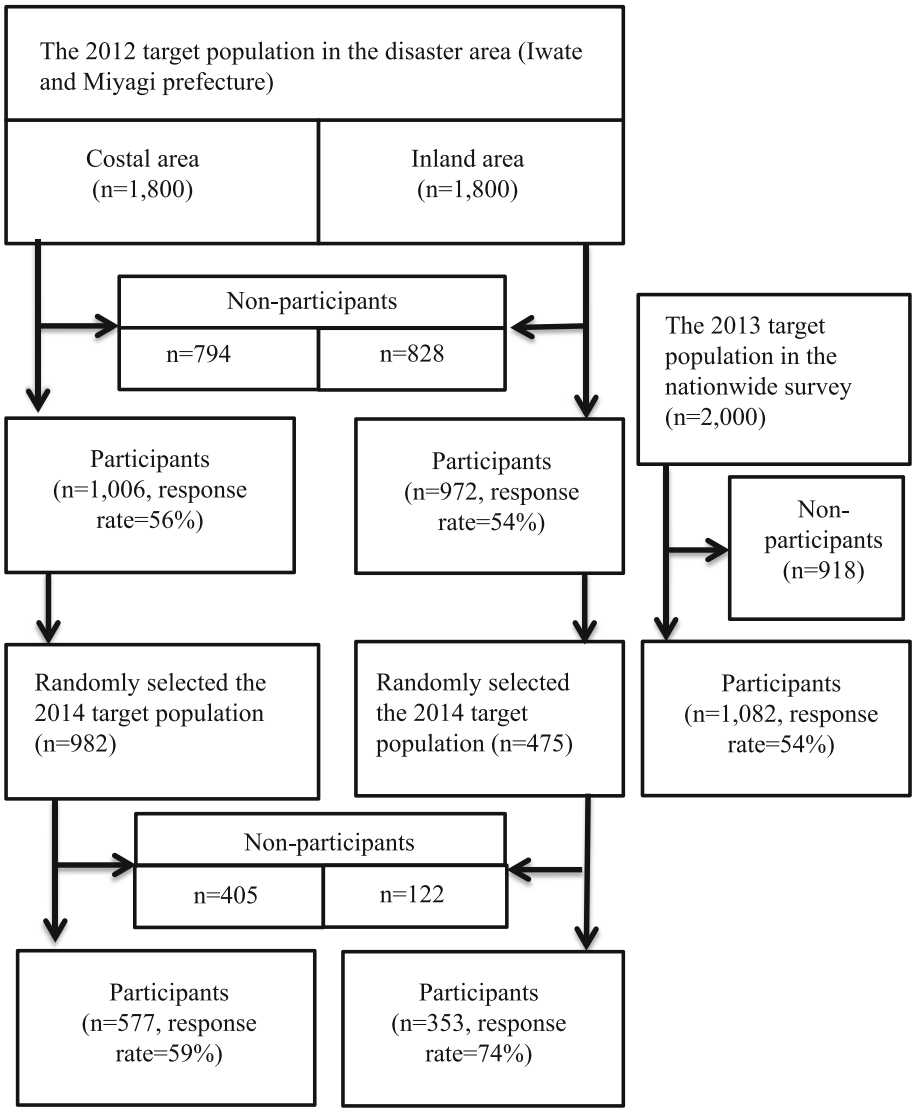

Fig. 1 Flow chart for this survey

disaster-hit prefectures (Iwate, Miyagi, and Fukushima). We randomly selected 2000 people by two-stage random sampling based on the points and the resident registers. We obtained answers from 1082 people (54% of response rate, 59% of real response rate; including one incomplete questionnaire). The survey period was from November to December 2013. The content of the questionnaire was similar to that of the 2012 survey conducted in the disaster area. The 2014 survey was conducted with the respondents of the 2012 survey, though funding limitations meant only half as many participants in the inland area could be interviewed. Thus, 982 people from the coastal area and 475 people from the inland area (total of 1457) were asked to take the second survey, and 577 (59% of response rate) and 353 people (74% of response rate) agreed to do so (a total of 930 respondents). The survey period was from November to December 2014. Many respondents who were registered in the coastal area in the 2012 survey could not be contacted in 2014 survey: 199 people had moved to unknown places; 40 people were absent for a long time, and the addresses of 19 people were not exist out of 982 coastal samples. The actual response rate for the coastal area was 80%, similar to the 84% for the inland area.

Measures

The survey covered current smoking status, nicotine dependence (FTND, Fagerström Test for Nicotine Dependence; TDS, Tobacco Dependence Screener) [12, 13], damage or challenges due to the situation during and after the tsunami and earthquake, and sociodemographic factors. Smoking status was classified into three groups

(current smoker, ex-smoker, never smoker) according to the two questions: "Have you ever smoked a conventional cigarette more than 100?," and "Did you every day or sometimes smoke cigarettes for this one month?"

FTND scale contains six items that evaluate the quantity of cigarette consumption, the compulsion to use, and dependence. Questionnaires are as follows. (1) How soon after you wake up do you smoke your first cigarette? (2) Do you find it difficult to refrain from smoking in places where it is forbidden? (3) Which cigarette would you hate most to give up? (the first one in the morning or any other cigarette), (4) How many cigarettes per day do you smoke? (5) Do you smoke more frequently during the first hours after waking than during the rest of the day? (6) Do you smoke when you are so ill that you are in bed most of the day? For scoring of FTND, yes/no items are scored from 0 to 1, and multiple-choice items are scored from 0 to 3. The items are summed to yield a total score of 0–10. The higher the total score, the more intense is the patient's physical dependence on nicotine.

The indexes used for the analyses were the mean of FTND, the proportion of persons with moderate or severe nicotine dependence (scores higher four points) as per FTND, the proportion of persons with severe nicotine dependence (more than seven points) as per FTND, the mean of TDS, and the proportion of person with nicotine dependence as per TDS (more than five points). Exacerbation of the smoking status in the panel survey is that never smokers or ex-smokers become current smokers, and improvement of the smoking status is that current smokers become ex-smokers. AUDIT (Alcohol Use Disorders Identification Test) was used as a screening test for alcoholism [14]. It is said that the cut-off point of AUDIT varies from country to country, and studies conducted in Japan have used more than 12 points for problem drinking and more than 15 points for alcohol dependence [15].

Data analysis

For statistical testing for means, the *t* test was used for the analysis, and the paired *t* test for the comparison of 2012 with 2014 results. For statistical testing for proportions, the chi-squared test was used to test the difference in proportion of 2012 and 2014. When the expectation numbers for chi-squared test are small, we used a Fisher's exact test. We conducted multiple logistic regression analysis using the variable increase method by the likelihood ratio. We conducted multivariable analysis with smoking status or dependence status as a dependent variable. The dependent variable was current smoking in 2012 or 2014, and independent variables were coast area/inland area, sex, age, years of education, marriage status, employment status, and damage due to the disaster (as of 2012 or 2014). Because the association between candidate factors was strong especially for damage due to the disaster, the statistical analysis to examine each factor was repeated using a statistical model including sex, age, and each candidate factor. We analyzed data with personal information removed, using SPSS Ver. 24 (IBM SPSS, Chicago, IL, USA).

Results

The current smoking rate in the coastal area affected by both the earthquake and the tsunami was 50.0% for male and 21.4% for female participants in 2012, higher than in the inland area affected by the earthquake only (34.7% for male and 7.6% for female). Smoking prevalence in the coastal area was higher than that in the nationwide survey in 2013 (31.2% for male and 10.6% for female) (Table 1).

The proportion of quitters in the coastal area in 2012 was 20.8% for male and 8.0% for female, whereas that in the inland area was 23.4% for male and 5.5% for female. These figures in coastal area were statistically similar to those in the inland area, and the figure for males in coastal area was statistically lower than the figure from a nationwide survey in 2013 (30.5% for male and 7.7% for female).

The prevalence of people with nicotine dependence in the coastal area in 2012 according to the FTND test was 8.7% for severely dependent males and 29.4% for moderately dependent males and 2.8% for severely dependent

Table 1 Smoking status by area (disaster are in 2012, all Japan in 2013)

age group	Coastal area (Iwate and Miyagi; n=1,006)				Inland area (Iwate and Miyagi; n=972)				All Japan (n=1081)			
	male (n=436)		female (n=570)		male (n=426)		female (n=546)		male (n=493)		female (n=588)	
	current smoker (%)	quitter (%)	current (%)	quitter (%)	current (%)	quitter (%)	current(%)	quitter (%)	current (%)	quitter (%)	current (%)	quitter (%)
20–29	47.1	11.8	34.5	13.8	37.5	6.3	12.0	10.0	25.6	0.0	17.2	4.7
30–39	60.0	8.0	34.5	15.5	44.4	20.4	18.5	6.2	39.2	21.6	9.7	15.1
40–49	64.2	15.1	25.6	11.0	41.1	21.4	8.6	5.7	41.3	22.7	14.8	11.1
50–59	51.6	25.8	33.3	5.6	46.9	20.3	4.9	6.8	40.9	35.2	11.5	6.7
60–69	47.2	22.8	12.8	1.6	27.0	33.3	5.8	4.8	27.5	40.4	4.1	9.8
70–79	32.4	35.1	3.8	3.2	11.4	39.2	1.1	4.4	17.9	53.6	7.6	2.5
80 and over	26.8	46.3	2.1	6.3	20.0	23.3	0.0	0.0	4.2	58.3	11.1	0.0
crude rate	45.0	26.4	17.2	6.3	31.5	26.5	7.1	5.5	30.8	33.9	10.4	8.5
adjusted rate	50.0	20.8	21.4	8.0	34.7	23.4	7.6	5.5	31.2	30.5	10.6	7.7
95% CI	(49.2–50.9)	(20.3–21.3)	(21.0–21.9)	(7.8–8.3)	(34.0–35.3)	(23.0–23.9)	(7.3–7.8)	(5.3–5.7)	(30.7–31.7)	(30.0–30.9)	(10.3–10.9)	(7.5–7.9)
testing (vs. Japan)	p<0.01	p<0.01	p<0.01	p=0.34	p=0.55	p<0.01	p=0.14	p=0.11				
testing (vs. inland)	p<0.01	p=0.40	p<0.01	p=0.27								

Adjusted rate was calculated using the 2012 national population. *CI* confidence interval

females and 11.0% for moderately dependent females, whereas that in the inland area was 4.4% and 16.1% for males and 0.6% and 3.9% for females. The figures in the coastal area were statistically higher than those in the inland area (Table 2); they were also significantly higher than those from the nationwide survey in 2013 (2.6% and 15.3% for males, and 0.3% and 3.4% for females).

When we calculate change in smoking status between 2012 and 2014 among respondents to both surveys, respective rates of no change, improvement, and aggravation were 88.8%, 3.0%, and 8.2% for coastal males and 94.5%, 2.3%, and 3.2% for coastal females, while they were 96.2%, 1.3%, and 2.5% for inland males and 97.4%, 2.0%, and 0.5% for inland females. There were fewer persons with no change of smoking status in the coastal area compared with the inland area, and the rate of aggravation tended to be higher in coastal areas than in inland areas (Table 3).

When we calculate change in nicotine dependence between 2012 and 2014 in the disaster area, we see no change, improvement, and aggravation at 84.7%, 9.4%, and 5.8% respectively for coastal males and 94.3%, 3.3%, and 2.4% for coastal females, whereas those figures are 84.8%, 5.7%, and 9.6% for inland males and 98.5%, 1.0%, and 0.5% for inland females. The rate of aggravation thus tended to be higher in coastal females and inland males (Table 4).

We applied multivariable analysis to examine factors associated with smoking behavior. In a statistical model explaining smoking status in 2012 (with covariates as of 2012), statistically significant risk factors for current smoking in 2012 were living in coastal area, divorce, under 9 years of education, unemployment, complete destruction of house, living in temporary housing, problem drinking (AUDIT score 12 points and over), and pathological gambling; a protective factor was professional agriculture, forestry, or fishery engagement (Table 5). The results of the multivariate analysis, which took into account the model fitness, showed that the complete destruction of houses was a significant risk factor.

In the statistical model explaining smoking status in 2014 (with covariates as of 2014), significant risk factors for current smoking were coastal area, divorce, temporary housing, and prescribed drug dependence, while a protective factor was complete destruction of house. The results of the multivariate analysis, which took into account the model fitness, showed that the coastal area, divorce, complete destruction of houses, and temporary housing were significant risk factors.

In the statistical model to explain smoking status in 2014 with covariates as of 2012, the statistically significant risk factors were coastal area, divorce, under 9 years of education, complete destruction of house, temporary housing, and problem drinking (AUDIT score 15 points and over). In the statistical model explaining aggravation of smoking status in 2014 with covariates in 2012, the no statistically significant factors were found. However, the factors costal area, divorce, losing job by the disaster, complete destruction of house, temporary housing, and loss of family member tended to be risk factors for worsening smoking status. The results of multivariate analysis with the dependent variable replaced by nicotine dependence assessed by FTND or TDS were similar to these results (supplement tables).

Discussion

This study has revealed the high smoking rate among both sexes in the tsunami disaster area after the great East Japan Earthquake and the low prevalence of male quitters in the area. The prevalence of nicotine-dependent people in the area was also higher than in the inland area or in other areas of Japan. The differences in prevalence were quite large. The high smoking rate and the rate of nicotine dependence in the coastal disaster area might have already been present in this area—coastal Tohoku region. Because there were no data before the earthquake disaster, we divided data from the nationwide survey in 2013 into respondents who lived under non-coastal and coastal local governments and compared the prevalence of smoking and nicotine dependence. There was no statistically significant difference in prevalence between these two areas. This

Table 2 Nicotine dependence status by area (disaster area in 2012, all Japan in 2013)

age group	Coastal area (Iwate and Miyagi, n=973)				Inland area (Iwate and Miyagi, n=944)				All Japan (n=1055)			
	male (n=420)		female (n=553)		male (n=409)		female (n=535)		male (n=477)		female (n=578)	
	severe (%)	moderate (%)	severe (%)	moderate (%)	severe (%)	moderate (%)	severe (%)	moderate (%)	severe (%)	moderate (%)	severe (%)	moderate (%)
20–29	11.8	29.4	3.8	19.2	3.3	23.3	0.0	8.2	0.0	11.1	0.0	7.9
30–39	13.0	30.4	0.0	17.9	9.3	18.5	2.5	7.6	2.7	21.9	0.0	1.1
40–49	6.0	38.0	6.2	8.6	5.6	20.4	0.0	7.2	4.1	16.2	0.9	1.9
50–59	8.6	34.5	8.5	15.5	4.8	19.0	0.0	0.0	3.5	23.5	0.0	3.9
60–69	9.6	26.4	0.8	8.3	2.8	14.0	1.0	3.0	4.6	13.8	0.8	3.3
70–79	4.7	21.5	0.0	2.6	1.4	4.1	0.0	0.0	0.0	8.9	0.0	1.3
80 and over	2.5	12.5	0.0	4.3	0.0	3.7	0.0	0.0	0.0	0.0	0.0	5.9
crude rate	7.4	26.7	2.4	8.9	3.9	14.4	0.6	3.4	2.7	15.5	0.3	3.1
adjusted rate	8.7	29.4	2.8	11.0	4.4	16.1	0.6	3.9	2.6	15.3	0.3	3.4
95% CI	(8.3–9.1)	(28.7–30.0)	(2.7–3.0)	(10.7–11.3)	(4.2–4.7)	(15.7–16.5)	(0.5–0.6)	(3.7–4.0)	(2.4–2.7)	(15.0–15.7)	(0.3–0.3)	(3.2–3.6)
testing (vs. Japan)	p<0.01	p<0.01	p<0.01	p<0.01	p=0.24	p=0.99	p=0.52	p=0.55				
testing (vs. inland)	p=0.01	p<0.01	p=0.01	p<0.01								

Adjusted rate was calculated by using 2012 national population. Nicotine dependence status was assessed by FTND. *CI* confidence interval. Severe ≥ 7 points, moderate = 4–6 points

Table 3 Change of smoking status from 2012 to 2014 (panel survey in disaster areas)

	Coastal area (Iwate and Miyagi; n=577)				Inland area (Iwate and Miyagi; n=353)			
	male (n=232)		female (n=345)		male (n=157)		female (n=196)	
	number	%	number	%	number	%	number	%
Smoke → Smoke	78	33.6	44	12.8	49	31.2	11	5.6
NS, Quit → NS, Quit	128	55.2	282	81.7	102	65.0	180	91.8
Improvement	7	3.0	8	2.3	2	1.3	4	2.0
testing (vs inland)		p=0.32		p=1.00				
Exacerbation	19	8.2	11	3.2	4	2.5	1	0.5
testing (vs inland)		p=0.03		p=0.06				

NS non-smoker

suggests that the prevalence of smoking and nicotine dependence in the coastal area was elevated after the tsunami disaster and had not improved 3 years after the disaster. This health-related behavior may create and exacerbate future health problems in the disaster area.

Several articles on smoking behavior after disasters have been published. Smoking behavior before and after the 9/11 terrorist attacks was studied through a telephone survey, which found a higher smoking rate after the attacks [3]. In addition, low smoking cessation rate was reported among affected residents [4], rescue workers, and police officers with PTSD after the attacks [5]. It has been reported that high smoking rates and worsening of smoking status among residents are strongly related to posttraumatic stress disorder (PTSD) and major depression [16, 17].

High smoking prevalence among victims of Hurricane Katrina was also reported [6, 7]. A study on victims of Hurricane Katrina reported that PTSD and depressive symptoms are associated with smoking relapse [18]. There is a report that psychological distress after the disaster is not associated with worsening smoking behavior (increase of daily cigarette intake and nicotine dependence) [19]. In addition, the cigarette consumption was reported to increase after the Australian bushfires [8], while a follow-up study of the victims of the fireworks disaster reported that smoking became a predictor of mental disorder [20].

Previous articles related to change in smoking behaviors after an earthquake in New Zealand have been published; elevated smoking prevalence and nicotine dependence also were reported [10]. One article also claimed that there was a relationship between smoking behavior and PTSD (posttraumatic stress disorder) symptoms among Swiss victims of the Indian Ocean tsunami of 2004 [21]. As described above, there are many reports that the smoking prevalence and nicotine dependence of victims increases after natural disasters.

There are few articles reporting smoking behavior among victims by the tsunami after the great East Japan Earthquake. According to a report from Fukushima, few people started smoking after the disaster; the smoking rate was not high among victims in 2012 compared with smoking rate among the general population, and smoking rate decreased after the disaster [11]. A longitudinal study of elderly people in Iwate Prefecture from 2012 to 2015 found that smoking prevalence was higher among people with complete destroyed houses and that continued decreasing from 2011 through 2014 and increased in 2015 [22].

Although the Fukushima study was conducted on a large-scale, the response rate was low (41%); moreover, the study was cross-sectional rather than longitudinal. The Iwate study was limited to the elderly. The strengths of the present study are that it included the coastal, tsunami-hit area; participants were randomly sampled

Table 4 Change of nicotine dependence status from 2012 to 2014 (panel survey in disaster areas)

	Coastal area (Iwate and Miyagi; n=556)				Inland area (Iwate and Miyagi; n=348)			
	male (n=223)		female (n=333)		male (n=157)		female (n=191)	
	number	%	number	%	number	%	number	%
Low → Low	141	63.2	291	87.4	118	75.2	181	94.8
Moderate+ → Moderate+	48	21.5	23	6.9	15	9.6	7	3.7
Improvement	21	9.4	11	3.3	9	5.7	2	1.0
testing (vs inland)		p=0.32		p=1.00				
Exacerbation	13	5.8	8	2.4	15	9.6	1	0.5
testing (vs inland)		p=0.03		p=0.06				

NS non-smoker, *Moderate+* moderate or severe

Table 5 Factors associated with smoking status in 2012, 2014, and change of the status from 2012 to 2014

dependent variable	smokers in 2012					smokers in 2014					smokers in 2014					deterioration of smoking status in 2014		
covariates	factors in 2012					factors in 2014					factors in 2012					factors in 2012		
	smoker (n=467) number	non-smoker (n=1511) number	total (n=1,978) Odds ratio	95% CI		smoker (n=203) number	non-smoker (n=726) number	total (n=929) Odds ratio	95% CI		smoker (n=203) number	non-smoker (n=726) number	Odds ratio	total n=929) 95% CI		deterioration (n=21) Odds ratio	95% CI	
costal area	204	712	2.59	(2.04–3.28)	*	137	440	1.76	(1.23–2.52)	*	137	440	1.76	(1.23–2.52)	*	1.81	(0.69–4.77)	
divorced	73	74	4.20	(2.86–6.18)	*	43	44	4.10	(2.47–6.79)	*	39	40	4.21	(2.49–7.12)	*	2.57	(0.85–2.37)	
widowed	30	263	0.91	(0.66–1.27)		13	160	0.89	(0.46–1.73)		12	159	0.81	(0.41–1.59)		-	-	
single	93	200	0.90	(0.58–1.40)		31	83	0.84	(0.50–1.41)		38	88	0.96	(0.59–1.56)		0.62	(0.16–2.35)	
years of education ≤9	120	415	1.60	(1.20–2.13)		52	239	1.26	(0.84–1.91)		54	294	1.52	(1.00–2.31)	*	1.97	(0.67–5.83)	
non-permanent job	89	241	1.29	(0.96–1.74)		34	113	0.93	(0.59–1.47)		34	96	1.19	(0.74–1.91)		0.63	(0.17–2.27)	
unemployment	40	112	1.57	(1.04–2.35)		12	62	0.91	(0.47–1.77)		23	73	1.43	(0.84–2.43)		1.84	(0.52–6.53)	
annual income ≤2 million yen	208	831	1.16	(0.92–1.47)		118	523	1.11	(0.76–1.61)		98	426	1.28	(0.90–1.83)		1.01	(0.41–2.51)	
complete destruction of house	255	665	1.90	(1.51–2.39)	*	71	294	0.66	(0.46–0.94)	*	123	415	1.46	(1.03–2.06)	*	2.18	(0.82–5.74)	
temporary housing	206	698	2.73	(2.15–3.46)	*	123	404	1.51	(1.07–2.14)	*	137	435	1.79	(1.25–2.57)	*	1.46	(0.57–3.69)	
loss of family members	141	451	1.23	(0.96–1.58)							63	275	0.90	(0.63–1.28)		1.56	(0.64–3.81)	
agriculture, forestry, fishery	13	79	0.49	(0.26–0.91)	*	11	39	0.87	(0.42–1.81)		8	42	0.62	(0.27–1.41)		-		
AUDIT 8 points and over	98	121	1.74	(1.27–2.38)	*	33	52	1.45	(0.88–2.40)		41	63	1.52	(0.95–2.42)		1.80	(0.55–5.89)	
AUDIT 12 points and over	43	53	1.74	(1.12–2.71)	*	18	27	1.15	(0.58–2.29)		18	30	1.45	(0.77–2.76)		0.99	(0.12–7.91)	
AUDIT 15 points and over	26	20	2.89	(1.55–5.39)	*	7	13	0.85	(0.32–2.25)		10	9	2.90	(1.12–7.48)	*	-		

Results of multiple logistic regression analysis, dependent variable; current smoking. All covariates were adjusted by sex and age. Annual income means the individual income. *Statistically significant associated factors with good model fitness assessed by Homer-Lemeshow test

and included people aged 20 years and older; home visits were conducted for the survey interview; a nationwide survey was conducted for comparison; and some respondents were surveyed twice (longitudinally). Thus, this study was able to reveal changes in smoking behavior after a tsunami disaster, which worsened initially and did not improve 3 years later because of the protractedly damaged and difficult life situation that respondents were still facing due to the earthquake and tsunami. Although the results of current study are not similar to other reports from Japan, they are similar to results from other countries about smoking behavior after disasters.

There are reports that the prevalence of posttraumatic stress reaction and depressive reaction among resident survivors after the tsunami following the great East Japan Earthquake was high, and these symptoms were related to house flooding [23, 24]. There is a report that 3 years after the disaster, the depressive symptoms of survivors with loss of loved ones have recovered, but those have prolonged among survivors with property loss [25].

Therefore, it can be inferred that the high smoking rate and nicotine dependence observed in the current study have occurred through psychological distress due to damaged houses and long-term evacuation life caused by the tsunami. The smoking behavior may have been due to stress from crowding living conditions and interaction among the inhabitants of the temporary housing. Treatment for quitting thus be important for health care in temporary housing. In general, socioeconomic conditions, such as education level, income, and working conditions, are also related to smoking behavior [26, 27]. This study has revealed that the destruction of the house and subsequent temporary housing life after the disaster become important risk factors for smoking behavior even after adjusting for these socio-economic factors by multiple logistic regression analyses.

The present study has some limitations. First, the study participants did not include inhabitants of the Fukushima Prefecture. The sampling of participants from the Fukushima Prefecture was difficult because many evacuated people lived far away from their registered addresses. Second, the response rate relatively low. However, there are many inaccessible residents, and many people were exhausted from surveys by various researchers. Response rate of this survey was high one for surveys in the disaster areas because of the home visit interviews. Third, the follow-up survey was carried out only 2 years later. Since the research funds were limited, we could conduct the survey only twice. Fourth, the smoking status before the disaster is unknown; this is because survey was conducted after the disaster. We conducted a nationwide survey, excluding the three disaster prefectures, in 2013 using same survey methods and questionnaire, and compared the results with the results from the disaster areas, so that we were able to confirm that high smoking rate was a phenomenon persistent only in disaster areas.

Conclusions

As shown in this study, smoking behavior and nicotine dependence worsened among victims of the tsunami disaster after the great East Japan Earthquake and had not improved after 3 years. In particular, the smoking behavior of inhabitants living in temporary housing is serious. The findings of this study stress the importance of improvising measures for smoking control in disaster areas in the long term to reduce future health hazards.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12199-020-00858-5.

Additional file 1. Table a. Propotion of nicotine dependence accessed by TSD, by area (disaster area in 2012, All Japan in 2013). Table b. Change of nicotine dependence status accessed by TSD from 2012 to 2014 (Panel survey in disaster areas). Table c. Factors associated with nicotine dependence assessed by FTND score. Table d. Factors associated with nicotine dependence assessed by TDS score

Abbreviations

Mw: Moment magnitude scale; FTND: Fagerström Test for Nicotine Dependence; TDS: Tobacco Dependence Screener; AUDIT: Alcohol Use

Disorders Identification Test; CI: Confidence interval; NS: Non-smoker; Moderate+: Moderate or severe; PTSD: Posttraumatic stress disorder

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Authors' contributions
All authors have materially participated in the research or article preparation. Authors YO and SM designed the study and wrote the protocol. SH, HM, RM, and YM conducted literature searches and provided summaries of previous studies. AK, YK, AI, and YO conducted the statistical analysis. SH, SM, AK, YK, and YO contributed in interpreting the results of the analyses. YO, SM, RM, and HM wrote the first draft of the manuscript, and all authors contributed to and have approved the final manuscript.

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Availability of data and materials
The datasets are not open to the public. Since all analyzes have not been completed, the consent from the members of this research group cannot be obtained.

Ethics approval and consent to participate
The study and surveys were approved by the institutional ethical committee of Kurihama Medical and Addiction Center (#2012181). This study was carried out in accordance with the Declaration of Helsinki. The interview survey was conducted for those who gave consent after explaining the purpose of the survey.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Publisher's Note

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RESEARCH ARTICLE Open Access

Heat-not-burn tobacco, electronic cigarettes, and combustible cigarette use among Japanese adolescents: a nationwide population survey 2017

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Abstract

Background: From among the global public health concerns, smoking remains one of the most crucial challenges. Especially for adolescents, the increase in the use of electronic cigarettes is controversial, as its use may lead to established smoking. In Japan, where a unique tobacco regulation system exists, the heat-not-burn tobacco market has been growing. However, the prevalence and association of combustible cigarettes and new tobacco-related products have not yet been closely investigated among Japanese adolescents. This study aimed to clarify the prevalence of smoking among adolescents, including new types of tobacco-related products, and to compare the characteristics of their users.

Methods: The 2017 Lifestyle Survey of Adolescents is a nationally-representative survey collected in Japan. From the national school directory, 98 junior high schools and 86 high schools were randomly sampled throughout Japan. The students completed an anonymous questionnaire at school. We calculated the prevalence of use for each type of tobacco product. Then, the use of a combination of products and the characteristics of different types of products were examined.

Results: In total, 64,152 students from 48 junior high schools and 55 high schools were included the analysis (school response rate = 56%, M_{age} = 15.7 years, 53.9% boys). The age-adjusted rate of ever (current) use of electronic cigarettes was 2.1% (0.7%) in junior high school and 3.5% (1.0%) in high school; that of combustible cigarettes was 2.6% (0.6%) in junior high school and 5.1% (1.5%) in high school. The rate of heat-not-burn tobacco use was lower relative to other products: 1.1% (0.5%) in junior high school and 2.2% (0.9%) in high school. An examination of the combined use of the three products identified a high number of dual users. Comparisons between different types of users indicated different backgrounds for combustible cigarette users and new product users.

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Conclusions: The prevalence of new tobacco-alternative products is growing in popularity among Japanese adolescents. Dual use is common, and many adolescents use new products only. Moreover, e-cigarettes might attract a broader range of groups to smoking. Continuous monitoring and research are needed to investigate their influence as a possible gateway to tobacco smoking.

Keywords: Cigarette smoking, E-cigarettes, Tobacco use, Adolescents, Smoking, Heat-not-burn tobacco, Prevalence

Background

Smoking is a preventable health risk factor that results in numerous diseases and deaths [1, 2]. Smoking control is particularly critical among adolescents, as individuals who use tobacco at a young age are at a considerably higher risk of becoming subsequent smokers [3]. Moreover, tobacco can be a gateway to other types of drug dependence [4]. Therefore, smoking control during adolescence is a crucial public health issue. The National Health Promotion Act has focused on tobacco control, and the prevalence of adolescents who report having smoked combustible cigarettes within last 30 days has continued to decline from 2000 to 2014; 9.4/5.6% (boys/girls) to 1.3/0.6% in junior high school students and 29.9/13.1% to 3.5/1.5% in high school students [5]. However, in recent years, tobacco industries have begun selling new tobacco-related products such as electronic cigarettes (e-cigarettes) and heat-not-burn (HNB) tobacco as alternatives to combustible cigarettes [6].

E-cigarettes use a battery to heat a cartridge containing a liquid, generating steam (i.e. smoke from burning is not generated) [7, 8]. E-cigarettes were first launched in China in 2003, and their consumption has shown a global growth through intense promotion via media geared towards young people, such as YouTube [9, 10]. In smoking surveys worldwide, a rapid rise in the use of e-cigarettes has been seen among adults and adolescents [11–13]. Some of the purported benefits of e-cigarettes are that fewer harmful substances are generated compared to combustible cigarettes [14, 15] and that they can lead to the reduction or cessation of combustible cigarette use. However, there is a concern, particularly for adolescents, that the use of e-cigarettes may cause an increase in established smokers in the future [16]. Moreover, the longitudinal health impact of e-cigarettes has not yet been sufficiently clarified [17]; thus, its use involves potential harm. In Japan, the emergence of e-cigarettes was evaluated by the authorities, and the sale of e-cigarettes containing nicotine is prohibited by the Pharmaceutical Affairs Law of 2010. However, e-cigarettes without nicotine are accessible to adolescents and youth because they are not covered by this law.

HNB tobacco, also known as the 'I-quit-ordinary-smoking' (IQOS) system, involves an electronic device that heats tobacco leaves in a stick, and the user inhales the generated aerosol instead of smoke [18]. Tobacco companies in Japan are promoting HNB tobacco as a cigarette that causes less harm to users and bystanders. Philip Morris International (PMI) petitioned the US Food and Drug Administration for approval of HNB tobacco products as a smoking cessation tool, but the application was declined. In 2014, PMI introduced IQOS only in Japan and Italy and was available in 37 countries by August 2018. Japan is the unique country in which HNB tobacco was legally sold nationwide under the Tobacco Industries Act, making it an important market for companies that produce HNB products [19]. The popularity and use of HNB tobacco have increased [20]; in October 2016, Japan comprised 98% of the worldwide IQOS sales [21]. Other HNB products include Japan Tobacco's Ploom TECH (2016) and British American Tobacco's Glo product line (2016). Thus, tobacco companies are looking to expand their market offerings [22].

In Japan, where there is a unique market for tobacco-related products, reports on the prevalence of e-cigarette and HNB tobacco use are limited to Internet surveys targeting individuals aged over 18 [23]. As the rapid increase in the popularity of e-cigarettes among adolescents in other countries and of HNB tobacco use in Japan, investigating the prevalence of new products among adolescents is important. Thus, from the 2017 Lifestyle Survey of Adolescents, we obtained data on junior high and high school students' smoking habits and their use of the new types of tobacco-related products in Japan. Our study aimed to clarify the prevalence of smoking of combustible cigarettes and new tobacco products, as well as the combined use of these products and to compare the background of adolescent users of different types of products.

Methods

Study population

This study aimed to evaluate the nationwide prevalence of use of cigarettes and alternative tobacco products. Considering sampling bias, this study involved a cross-sectional random sample survey with single-stage cluster sampling [24], wherein the school was set as the cluster unit. Using the national school directory, junior high schools attended by students aged 12 to 15 and high schools, attended by students aged 15 to 18, throughout Japan were randomly selected, and the survey was

distributed to all students in these schools in 2017. A total of 98 of Japan's 10,325 junior high schools and 86 of the 4907 high schools were sampled. The proportion of private schools was 8.2% of junior high schools and 19.8% of high schools. The survey period was from December 2017 to February 2018.

Data collection

We asked the school principals for cooperation and sent the survey forms to them for distribution to students through class teachers, who explained to the students that participation was voluntary and that they should answer honestly. The students were given anonymous questionnaires and envelopes, which were completed and sealed by the students, collected by their teachers, and then returned to our research office with the seals intact. This survey was approved by the Ethics Review Committee of Tottori University Faculty of Medicine.

Measures

The questionnaire survey focused on adolescents' lifestyle, such as smoking behaviour, alcohol use, and school life (Additional File 1). Referring to the questionnaires used by Centers of Disease Control and Prevention and WHO [25, 26], the questions about smoking included experience with and frequency of combustible cigarette smoking: 'Have you ever smoked a combustible cigarette including even a single puff?' and 'How many days have you smoked combustible cigarettes in the previous 30 days?'. Similar questions were used for new tobacco-alternative products. *Ever users*, *current users*, and *daily users* were defined as those who had smoked even once in the past, had smoked at least once in the past 30 days, and had smoked every day for the past 30 days, respectively. These definitions of frequency were also used for users of e-cigarettes and HNB tobacco.

Tobacco products

Since we needed to discriminate between combustible cigarettes and new tobacco-alternative products, in the questionnaire, we described a combustible cigarette as 'a cigarette made from rolled paper and tobacco and smoked with fire'. Due to the number of e-cigarette brands currently for sale, we used the names of the most popular brands in the questionnaire, stating 'electronic cigarettes include brands such as フレヴォ (FLEVO), エミリ (EMILI), ビタフル (VITAFUL), and ビタシグ (VITASIG)'. The question for HNB tobacco also included product names to avoid any confusion: 'heat-not-burn tobacco is any product such as アイコス (IQOS), プルームテック (Plume Tech), or グロー (glo)'.

Data analysis

The age-adjusted prevalence rates were calculated using the number of junior high and high school students nationwide from the School Basic Survey of the Ministry of Education, Science and Technology (2017) as a standard population. Proportions with a 95% confidence interval (95% CI), as presented in the tables, were calculated using a weighting method based on one-stage cluster random sampling [24]. Two proportion *Z*-tests were conducted to compare the prevalence of each product between boys and girls. To observe the associations between the use of the three different types of products, we calculated the prevalence of combined use. Then, the proportions of combined use of products were calculated, which made the comparison of combined use easier. Moreover, the background of ever users of different products was compared in terms of gender, school grade, municipality size, having breakfast, and participating in club activities. IBM SPSS 25.0 was used for all data analyses.

Results

A total of 56% of 184 schools, including 48 of 98 junior high schools (response rate: 49%) and 55 of 86 high schools (response rate: 64%) took part in the survey. In total, 64,417 questionnaires were returned to the research office. After excluding the questionnaires that were blank, or had invalid/missing gender information or inconsistent responses, 64,152 questionnaires were analysed. The characteristics of the study participants are shown in Table 1. The mean age (standard deviation) of students in junior high school was 13.7 (1.0) years, and 16.7 (0.9) years for high school students. For the gender-ratio, 50.3% of junior high school students and 55.8% of high school students were boys.

Rates of cigarette and new tobacco-alternative product use

Broken down by product type and student gender, the age-adjusted rate of students who were ever/current/every day users of cigarettes, e-cigarettes, or HNB tobacco are shown in Table 2.

The rate of ever users of cigarettes (male/female/both) was 3.1% (95% CI: 3.0, 3.2)/2.1% (95% CI: 2.0, 2.2)/2.6% (95% CI: 2.5, 2.7) for junior high school students, and 6.9% (95% CI: 6.6, 7.2)/3.3% (95% CI: 2.0, 2.2)/5.1% (95% CI: 2.3, 2.9) for high school students. E-cigarette use was slightly lower than cigarette use, at 2.4% (95% CI: 2.3, 2.5)/1.7% (95% CI: 1.6, 1.8)/2.1% (95% CI: 2.0, 2.2) among junior high school students, and 4.9% (95% CI: 4.7, 5.1)/2.1% (95% CI: 2.1, 2.1)/3.5% (95% CI: 3.3, 3.7) among high school students. The rate of HNB tobacco users was relatively lower relative to other products, at 1.3% (95% CI: 1.3, 1.3)/0.9% (95% CI: 0.9, 0.9)/1.1% (95%

Table 1 Baseline characteristics of the study participants

	Male		Female		Total	
	n = 34,582		*n* = 29,570		*n* = 64,152	
	n	%	n	%	n	%
School grade						
Junior high school (12–15 y/o)						
Grade 7	3740	10.8	3644	12.3	7384	11.5
Grade 8	3687	10.7	3642	12.3	7329	11.4
Grade 9	3702	10.7	3713	12.6	7415	11.6
High school (15–18 y/o)						
Grade 10	7963	23.0	6238	21.1	14,201	22.1
Grade 11	7903	22.9	6309	21.3	14,212	22.2
Grade 12	7470	21.6	5934	20.1	13,404	20.9
Unknown	117	0.3	90	0.3	207	0.3
Municipality size groups						
Large cities	5551	16.1	5968	20.2	11,519	18.0
Cities with populations ≥300,000	10,203	29.5	7288	24.6	17,491	27.3
Cities with populations ≥100,000	11,049	32.0	9339	31.6	20,388	31.8
Cities with populations < 100,000	5995	17.3	5168	17.5	11,163	17.4
Smaller towns and villages	1784	5.2	1807	6.1	3591	5.6
Having breakfast						
Every day	28,070	81.2	25,192	85.2	53,262	83.0
Sometimes	3079	8.9	2600	8.8	5679	8.9
Seldom	2169	6.3	1321	4.5	3490	5.4
Unknown	1264	3.7	457	1.5	1721	2.7
Participating in club activities						
Active	20,106	58.1	16,136	54.6	36,242	56.5
Passive	4667	13.5	4232	14.3	8899	13.9
Not engaging	8477	24.5	8646	29.2	17,123	26.7
Unknown	1332	3.9	556	1.9	1888	2.9

CI: 1.0, 1.2) among junior high school students, and 2.9% (95% CI: 2.8, 3.0)/1.4% (95% CI: 1.4, 1.4)/2.2% (95% CI: 2.0, 2.4) among high school students. Experience with of all products was significantly higher among adolescent boys than girls.

The rate of current use of the three products (male/female/both) was rare. For cigarettes, the rate was 0.7% (95% CI: 0.7, 0.7)/0.5% (95% CI: 0.5, 0.5)/0.6% (95% CI: 0.5, 0.7) among junior high school students, and 2.0% (95% CI: 1.9, 2.1)/0.9% (95% CI: 0.9, 0.9)/1.5% (95% CI: 1.4, 1.6) among high school students. For e-cigarettes, it was 0.8% (95% CI: 0.8, 0.8)/0.5% (95% CI: 0.5, 0.5)/0.7% (95% CI: 0.6, 0.8) for junior high school students, and 1.5% (95% CI: 1.4, 1.6)/0.5% (95% CI: 0.5, 0.5)/1.0% (95% CI: 0.9, 1.1) for high school students. For HNB tobacco, it was 0.6% (95% CI: 0.6, 0.6)/0.4% (95% CI: 0.3, 0.5)/0.5% (95% CI: 0.5, 0.5) for junior high school students, and 1.2% (95% CI: 1.1, 1.3)/0.6% (95% CI: 0.6, 0.6)/0.9% (95% CI: 0.8, 1.0) for high school students. Among high school students, current use of three products were significantly higher among boys than girls. Significant difference was observed only in e-cigarette use among junior high school students.

The proportion of students who used the products every day was quite low, with the highest prevalence being that of cigarette use among high school students (male/female/both): 0.7% (95% CI: 0.6, 0.8)/0.2% (95% CI: 0.2, 0.2)/0.5% (95% CI: 0.4, 0.6). The age-adjusted rates for the new products were 0.1% or less.

As shown in Fig. 1, the use of combustible cigarettes was the most prevalent regardless of grade level. Ever use of e-cigarettes followed slightly below that of cigarettes, especially among the younger generation. A divergence was evident between ever use of HNB tobacco and that of the two other types. As for current use, the graphs of the three products overlapped each other in

Table 2 Junior high (grades 7–9) and high school (grades 10–12) students' age-adjusted smoking prevalence rates by gender

	Ever C use		Ever EC use		Ever HNB use	
	%	95% CI	%	95% CI	%	95% CI
Grades 7–9						
Male	3.1	3.0, 3.2	2.4	2.3, 2.5	1.3	1.3, 1.3
Female	2.1**	2.0, 2.2	1.7**	1.6, 1.8	0.9*	0.9, 0.9
Both	2.6	2.5, 2.7	2.1	2.0, 2.2	1.1	1.0, 1.2
Grades 10–12						
Male	6.9	6.6, 7.2	4.9	4.7, 5.1	2.9	2.8, 3.0
Female	3.3**	3.2, 3.4	2.1**	2.1, 2.1	1.4**	1.4, 1.4
Both	5.1	4.8, 5.4	3.5	3.3, 3.7	2.2	2.0, 2.4
	Current C use		Current EC use		Current HNB use	
	%	95% CI	%	95% CI	%	95% CI
Grades 7–9						
Male	0.7	0.7, 0.7	0.8	0.8, 0.8	0.6	0.6, 0.6
Female	0.5	0.5, 0.5	0.5**	0.5, 0.5	0.4	0.4, 0.4
Both	0.6	0.5, 0.7	0.7	0.6, 0.8	0.5	0.5, 0.5
Grades 10–12						
Male	2.0	1.9, 2.1	1.5	1.4, 1.6	1.2	1.1, 1.3
Female	0.9**	0.9, 0.9	0.5**	0.5, 0.5	0.6**	0.6, 0.6
Both	1.5	1.4, 1.6	1.0	0.9, 1.1	0.9	0.8, 1.0
	Daily C use		Daily EC use		Daily HNB use	
	%	95% CI	%	95% CI	%	95% CI
Grades 7–9						
Male	0.2	0.2, 0.2	0.1	0.1, 0.1	0.1	0.1, 0.1
Female	0.1	0.1, 0.1	0.1	0.1, 0.1	0.1	0.1, 0.1
Both	0.1	0.1, 0.1	0.1	0.1, 0.1	0.1	0.0, 0.2
Grades 10–12						
Male	0.7	0.6, 0.8	0.1	0.1, 0.1	0.1	0.1, 0.1
Female	0.2**	0.2, 0.2	0.1	0.1, 0.1	0.0**	0.0, 0.0
Both	0.5	0.4, 0.6	0.1	0.1, 0.1	0.1	0.1, 0.1

C combustible cigarette, *EC* electronic cigarette, *HNB* heat-not-burn tobacco, *CI* confidence interval
Two proportion Z-tests were conducted to compare male and female.
**$P < 0.01$, *$P < 0.05$

the younger generation, but in grades 11 and 12, combustible cigarette use was significantly higher than the use of the other two products.

Combined use of any tobacco product

The age-adjusted rates of combined use of tobacco-related products were calculated (Additional File 2), including all possible combinations of combustible cigarettes, e-cigarettes, and HNB tobacco. Across the various patterns, the exclusive users of cigarettes and exclusive users of e-cigarettes were the largest groups.

Moreover, to make comparisons more understandable, the proportions of ever and current users of any product are shown in Table 3. In terms of ever use, the proportion of exclusive users of combustible cigarettes was about 40% of users of any product in both junior high schools and high schools. Meanwhile, around 36% of users of any product used only e-cigarettes and/or HNB tobacco in junior high schools. Among high school users, around 25% of males and 32% of females ever used either one or both new alternative products. Furthermore, among junior high school students who currently used any product, exclusive e-cigarette users were the largest group among all patterns of use. In high school, exclusive combustible cigarette use, 30%, was dominant across the patterns; however, more than 30% of users currently used only new alternative products. It is worth mentioning that dual users who currently used both cigarettes and another type of products exceeded 30% in junior high school as well as in high school.

Additional File 3 shows the comparison of ever users of different products according to gender, school grade, municipality size, custom of having breakfast, and participation in club activities. Across the different users, the proportions of males were higher than those of females. However, gender differences were smaller when comparing e-cigarette users and HNB users with cigarette users. There were upward trends from lower to higher school grades in exclusive cigarette use and cigarette use combined with other products, but the trends were not clear among new alternative products users. Regarding lifestyle, adolescents who ever used new types of products showed acceptable habits. The percentage of individuals who had breakfast every day and participated in club activities was higher among new products users than among cigarette users.

Discussion

This study is the first in Japan to examine the prevalence of use of combustible cigarettes and new tobacco-alternative products among adolescents. At present, the rate of combustible cigarette use was the highest, followed by e-cigarettes and HNB tobacco use. The rates of use for all three products rose in tandem with increasing school grade. The prevalence of combustible cigarette use was much higher relative to alternative products among high school students, as these alternative products had been introduced into the market more recently. However, ever use of e-cigarettes became close to that of combustible cigarettes among the younger generations. Moreover, the current use of the three products was quite similar, suggesting that new tobacco-alternative products are becoming popular among young users.

Japan is included in the countries with the lowest smoking prevalence according to a World Health Organization report on the global tobacco epidemic

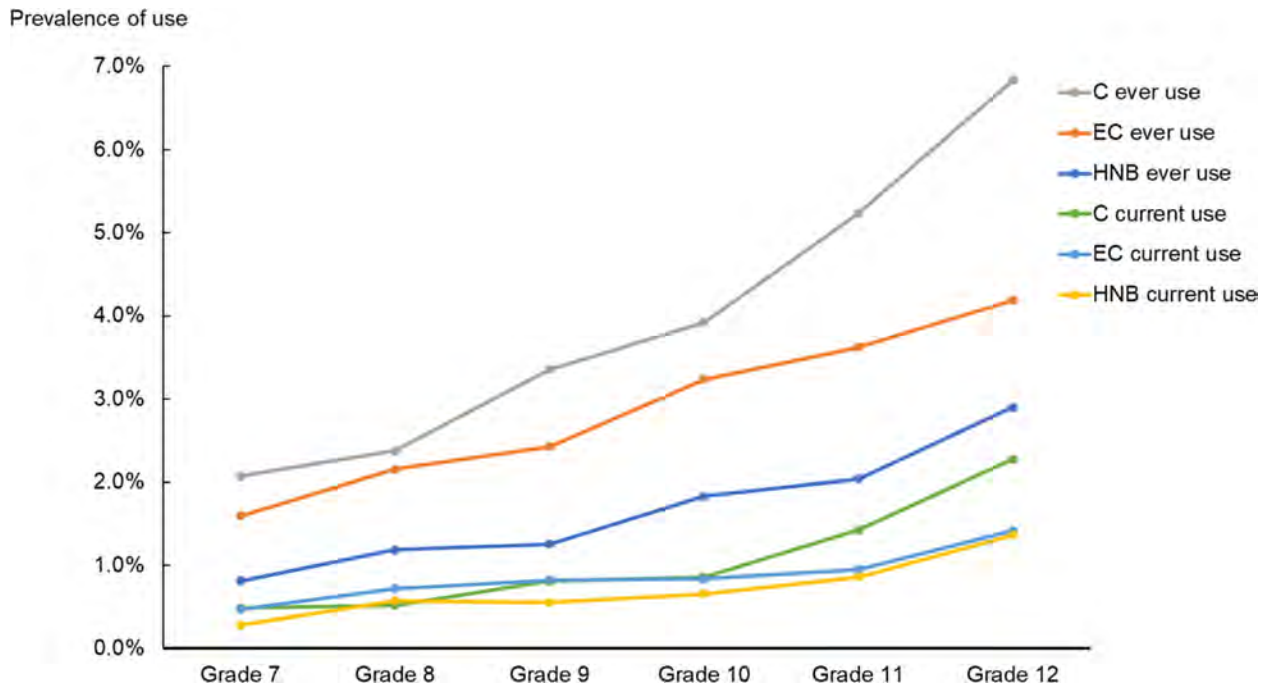

Fig. 1 Prevalence of the three tobacco-related products in each grade (both genders). C: combustible cigarette, EC: electronic cigarette, HNB: heat-not-burn tobacco

Table 3 Junior high (grades 7–9) and high school (grades 10–12) students' age-adjusted prevalence of combined smoking by gender

Proportions of students who ever used either

			Grades 7–9, ever use (%)			Grades 10–12, ever use (%)		
C	EC	HNB	Male	Female	Both	Male	Female	Both
+	–	–	41.1	40.3	40.8	38.4	43.2	39.8
+	+	–	7.8	6.5	7.3	11.6	6.0	10.0
+	–	+	5.6	4.4	5.1	8.1	7.9	8.0
+	+	+	9.6	12.3	10.7	16.7	10.2	14.8
–	+	–	26.3	27.5	26.8	20.0	23.6	21.1
–	–	+	5.0	4.4	4.7	2.7	5.5	3.5
–	+	+	4.6	4.6	4.6	2.4	3.5	2.7

Proportions of students who currently used either

			Grades 7–9, current use (%)			Grades 10–12, current use (%)		
C	EC	HNB	Male	Female	Both	Male	Female	Both
+	–	–	23.3	20.9	22.4	30.7	29.9	30.5
+	+	–	4.6	3.2	4.1	6.8	6.6	6.8
+	–	+	4.7	9.9	6.6	13.7	17.4	14.6
+	+	+	18.7	28.5	22.4	16.0	14.6	15.7
–	+	–	31.3	28.6	30.3	21.3	16.0	20.0
–	–	+	10.0	7.7	9.1	6.5	9.5	7.3
–	+	+	7.3	1.1	5.0	4.9	6.0	5.1

Proportions excluding those who did not smoke any products
C combustible cigarette, *EC* electronic cigarette, *HNB* heat-not-burn tobacco

[27]. The present study focused on the use of new tobacco-alternative products among Japanese adolescents. However, even considering the increasing prevalence of these new products, the smoking rate has shown a downward trend compared with the respective proportions in time-series data. The current use of e-cigarettes of 0.7% in junior high schools and 1.0% in high schools in Japan is lower than that reported by the 2017 National Youth Tobacco Survey in the US (3.3% in middle school and 11.7% in high school) [28]. The law that regulates the sale of e-cigarettes containing nicotine in Japan might contribute to the lower use of these products. Another explanation may be that HNB tobacco exists as a substitute for e-cigarettes. Even though the current use of new products was low in our study, the use of e-cigarettes has been increasing in several countries. Continuous monitoring of e-cigarette use is thus indispensable.

Moreover, given the large population of e-cigarettes among any products users, it is of significance in assessing whether e-cigarettes used by Japanese adolescents contain nicotine or not. A previous study among Canadian high school students by Hamilton et al. showed that approximately 72% of those adolescents who were ever e-cigarettes users used non-nicotine e-cigarettes, while about 28% used nicotine e-cigarettes [29]. Similarly, a previous study indicated that in Japan, about 30% of ever users of new tobacco products used e-cigarettes containing nicotine [19]. The regulation of e-cigarettes in

Canada is quite similar to that in Japan, suggesting that the figures among the Japanese adolescents might be comparable to Hamilton's results. To note, Tabuchi et al. indicated that about 15% of those who were ever users had used e-cigarettes with unknown nicotine. Misinformation about nicotine content is concerning because nicotine might impact the developing brain of adolescents [29]. Future research should investigate these issues.

The prevalence of HNB tobacco use was lower than that of e-cigarette use; however, HNB tobacco use was still observed among adolescents. To our knowledge, there are no comparable reports about HNB tobacco use in other countries. Tabuchi et al. reported the current use as 3.6% in a 2017 internet survey targeting adults in Japan [23], which is comparable to our results. The prevalence of HNB tobacco use is more similar between adolescents and adults relative to the prevalence of combustible cigarette use. Awareness of and advertisements for HNB tobacco have increased in recent years [22]; a domestic Japanese newspaper reported in 2018 that the sales units of HNB tobacco exceeded 2 million for Glo, 5 million for IQOS, and 4 million for Ploom Tech, and indicated that the tobacco market was accelerating the shift to HNB tobacco [30]. The association between smoking rates and tobacco advertisements has been previously studied, and the increase in the use of e-cigarettes in Western countries has been attributed to media promotion [31]. The current momentum of HNB tobacco in Japan is expected to affect its future use rates. Its prevalence should be monitored, as there is substantial uncertainty regarding the health consequences of HNB tobacco [32, 33].

Gender differences in the prevalence rates were examined in the current study. Boys were more likely to use the tobacco-related products, which is consistent with the results previously reported by the WHO [27] and another study conducted in Japan [19, 23]. Previous research has indicated the importance of investigating gender difference in e-cigarette marketing strategies including innovations in product features (e.g., packaging and device design, appealing flavours), as they can influence gender difference in consumption. The authors also highlighted the necessity of examining gender differences in nicotine use by quantifying the amount of nicotine in the e-cigarettes being used by youth [34]. To our knowledge, no research to date has investigated gender difference in HNB consumption. Future research should examine the context in which gender differences in nicotine use might occur.

This study also examined the various patterns of use of the three products. As for adolescents' ever use and current use, exclusive cigarette use was dominant in all cases except for the exclusive use of e-cigarettes in junior high school. A considerable proportion of any-product users were ever or current users of new alternative products only. Therefore, it is an important concern whether e-cigarette or HNB tobacco use can lead to established cigarette use in the future. A previous systematic review indicated that the use of e-cigarettes among adolescents was likely to cause subsequent cigarette smoking [16]. Although it is unclear, it is plausible that the use of HNB tobacco use has the same consequences. Future research is required to clarify this issue.

Another concern is 'dual use' which refers to the use of both combustible cigarette and at least one new tobacco products. Our results suggest that the proportion of dual users exceeded 30% in junior high school as well as in high school. Although the latest expert consensus indicated that e-cigarette use is much less harmful than smoking combustible cigarettes [17], dual use potentially denotes the addition of unknown harm from e-cigarettes or HNB tobacco to that of smoke from combustible cigarettes [17]. There is controversy over whether dual use of e-cigarettes can assist with smoking cessation or not. A recent systematic review has indicated that e-cigarettes are not likely to lead to smoking cessation [16]. Furthermore, to date, there has been no empirical evidence that has indicated that HNB tobacco products play a role in cessation. Future research should investigate these issues in order to clarify their implications for the overall health impact of e-cigarettes and HNB tobacco in Japan.

Moreover, our results indicated different characteristics in the healthy behaviours between those who were cigarette users and new products users. Previous studies have suggested that smoking is associated with an unhealthy lifestyle [35, 36]. Similarly, an association between health risk behaviour and e-cigarettes use has been reported [37]. However, to our knowledge, the relationship between new products and healthy behaviour among adolescents has not been sufficiently investigated. Dunbar et al. concluded that e-cigarettes use among adolescents is not necessarily associated with greater engagement in health behaviours compared to cigarette use [37]. With regard to HNB tobacco, Lee et al. indicated that physically active adolescents were more likely to use cigarettes as well as new products [38] and theorised that these findings were owing to peer influences from participating social activities. However, our results suggest that new products may be an entrance to smoking for a broad variety of adolescents, who are less likely to begin smoking if using combustible cigarettes alone. Previous studies indicated that new products might entice new groups of consumers with characteristics distinct from those of combustible cigarette smokers [39, 40]. Although the mechanism has not been

sufficiently clarified, it could be that new adolescent users may believe that the new products are 'safe' [41]. Future studies are needed to examine the association between health behaviours and the type of products used by adolescents. It is also significant to clarify whether young people who are at low-risk of becoming smokers are more attracted by new products.

A strength of the present study is that our large student sample represents the nationwide adolescent population of Japan. In addition, considering our specific tobacco regulation, Japan is a fertile market for tobacco industries. Our study is unique in that it reports on a novel product, HNB tobacco, which is not available in all countries. However, in this survey, the number of schools selected was relatively smaller than in past studies. Additionally, the response rates in junior high schools were low, leading to the use of age-adjusted rates in the tables. This study required strict ethical considerations due to the age groups taking part, which may have contributed to the low response rate. Although we devised questions about e-cigarettes and HNB tobacco, including the trade names of popular products, students still may not have recognised these products correctly and could have confused e-cigarettes and HNB tobacco. It is also difficult to confirm the validity of self-report answers. Continuous monitoring using the same standards and methods may be the only feasible option. Furthermore, this study entailed a cross-sectional analysis; therefore, the temporal relationship of how the smokers' practices changed as a consequence of the emergence of new tobacco products could not be clarified. Future research should address these limitations.

Conclusions

According to this nationwide population survey, the prevalence of new tobacco-related products is just below the use of combustible tobacco among Japanese adolescents. Dual use is common, and e-cigarettes or HNB tobacco use represent a considerable proportion of the tobacco-related products used by youth. Findings from background comparison suggest that new tobacco-related products might lure a broader population into smoking. The longitudinal impact of these new products remains unclear; thus, continuous monitoring and further research are necessary to provide guidance for the implementation of enhanced public measures against smoking and the use of new tobacco-related products.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12889-020-08916-x.

Additional file 1. The list of questions from the survey questionnaire

Additional file 2. Junior high (grades 7–9) and high school (grades 10–12) students' age-adjusted combined smoking prevalence rates by gender.

Additional file 3. Patterns of ever use of tobacco-related products by demographics, lifestyle, and future education intention.

Abbreviations

E-cigarette: Electronic cigarette; HNB: Heat-not-burn; CI: Confidence interval; WHO: World Health Organization

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Authors' contributions

YO, SH, and YoK designed the study and devised the study protocols. OI, YuO, MJ, and HY did the literature review and helped summarise previous research studies. HK, AK, MF, and AI carried out the statistical analyses. YK wrote the first draft of the manuscript. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets used in the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The participants were older than 12 years of age. Before the survey, the school principals provided participants' parents with the details of the survey. The parents were advised that they were allowed to refuse participation if they were reluctant to allow their children to take part in the survey. In other words, the parents were given the opportunity to opt their children out of the survey if they were not comfortable with them participating in the survey. The students whose parents refused permission for the survey were not included. This survey and opt out parental consent procedure were approved by the Ethics Review Committee of Tottori University Faculty of Medicine (reference no. 17A078).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Publisher's Note

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Comparing Factors Related to Any Conventional Cigarette Smokers, Exclusive New Alternative Product Users, and Non-Users among Japanese Youth: A Nationwide Survey

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Abstract: The impact of heated-tobacco-products (HTPs) and electronic cigarettes (e-cigarettes) on youth is a controversial public health issue, as it is unknown whether alternative products result in more youth using such products or smoking. In Japan, e-cigarettes with nicotine are prohibited, but e-cigarettes without nicotine are available. HTPs are marketed as tobacco products. Within this unique context, we aimed to compare any conventional cigarette smokers (including those who also used alternative products) with exclusive users of alternative products and examine factors relating to their use in Japan. In 2017, 22,275 students in grades 7–9 (age 12–15) and 42,142 in grades 10–12 (age 15–18) nationwide were surveyed. Overall, 1.8% were current users of any of the three products over the last month. Multivariable analysis revealed that risk factors for alternative product use were the same as those for cigarette use. Among all users, exclusive new product users were more likely to participate in club activities and intend to continue to higher education; any conventional cigarette users (including those who also used alternative products) were more likely to be exposed to secondhand smoke at home and to drink alcohol. Reducing adult smoking and disseminating health education remain relevant as strategies for preventing adolescents' future tobacco use.

Keywords: cigarette smoking; e-cigarettes; tobacco use; adolescents; smoking; heat-not-burn tobacco; heated tobacco product; Japan; tobacco control policies; WHO Framework Convention on Tobacco Control (FCTC); noncombustible tobacco/nicotine products; harm reduction

1. Introduction

Tobacco control presents a crucial public health challenge worldwide. A wide range of health problems are attributable to tobacco use, including not only non-communicable diseases, but also perinatal problems and impaired physical and mental development [1]. In fact, premature death due to tobacco use is more preventable than deaths caused by any other drugs [2]. Moreover, the younger people are when they start smoking, the more likely they are to continue smoking [3], making them susceptible to well established smoking-related diseases including cancer, cardiovascular disease and respiratory diseases. The World Health Organization (WHO) has taken the initiative in promoting

global tobacco control. Since 2008, the WHO Framework Convention on Tobacco Control (FCTC) has been endorsing practical and cost-effective ways to reduce tobacco demand worldwide using the acronym MPOWER, standing for Monitor (use and prevention), Protect (people from smoke), Offer (help in quitting), Warn (about dangers), Enforce (bans on advertising, promotions and sponsorship) and Raise (taxes on tobacco products).

Smoking cigarettes comprises one of the biggest risk factors for death and disease in Japan, as indicated by a study that estimated the contribution of several risk factors to disability-adjusted life years (DALYs) in Japan from the findings of the Global Burden of Disease (GBD) 2010 project [4]. The Institute for Health Metrics and Evaluation (IHME), a research center dedicating to measuring health problems affecting populations worldwide, reported that cigarette smoking was the dominant risk for death and disability combined in Japan for all years from 2007 through 2017 [5]. Due to the seriousness of the problems associated with smoking, the Ministry of Health, Labor, and Welfare (MHLW) has been tackling issues of tobacco control. In 2000, the national health promotion campaign 'Healthy Japan 21' was launched, which included dissemination of knowledge about the health effects of smoking, encouraging youth to stop smoking, calling for the separation of smoking areas and launching a smoking cessation program. In 2003, the Health Promotion Law mandated the management of public facilities to prevent public exposure to secondhand smoke. The law promoted the creation of smoke-free spaces and smoke-free regulation by local authorities. Since 2013, Healthy Japan 21 (second term) has been in effect. The tobacco control measure included four main objectives: (1) decrease the smoking rate for adults from 19.5% in 2010 to 12% in 11 years; (2) eliminate smoking among adolescents and young adults; (3) stop women from smoking during pregnancy; and (4) decrease the occurrence of secondhand smoke and eliminate smoke exposure in all administrative and medical institutions. These political measures added to the already-existing nationwide tobacco controls and smoking prevalence has been decreasing for both adults and adolescents over several decades [6], yet tobacco regulation in Japan still has not met all the FCTC's recommendations [7].

Meanwhile, new types of alternative nicotine delivery products such as e-cigarettes and various heated tobacco products (HTPs, also called heat-not-burn tobacco products) have emerged in the tobacco market. The e-cigarettes market has rapidly expanded according to a report from the WHO [8]. This matches the findings of a separate study that reported on the prevalence of these new products in several parts of the world [9]. Additionally, the U.S. Center for Disease Control recently reported the trial of e-cigarettes (people 'trying' the product) exceeds that of conventional cigarettes in the US [10]. A study from Japan also indicated an increase in the trial of new alternative products [11].

Recently, the U.S. Food and Drug Administration (FDA) permitted the sale of IQOS—an HTP that generates a nicotine aerosol compound—with restrictions on how it can be marketed [12]. While tobacco industries advertise that the tobacco used in HTPs is cleaner, public health experts are discussing the challenges and opportunities created by these new products.

Some of the challenges involve how to categorize and regulate the products, and regulation varies across different countries. Notably, Japan is unique in that national law prohibits selling e-cigarettes containing nicotine, but HTPs are sold as legal tobacco products. In terms of regulation, e-cigarettes without nicotine are available to everyone in Japan, but the purchase and use of HTPs are prohibited among people aged under twenty years old. The age requirement for cigarettes is also twenty years old.

There is a significant and controversial public health concern as to whether the novel products attract susceptible young non-users to initiate use of e-cigarettes or HTPs and then go on to smoking [13]. Previous studies have shown that some youth who are otherwise at low risk for smoking cigarettes, and therefore at low risk for using nicotine, are attracted to using e-cigarettes [14] and later begin to smoke conventional cigarettes [15]. Moreover, to consider the overall population impact of HTPs, more evidence is necessary to inform discussion of the likelihood of adolescents who are not tobacco users or who are former tobacco users adopting the use of nicotine with the new products [16]. On the other hand, if the novel products are confined to youth who are already likely to become smokers,

or who use them to stop smoking, they may represent an opportunity to reduce the number of adolescents who are harmed by the effects of combustible cigarettes [17].

The purpose of this study was to compare the background of conventional cigarette smokers with exclusive users of alternative products among young people aged 12 to 18 to highlight the difference between the groups.

2. Materials and Methods

2.1. Study Population

In 2017, Japan had 10,325 registered junior high schools and 4907 registered senior high schools in a total of 47 prefectures. For our study, schools were chosen for students to participate in a lifestyle survey of adolescents. The participating schools were selected using a cross-sectional random sample method with single-stage cluster sampling [18], wherein a school was considered a cluster unit. The sampling method included dividing Japan into regional blocks and randomly selecting schools from each block. The advantage of this methodology is the minimization of sampling bias [18]. Using the national school directory, junior high schools and senior high schools throughout Japan were randomly extracted, and the survey was administered to all students in these schools. Thereby, 98 of Japan's junior high schools from 44 prefectures and 86 of the senior high schools from 42 prefectures were sampled; therefore, the selection rates were 0.95% and 1.75% of all schools, respectively. Private schools comprised 8.2% of the junior high schools and 19.8% of the senior high schools in the study. The surveys were administered from December 2017 through February 2018.

2.2. Data Collection

We approached the principal of each school for cooperation and sent the survey forms to the schools. The principals arranged for class teachers to distribute the forms to the students. The teachers explained to the students that participation was voluntary and that they should answer honestly. The students were given anonymous questionnaires and envelopes, which were completed and sealed by the students, collected by their teachers, and then returned to the research office with the seals intact.

2.3. Measures

The questionnaire included information about basic demographic data (sex, school grade, type of school); use of cigarettes, e-cigarettes and HTPs; exposure to secondhand smoke and understanding of the harmful effects of smoking; lifestyle behaviors and intentions regarding future education; and alcohol use. The list of the questions was provided in Supplementary file 1.

2.4. Use of Cigarettes, e-Cigarettes and Heated Tobacco Products

2.4.1. Discrimination of the Three Products

The three products were described in detail to ensure students were able to distinguish between them. Since we focused on investigating alternative products, we explained that a conventional cigarette is considered, 'a cigarette made from rolled paper and tobacco and smoked with fire'. Due to the number of e-cigarettes currently for sale, we used the names of the most popular brands in the survey; for example, e-cigarettes included フレヴォ(FLEVO), エミリ (EMILI), ビタフル (VITAFUL) and ビタシグ (VITASIG). HTPs were also explained using product names to avoid any confusion; for example, heat-not-burn tobacco included アイコス (IQOS), プルームテック (Ploom Tech) and グロー (glo).

2.4.2. Frequency of Use

To assess the frequency of conventional cigarette use, with the explanation of products above, we used two questions: 'Have you ever smoked a conventional cigarette, including even a single puff?'

and 'How many days have you smoked conventional cigarettes in the previous 30 days?' Similar questions were used to determine the frequency of use of alternative products. For the experience question, 'No, I have not' or 'Yes, I have' were response options. To assess frequency of use, seven options were given: '0 days,' '1–2 days,' '3–5 days,' '6–9 days,' '10–19 days,' '20–29 days,' or 'every day'.

'Experience' of cigarette/e-cigarette/HTP use was defined as smoking/using even once in the past; 'current' use of cigarettes/e-cigarettes/HTPs was defined as smoking/using at least once in the past 30 days. 'Current use' is more relevant to actual smoking behavior and is commonly used as an indicator of adolescent smoking. Furthermore, previous studies suggest that even minimal use of cigarettes leads to a significantly higher risk of becoming a chronic smoker [19,20]. Therefore, we determined 'current use' as a feasible outcome to use for analysis.

Additionally, in our analyses, we used 'exclusive-use' categories, meaning the exclusive use of a particular type of product. For instance, if we described 'exclusive alternative product use', the group included participants who currently used either e-cigarettes or HTPs but did not use conventional cigarettes. 'Non-current user' was defined as those who currently used neither cigarettes, e-cigarettes, nor HTPs. 'Any conventional cigarette smokers' were defined as those who currently smoke conventional tobacco cigarettes, including those who currently smoke conventional tobacco cigarettes exclusively and those who currently use conventional tobacco products plus HTP and/or e-cigarettes.

2.5. Lifestyle Behaviors and Intentions towards Future Education

In Japan, many students participate in after-school clubs. Some students engage in sports clubs at school, such as baseball, tennis or basketball; others choose cultural clubs, such as brass band, tea ceremony and flower arrangement. The questions asked about how often students participated in such 'after school club' activities as well as how often they had breakfast and their plans for the future. For analysis, answers indicating they eat breakfast 'every day' were categorized into 'Yes'; answers of 'sometimes' or 'seldom' were categorized as 'No.' Regarding their plans for the future, students selected one out of seven options: 'vocational school,' 'junior college,' 'college,' 'postgraduate school,' 'taking a job after graduating the current school,' and 'not decided yet'. We categorized those who selected 'college' or 'postgraduate school' into the 'college or more' group.

2.6. Exposure to Secondhand Smoke and Understanding the Harmful Effects of Smoking

For the survey questions about smoking exposure, we did not discriminate between the three products and described smoke as from 'tobacco.' In addition, 'to smoke' was the same as 'to use tobacco.' Students were asked about if and how often they were exposed to secondhand smoke at home. Participants who indicated they had been exposed at least once in the preceding seven days were categorized as 'exposed.' Survey questions were also used to determine how much students understood about the health risks of smoking. We categorized those who selected 'I think that smoking is harmful' into 'Yes' for understanding the harmful effects of smoking; all other responses were categorized as 'No.' Likewise, understanding the harm associated with secondhand smoking was evaluated; participants who selected 'I think it is harmful' were categorized into the 'Yes' group for understanding and all other responses were considered 'No.'

2.7. Alcohol Use

We assessed how many days participants had engaged in drinking alcohol in the previous 30 days and the frequency of binge drinking. We consider drinking 'a lot' to be 'five or more' drinks of an ordinary can (350 mL) for beer and sweet cider. We defined a 'current drinker' as a student who had used alcohol on more than one or two days in the previous month and 'binge drinkers' as those who used alcohol including more than five cans of beer or sour at least once in a month. Specifically, having multiple drinks 'once or twice in a month', 'once or twice in a week', or 'more than three times in a week' were categorized as 'yes' for 'binge drinking' for the purpose of analysis.

2.8. Data Analysis

First, a descriptive analysis of the baseline characteristics of the study participants was performed including their grade levels (junior or senior high school), the overall prevalence of use of any products, and factors known to be associated with smoking. Second, Chi-squared tests were used to examine differences in each factor between any conventional cigarette smokers and non-current users. The Mantel–Haenszel test was used to compare the trends of the proportion of use in each school grade. Similarly, exclusive users of alternative products were compared with non-current users and then with any conventional cigarette smokers (including dual users and multiple users). For the latter comparison, we were interested in whether those youth who currently used only alternative products differed from those who currently smoked conventional cigarettes. Furthermore, in the comparison, we conducted the statistical tests for each of the 11 variables; hence, the Bonferroni correction was used to adjust the cut-off of p-values for significance due to multiplicity. Third, a multivariable logistic regression analysis was used to investigate the relationship between the use of cigarettes and several factors from the questionnaire. The adjusted odds ratio (OR) was calculated for each factor and its 95% confidence interval (95% CI) for cigarette use. Likewise, another logistic regression analysis was done with alternative product use. Finally, among any product users, the risk of alternative product use was compared with any conventional cigarette users in a third logistic regression model. Before the logistic regression analysis, the researchers discussed the relevance of all of the variables in this study and selected, by consensus, those most appropriate for inclusion in the models. Descriptive analysis and univariate analysis were performed using SPSS 25.0 (IBM Corp, New York, NY, USA). R i386 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria) was used to conduct multivariable logistic regression analyses. Missing data were excluded from the analysis. We also conduct a supplementary analysis to compare exclusive cigarette users and exclusive alternative products (APs) users.

2.9. Ethical Statement

According to the Ethical Guidelines for Epidemiological Studies jointly announced by the Ministry of Health, Labor and Welfare and the Ministry of Education, Culture, Sports, Science and Technology of Japan, personal information is defined as follows: information of a living individual and the name, birthday and other descriptions included in that information that can be used to identify a specific individual. The questionnaire in our survey did not include any such information in consideration of identity protection and safeguarding privacy. This survey was reviewed and approved by the Ethics Review Committee of Tottori University School of Medicine when we conducted the survey (reference no. 17A078).

3. Results

The flow and results of the data collection are described in Figure 1. A total of 184 schools (98 junior high, 86 high school) were invited and 56.0% (103), including 49.0% of junior highs (48) and 64.0% of high schools (55), agreed to participate. The response rate of all students in the participating schools was 90.5% (64,152 of 70,927) for fully completed surveys, including 84.0% (22,215 of 26,604) from the junior highs and 94.6% (41,937 of 44,323) from the high schools.

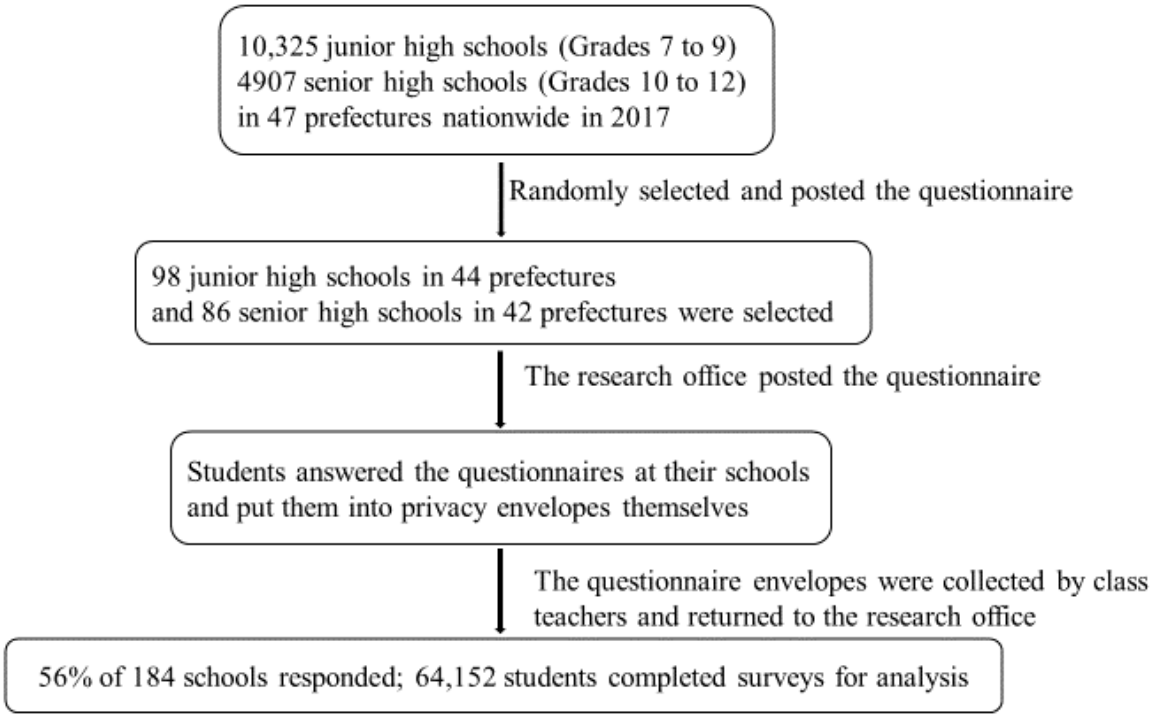

Figure 1. Flowchart of data collection.

3.1. Participant Characteristics

Table 1 shows the baseline characteristics of the study participants. In terms of lifestyles, the proportions of participants who indicated mostly healthy lifestyle habits was higher in junior high school students than senior high school students; however, more senior high students than junior high students intended to go to college or university. Regarding students who had used any products (tobacco or alternative): 4.1% in junior high and 7.3% in senior high school had at some time in their lives; 1.1% in junior high and 2.2% in senior high had at least once within the 30 days preceding the survey. The percentage of students who reported drinking alcohol at least once in the past month was 2.9% in junior high and 7.0% in senior high school. While binge drinking was quite rare in junior high school (0.6%), 1.9% of senior high school students responded that they had five or more cans of alcoholic beverages in one bout of drinking at least once in the preceding month.

To clarify the relationships between the use of the three different products, we created a Venn diagram (Figure 2) to show the total number of respondents who were 'currently' using each product. Overall, 1.8% (n = 1183) students reported using any product at least once in the prior month. Just over 40% were currently using more than one product; 200 students (17% of all current users) were 'currently' using all three products. Thirty percent of those using any product were exclusive e-cigarette or exclusive HTPs users, although compared to cigarettes and e-cigarettes, the number of respondents who only used HTPs was small. Thus, HTPs were most commonly used along with other products.

Table 1. Baseline characteristics of the study participants.

		Junior High School (Grades 7 to 9)		Senior High School (Grades 10 to 12)	
		N = 22,215		*N* = 41,937	
		n	**(%)**	***n***	**(%)**
Sex (Female)		11,036	(49.7)	18,534	(44.2)
School grade					
	First grade	7384	(33.2)	14,201	(33.9)
	Second grade	7329	(33.0)	14,212	(33.9)
	Third grade	7415	(33.4)	13,404	(32.0)
Having breakfast every day		19,079	(85.9)	34,183	(81.5)
Engaging in club activities		17,605	(79.3)	27,536	(65.6)
Future education intention (College or more)		4253	(19.1)	23,262	(55.5)
Experience of any tobacco or alternative products (Once in life)		911	(4.1)	3063	(7.3)
Current use of any tobacco or alternative products (Once in last 30 days)		244	(1.1)	939	(2.2)
Currently drinking alcohol (Once in last 30 days)		634	(2.9)	2950	(7.0)
Binge drinking [a]		134	(0.6)	809	(1.9)

[a] People who drink more than five cans of beer or sour at least once in a month.

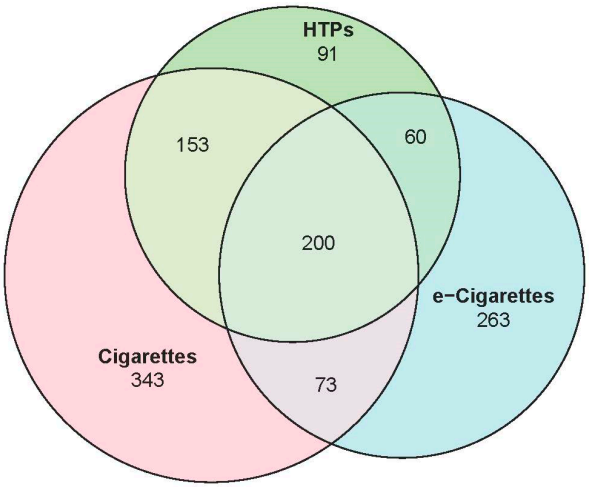

Figure 2. The number of current users of any products, Grade 7–12, male and female. In total, $n = 1183$ (1.8%; $N = 64,152$) The overlap areas represent those who used both or all; the non-overlap area indicates the total number of students who used each product exclusively. Abbreviations: HTPs = heated-tobacco-products.

3.2. Comparison among Any Conventional Cigarette Users, Exclusive Alternative Products Users and Non-Users

Table 2 compares the proportion of respondents according to sociodemographic, lifestyle and other variables among three groups: people who do not currently use any products, any conventional cigarette users and exclusive AP users (the numbers vary slightly from table to table due to missing data). By Bonferroni correction, we adjusted the cut-off for significance as $p < 0.0045$. Overall, more males than females were users of any type of product; however, there was no significant difference between genders among users in terms of which type of product they used (cigarettes or APs). Regarding school grade, the trend in the proportions of the three groups were significantly different. For other variables—having breakfast every day, engaging in club activities, understanding the health effects of smoking, exposure to secondhand smoke and alcohol use—the proportions of students

were significantly different between non-users and the other two groups. Moreover, the statistical tests showed that there were significant differences in those variables between AP users and any conventional cigarette users, except for that of having breakfast every day, future education intention and understanding of harmful effects of smoking.

Table 2. Cross-comparison of three group: non-users with any conventional cigarette smokers and exclusive alternative-product use in youth, including demographics, lifestyles, school life and drinking habits.

	1. People Who Say They Do Not Use Any Products		2. Any Conventional Cigarette Users		3. Exclusive AP Users		1 vs. 2	1 vs. 3	2 vs. 3
	N = 62,969		*N* = 769		*N* = 414				
Variables	***n***	**(%)**	***n***	**(%)**	***n***	**(%)**	***p*-Value**	***p*-Value**	***p*-Value**
Female gender	29,243	(46.4)	218	(28.3)	109	(26.3)	<0.001	<0.001	0.459
School grade [a]							<0.001 [b]	<0.001 [b]	<0.001 [b]
Grade 7	7327	(99.2)	36	(0.5)	21	(0.3)			
Grade 8	7246	(98.9)	38	(0.5)	45	(0.6)			
Grade 9	7314	(98.6)	60	(0.8)	41	(0.6)			
Grade 10	13,981	(98.5)	122	(0.9)	98	(0.7)			
Grade 11	13,914	(97.9)	203	(1.4)	95	(0.7)			
Grade 12	12,989	(96.9)	305	(2.3)	110	(0.8)			
Having breakfast every day	52,605	(83.5)	406	(52.8)	251	(60.6)	<0.001	<0.001	0.010
Engaging in club activities	44,558	(70.8)	330	(42.9)	253	(61.1)	<0.001	<0.001	<0.001
Future education intention (College or more)	27,251	(43.3)	155	(20.2)	109	(26.3)	<0.001	<0.001	0.015
Understanding that smoking is harmful	57,188	(90.8)	514	(66.8)	296	(71.5)	<0.001	<0.001	<0.100
Understanding that secondhand smoking is harmful	55,239	(87.7)	574	(74.6)	298	(72.0)	<0.001	<0.001	<0.321
Secondhand smoking at home	16,526	(26.2)	530	(68.9)	224	(54.1)	<0.001	<0.001	<0.001
Secondhand smoking out of home	18,576	(29.5)	621	(80.8)	225	(54.3)	<0.001	<0.001	<0.001
Currently drinking alcohol (Once in 30 days)	2884	(4.6)	546	(71.4)	154	(37.6)	<0.001	<0.001	<0.001
Binge drinking [b]	583	(0.9)	316	(41.1)	44	(10.6)	<0.001	<0.001	<0.001

Abbreviations: APs = alternative products. Missing data were excluded in each analysis. *p*-Values are based on Chi-squared test. [a.] Mantel–Haenszel test for trend is used in the variable. [b] People who drink more than five cans of beer or cider at least once in a month.

3.3. The Association between Selected Factors and Any Conventional Cigarette Smoking or Exclusive Alternative Products Use

The results of a logistic regression analysis examining the risk factors for any conventional cigarette smokers compared with non-users are shown in Table 3. All factors—sex, school grade, understanding that smoking is harmful, having breakfast every day, participating in club activities, intending to go to college or a higher education course and present alcohol drinking—were significantly associated with any conventional cigarette smoking after mutual adjustment. Similarly, an analysis comparing lifestyle variables of exclusive AP users with those of non-users revealed that seven out of eight variables were significantly associated with AP use (Table 4). Although the students engaging in club activities were less likely to smoke cigarettes (OR 0.64, 95% CI 0.54, 0.76), the variable was not a significant preventive factor for exclusive AP use (OR 1.17, 95% CI 0.94, 1.48).

Table 3. Results of logistic regression: association between selected factors and any conventional cigarette smokers (n = 63,738).

Variables	OR	95% CI			p-Value
Sex					
Female	0.50	0.42	to	0.59	<0.01
Male (reference)	1.00				
School grade *	1.06	1.04	to	1.08	<0.01
Understand that smoking is harmful					
Yes	0.45	0.38	to	0.55	<0.01
No (reference)	1.00				
Having breakfast every day					
Everyday	0.69	0.58	to	0.83	<0.01
Sometimes, seldom (reference)	1.00				
Participating in club activities					
Yes	0.64	0.54	to	0.76	<0.01
No (reference)	1.00				
Intending to pursue higher education					
College or postgraduate school	0.49	0.40	to	0.59	<0.01
Others (reference)	1.00				
Secondhand smoking at home					
At least once in the preceding 7 days	3.18	2.68	to	3.78	<0.01
None in the preceding 7 days (reference)	1.00				
Currently drinking alcohol					
At least once in the previous month	34.66	29.31	to	41.12	<0.01
None in the previous month (reference)	1.00				

* This variable was modeled as a continuous variable. Abbreviations: OR = Odds ratio, 95% CI = 95% confidence interval.

Table 4. Results of logistic regression: association between selected lifestyle variable factors and exclusive alternative products use (n = 63,383).

Variables	OR	95% CI			p-Value
Sex					
Female	0.48	0.38	to	0.60	<0.01
Male (reference)	1.00				
School grade *	1.03	1.01	to	1.06	<0.01
Understand that smoking is harmful					
Yes	0.47	0.37	to	0.60	0.01
No (reference)	1.00				
Having breakfast every day					
Everyday	0.59	0.47	to	0.75	<0.01
Sometimes, seldom (reference)	1.00				
Participating in club activities					
Yes	1.17	0.94	to	1.48	0.17
No (reference)	1.00				
Intending to pursue higher education					
College or postgraduate school	0.61	0.48	to	0.77	<0.01
Others (reference)	1.00				
Secondhand smoking at home					
At least once in the preceding 7 days	2.24	1.82	to	2.76	<0.01
None in the preceding 7 days (reference)	1.00				
Currently drinking alcohol					
At least once in the previous month	9.29	7.51	to	11.46	<0.01
None in the previous month (reference)	1.00				

* This variable was modeled as a continuous variable. Abbreviations: OR = odds ratio, 95% CI = 95% confidence interval.

3.4. The Risk of Exclusive Alternative Product Use Compared with Any Conventional Cigarette Smoking among Any Product Users

Table 5 shows the result of logistic regression analysis which examined risk-associated lifestyle variables for exclusive AP users compared with those for any conventional cigarette smokers among users of any products. The results show that AP users were less likely to be higher school grade, more likely to participate in club activities (OR 1.61, 95% CI 1.22, 2.12), less likely to be exposed to secondhand smoking at home (OR 0.68, 95% CI 0.52, 0.90) and less likely to be current alcohol drinkers (OR 0.27, 95% CI 0.21, 0.35). In addition, there was a borderline significant association of exclusive AP users with 'intention to pursue higher education' (OR 1.35, 95% CI 0.99, 1.83).

Table 5. The risk of exclusive alternative product use compared with any conventional cigarette use among any product users (n = 1183).

Variables	OR	95% CI			p-Value
Sex					
Female	1.02	0.75	to	1.37	0.91
Male (reference)	1.00				
School grade *	0.96	0.93	to	0.99	0.02
Understand that smoking is harmful					
Yes	1.18	0.89	to	1.57	0.26
No (reference)	1.00				
Having breakfast everyday					
Everyday	1.03	0.78	to	1.35	0.84
Sometimes, seldom (reference)	1.00				
Participating in club activities					
Yes	1.61	1.22	to	2.12	<0.01
No (reference)	1.00				
Intending to pursue higher education					
College or postgraduate school	1.35	0.99	to	1.83	0.06
Others (reference)	1.00				
Secondhand smoking at home					
At least once in the preceding 7 days	0.68	0.52	to	0.90	0.01
None in the preceding 7 days (reference)	1.00				
Currently drinking alcohol					
At least once in the previous month	0.27	0.21	to	0.35	<0.01
None in the previous month (reference)	1.00				

* This variable was modeled as a continuous variable. Abbreviations: OR = Odds ratio, 95% CI = 95% confidence interval. An odds ratio of greater than one indicates that exclusive alternative product users had higher odds of the factor than any conventional cigarette users.

The results of an additional logistic regression analysis were the same as for the groups compared above regarding club activities and alcohol use when comparing exclusive combustible cigarette smoking (conventional cigarettes only) to exclusive AP use, (Supplementary file 2).

4. Discussion

The prevalence of any current product use in this Japanese sample, (1.1% of junior high school and 2.2% of senior high school) in 2017, was much lower than has been shown for students in the U.S. (7.2% of middle school and 27.1% of high school [10]) and UK (5% of 11–15 years old who smoke cigarettes at least once in a week and 6% of young people estimated as current e-cigarette users [21]). The prevalence of current cigarette smoking has continued to decline from 2000 to 2014; 9.4/5.6% (boys/girls) to 1.3/0.6% in junior high school students and 29.9/13.1% to 3.5/1.5% in high school students [6]. Our data indicates the continuous downward trends. The relationship between the three products illustrates a significant minority (30%) of those who used any products were exclusive AP users. The prevalence of smoking was much lower than alcohol use among Japanese adolescents.

We were interested in whether the factors related to exclusive use of APs are different from those of any conventional cigarette smokers. To examine this question, we compared three groups: people who do not currently use any products, current AP-exclusive users and any current conventional cigarette smokers. There were significant differences between non-users and exclusive APs users or any cigarette smokers (in all variables studied. In addition, comparing exclusive APs users and any cigarette smokers), four of the eight factors were statistically significant. These results suggest that participant characteristics may be different between non-users and any product users and some of these differed also between AP users and cigarette smokers. Across each variable, the results for AP users fell between the variable results for non-users and those for cigarette users.

The results of logistic regression analysis showed that known factors were significantly associated with any conventional cigarette smoking and APs use even after mutual adjustment. When exploring the difference between exclusive APs users and any conventional cigarette smokers—including those who also use HTPs or e-cigarettes, the conventional cigarette users were more likely to be exposed to secondhand smoke and drinking at home than AP-only users. Moreover, we found that there were differences in participating in club activities between the two groups; intention to pursue higher education also showed borderline significance. These results may suggest different factors—including social circumstances such as parental support, family income, or personal characteristics—may exist between exclusive AP users and those smoking cigarettes with or without the use of other products. Broadly consistent results were found when comparing exclusive cigarette smokes with exclusive AP users. The implications of this are unclear as those exclusively using APs may have previously smoked conventional cigarettes and stopped or may go on to smoke conventional cigarettes or remain exclusive AP users. This requires further research.

Our analytical strategy followed that of a previous study by Hanewinkel et al. that investigated risk factors associated with the use of e-cigarettes in a cohort study among German adolescents [22]. They compared the effect of each risk factor across e-cigarette, conventional cigarette and dual product use. The study implied the possibility that e-cigarettes attract a broader range of adolescents compared to conventional cigarettes. Several results of the present cross-sectional study were consistent with the Hanewinkel's study. Gender and parent smoking showed significant effects on the use of both e-cigarettes and cigarettes. In addition, in their study, the relationship with a future academic career varied between e-cigarettes users and conventional cigarette users. Regarding HTPs, the findings of Wu et al.'s study indicate that relatively well-educated people tend to use HTPs [23]. These findings support our borderline significance in the association between education and exclusive APs use. Moreover, the previous cross-sectional study by Wills et al. [24] tried to determine whether established risk factors for smoking discriminate user categories by testing how e-cigarette users differed on a range of variables including social-cognitive factors, problem behavior risk factors and collateral substance use. Their findings showed parental factors, academic achievement, behavioral self-control, smoking expectancies, alcohol use, and heavy drinking significantly varied across non-users, e-cigarette exclusive users and dual users. Thus, their results also support our findings.

On the other hand, East et al. explained the former issue in a more nuanced way [25]. In their longitudinal study, they indicated that e-cigarette use was associated with cigarette use and vice versa. Certain psychological processes ('common liabilities') are used to explain the relationship of two. Specifically, curiosity, rebelliousness, and sensation-seeking were indicated as the psychological factors affecting product use. These psychological mechanisms also influence alcohol use. Hence, the strong association between any conventional cigarette smokers and alcohol use may be explained by these factors. In addition, the authors discussed several important differences to consider. In the UK, e-cigarettes are more accessible and convenient for young people compared to combustible cigarettes. Novel devices, the variety of flavors and the reduced risks of the new products have been demonstrated to be attractive to youth. Hair et al. also indicated that HTPs attract youth by the novelty [26]. Thus, several reports clarify that APs often appeal to those who are not smokers, but it remains unclear whether people in this group would have gone on to smoking if APs had not been on the market.

Furthermore, it is necessary to further investigate the exclusive conventional cigarette use and the use of conventional cigarettes plus APs and their association with secondhand smoke at home, as there may be an implication that APs users intentionally avoid being exposed to and exposing others to secondhand smoke. On the other hand, it is possible that exclusive conventional cigarette users and those that use them along with APs may be high-risk groups who do not care about the negative consequences of exposure to multiple substances.

Our findings suggest several implications for future tobacco control. From the consistent results related to secondhand smoking at home, the smoking status of any family members significantly affects any type of product use among younger populations, suggesting that public health measures are needed to decrease adult smoking in order to prevent smoking among younger people and vice versa. Although the systematic reviews showed inconsistent results about the effect of e-cigarettes on smoking cessation, the latest PHE reports deduced that a considerable number of smokers quit after e-cigarettes were introduced in the UK [27]. Similarly, Lee et al. estimated that introducing a reduced-risk product into Japan substantially reduced smoking-related deaths [28]; further independent research would be useful in this area [29]. It is also worth mentioning that there is a gap in the implementation of MPOWER between Japan and the UK. As mentioned above, the regulation of tobacco, including APs, in Japan is unique and is behind global standards.

Furthermore, understanding of the harmful effects of smoking showed a protective effect against any type of product use. This finding implies that health education about smoking is an indispensable tobacco control measure. Adolescent trends in tobacco use have been decreasing and are at their lowest level seen in many years. We must maintain this trend of fewer adolescents using tobacco and keep up the use of this essential strategy—health education—with younger generations. It is also important to continue to monitor the trend of tobacco use including the novel alternative products in order to evaluate our current public health measures for tobacco control.

Our study includes several strengths. The data were collected from a nationwide large sample survey. This methodology enabled us to minimize sampling bias [18]. Hence, the result of this study can potentially be generalizable nationwide for Japanese adolescents. Although the proportion of current users of any of the three products was relatively small, the large sample size enabled us to select 'current use of the products' as the outcome for analysis, in contrast to previous studies that selected 'having ever used' as an outcome. However, it should be noted that our definition of 'current use' (in line with other research) is 'any use within the last 30 days' so it picks up a range of users including some who may only be using intermittently. In addition, Japan has a unique regulatory environment. E-cigarettes without nicotine are available, but HTP products have also been widely promoted since 2014. This means that the situation around cigarettes and APs differ from other countries. Given Japan's unique situation, this study aimed to clarify the prevalence and risk factors of AP use among adolescents in Japan.

However, there are several limitations to the present study. First, the schools' response rates were not as high as we expected, though the student-response rate was preserved, as it was high among those schools that did participate. Despite the efforts of the research team, ethical concerns and inconvenience due to the need for strict explanations may have caused the lower rate of cooperation among schools. However, the higher ethical concern was required to meet the criteria for recent ethical approval. Second, the fact that class teachers distributed the forms may have impacted the results. As stated above, to address students' concerns about privacy, student questionnaires were anonymous, and the students put them into private envelopes themselves. In addition, the explanatory document given to the class teachers explained that they must ensure students' privacy. Third, the consequences of multiple testing must be considered. As shown in Table 2, many hypotheses tests were performed, increasing the possibility of spuriously significant results. However, most of the significant results were lower than the adjusted p values—less than 0.004—and we factored this into our interpretation of the results. Fourth, the survey questions for the smoking environment only about asked about 'tobacco'. This may have caused confusion for students answering questions as to if their parents used

APs or about their exposure to aerosol from APs. Finally, as stated above, we should be cautious in interpreting the presented relationships identified in this cross-sectional analysis as causal. In addition, it is possible that confounding causes spurious associations, either through residual confounding of recorded variables, or variables that were not recorded at all. Therefore, present results are limited with regard to investigating what causes the relationship and accurate effect size. However, by using available variables, we tried to explore the factors which were associated with cigarettes and APs and compare them to clarify the relationships. As mentioned above, similar results from previous literature can support our findings.

5. Conclusions

In conclusion, the study results show that currently there is a very low prevalence of smoking and/or alternative products among youth in Japan aged 12 to 18 years. We found that the characteristics of alternative product users and any conventional cigarette smokers, differ from non-users, and there were some differences between exclusive AP users and any conventional cigarette smokers. Conventional factors consistently related to alternative products' use indicate that reducing adult smoking and disseminating health education among adolescents remain important strategies for future tobacco control among adolescents. The priority must be to reduce tobacco use and nicotine addiction even further. To achieve the obvious goal, further research is necessary into the use of alternative products. Policymakers need to consider the updated measures on restrictions on labeling, advertising, sales to minors, pricing and taxation so that the Japanese national public health agenda goals can be achieved.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/9/3128/s1, Supplementary file 1: The list of questions from the survey questionnaire; Supplementary file 2: The risk of exclusive alternative product use compared with exclusive cigarette use among any product users.

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Original Article

The relationship between subjective happiness and sleep problems in Japanese adolescents

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ABSTRACT

Objectives: Low sleep quality in adolescents is an important public health concern, as it relates to both their current and future physical and mental health. Furthermore, subjective happiness is also often regarded as a major life goal. Although Japan is an economically powerful country, the reported levels of subjective happiness among Japanese adolescents is low. Thus, this study aims to examine the relationship between subjective happiness and sleep problems in Japanese adolescents.
Methods: We conducted a nationally representative cross-sectional study of adolescents enrolled in junior and senior high schools in Japan. We used a questionnaire to determine the prevalence of sleep problems (eg, insomnia, short sleep duration (SSD) and poor sleep quality) and to evaluate the participants' reported levels of subjective happiness. Multivariable logistic regression analyses were used to examine the associations between subjective happiness and sleep problems. Adjusted variables were basic demographic characteristics (eg, gender and school grade), lifestyle behaviors, and mental health status.
Results: Data from 64,329 students were analyzed (age range 12–18 years, mean age 15.7 years, 53.9% male). The results indicated that reported levels of subjective happiness were strongly associated with the prevalence of sleep problems. Linear relationships can be observed between sleep problems and subjective happiness scores. The multivariable logistic regression analysis showed that dose–response association of subjective happiness score was observed with all three sleep problems.
Conclusions: Due to these findings, we recommend that policy makers and school officials educate adolescents on the importance of both subjective happiness and good sleep hygiene.

1. Introduction

Sleep problems in adolescents are recognized internationally as a major health concern. Previous studies have reported that 11%–30% of adolescents suffer from sleep problems [1,2]. According to a study performed in 2004, the prevalence of Japanese adolescents (junior and senior high school students) who sleep for less than 6 h at night is 28.7% for male students and 32.6% for female students [3]. In particular, insomnia is common among Japanese adolescents, with a prevalence rate of 23.5%, as reported in a nationwide study performed in 2006 [4]. Sleep problems (eg, insomnia and short sleep duration) in adolescents have been associated with physical health problems such as obesity, insulin resistance, and a higher risk for cardiovascular abnormalities [5–7]. Sleep problems have also been shown to negatively impact adolescents' mental health, increasing the risk of several mental health concerns including

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anxiety, depression, suicidal behavior, and attention disorders [8–10]. Furthermore, poor well-being [11] and emotional dysregulation [12] were associated with sleep problems as well. Thus, sleep problems are one of the important public health problems related to adolescents' present and future physical and mental health.

Subjective happiness has received increasing attention from academics and policymakers around the world. Furthermore, subjective happiness is often regarded as a major life goal [13]. "Happiness" broadly refers to a general assessment of well-being and is a low arousal positive emotion [14,15]. Subjective happiness assesses the levels of positive and negative influences on one's well-being over a specific brief period of time [14] The Organization for Economic Cooperation and Development (OECD) reported that the subjective happiness levels of 15-year old students in Japan ranked 42 out of 47 countries [16]. Subjective happiness levels in adolescents are associated with lifestyle behaviors such as physical activity, eating habits, smoking, and drinking alcohol [17,18], and can also be negatively correlated with problematic Internet usage [19]. It has also numerous positive effects on physical and mental health in adult populations, including improved cardiovascular functioning [20], a stronger immune system [21], an increased survival rate [22], and an appropriate sleep duration [23].

Good sleep quality and fewer sleep problems have been associated with subjective happiness and positive affect in adult populations [24–26]. Pressman and Cohen [21] propose two general models by which responses to stress and positive affect (eg, happiness, joy, excitement, and contentment) can promote health. In the first model, positive affect directly influences overall-health related behavior regardless of its impact on stress responses. In the second model, positive affect may work to reduce negative assessments of distress and, therefore, facilitate adaptive coping [21]. Other studies have further examined the influence of sleep problems on subjective happiness [23,27]. In one study, the relationship between subjective happiness and sleep duration was found to be J-shaped, with women who reported sleeping for an average of 8 h per night also more likely to report being generally happy [22]. Thus, research has suggested that sleep and happiness may be associated through a bidirectional relationship [28,29].

However, previous research has primarily focused on adult populations. There is limited research on the association between subjective happiness and sleep problems in adolescents [14,18]. Moreover, there has been little investigation into possible differential effects of subjective happiness on different sleep problems, and there have been no nationwide studies conducted in Japan investigating their relationship. Therefore, in this study, we used three different sleep problems to examine the relationship between subjective happiness and sleep problems in adolescents. Previous studies have been limited by relatively-small sample sizes and a poor representation of the study population. In order to address these issues, we secured and analyzed a sufficient sample population with high representative quality. Based on the findings in previous research, we hypothesized that adolescents' lower subjective happiness levels would be negatively associated with sleep problems (eg, insomnia, short sleep duration, and poor sleep quality). Each region of the world has its own culture and tradition. However, physiological needs like sleep are important for all adolescents, regardless of culture. The exploration performed in this study of the associations between subjective happiness and sleep problems should result in findings that can be used to inform future research and policy on the importance of subjective happiness as it relates to good sleep hygiene in adolescents in Japan as well as other countries.

2. Methods

2.1. Survey procedure, design, and participants

We previously conducted cross-sectional nationwide surveys of lifestyle habits (eg, alcohol consumption, smoking habits, eating, and sleeping among Japanese adolescents) [4,30,31]. This was the eighth survey of its kind. Of the 10,235 junior and 4907 senior high schools registered in Japan in May 2017, we sampled from 98 junior and 86 senior high schools using a stratified, single-stage cluster-sampling method, which involved dividing Japan into regional blocks and selecting schools from each block at random. This method was used to limit sampling bias. The sample size was determined using the response rates and confidence intervals obtained from a previous study [30]. We sent a letter to the principals of selected schools requesting their cooperation, along with questionnaire forms and envelopes for enrolled students. In cooperating schools, classroom teachers were asked to inform students of the study, including its confidentiality and voluntary participation, and to ensure the protection of privacy. Written informed consent was obtained from all study participants. We used questionnaires devoid of all identifying information to safeguard participants' privacy and anonymity. Teachers delivered the completed questionnaires in sealed envelopes back to our department. We obtained replies from 48 junior high schools (response rate: 49.0%) and 55 senior high schools (response rate: 64.0%; response rate for all schools: 56.0%), for a total of 118,303 enrolled students. A total of 64,417 individuals responded. From those 64,417 responses, we excluded 265 questionnaires that were missing information regarding gender or had inconsistent responses or missing variables. Thus, 64,152 questionnaires were analyzed (effective response rate = 54.4%). The age range was 12–18 years (mean = 15.7 ± 1.7 years).

The survey period was from December 2017 to February 2018. This survey was approved by the Ethics Committee of Tottori University, School of Medicine. Financial support for this study was provided by a health science research grant from the Japanese Ministry of Health, Labor, and Welfare.

2.2. Measures

The questionnaire collected information on the following: (1) personal data, (2) sleep status, (3) subjective happiness, (4) lifestyle behaviors, and (5) mental health status. Personal data included gender, age, school grade, and school type (junior high school or senior high school).

For sleep status, we surveyed insomnia, sleep duration, and subjective sleep quality. To assess for symptoms of insomnia, we asked participants if they had difficulty in initiating sleep (DIS), difficulty in maintaining sleep (DMS), and/or early morning awakening (EMA) in the past 30 days. Participants could indicate "yes" or "no" to whether they experienced these symptoms, and participants who indicated experiencing at least one of the symptoms were considered to experience insomnia. These items are frequently used to assess sleep problems in epidemiologic studies [4,9,31]. Sleep duration was measured by self-report of average hours of sleep per night in the past 30 days, which was categorized into six groups: (1) less than 5 h, (2) 5–6 h, (3) 6–7 h, (4) 7–8 h, (5) 8–9 h, and (6) 9 h or more. We defined "short sleep duration" as a reported average of less than 6 h of sleep per night [31]. For subjective sleep quality, four options were provided: "very good," "good," "bad," and "very bad." Participants who responded with "bad" or "very bad" were considered to have poor sleep quality [31].

Subjective happiness was assessed using a single question: "In general, how would you describe your happiness right now?"

Participants responded using a visual analogue scale. Participants were instructed to: (a) focus on their global estimation and general feelings, (b) take note that 0 is the minimum and 10 is the maximum, and (c) select the number that best described their feelings. This single-item scale has been shown to have good concurrent, convergent, and divergent validity [32], and single-item happiness measures have been used widely throughout the world [33,34]. We categorized this scale into five groups and analyzed the resulting data.

For lifestyle behaviors, we assessed participants for the following: frequency of eating breakfast ("every day," "sometimes," or "seldom"), participation in sports club activities ("participation" or "no participation"), drinking and smoking habits, and Internet usage. For eating breakfast, respondents who selected "daily" in the "yes" category and those who selected "sometimes" or "never" in the "no" category were used for analysis. Participants were considered current smokers and/or drinkers if they indicated they engaged in these activities one day or more per week. To assess Internet usage, we used the 8-item version of the Young Diagnostic Questionnaire for Internet Addiction (YDQ) [35], translated into Japanese [36]. Each item on the YDQ is rated dichotomously ("yes" or "no"), and total scores range from 0 to 8. As in previous studies of adolescents, problematic Internet use was defined as providing affirmative answers to at least 5 YDQ items [37,38]. To evaluate participants' future direction, we used the following question: "What is your plan for your future life course?" Participants selected one of 7 options: "high school," "vocational school," "college," "university," "postgraduate school," "taking a job after leaving the current school," or "not decided yet." Those who selected "university" or "postgraduate school" were grouped as students who intended to go to university; otherwise, participants were grouped as students who did not intend to go to university or those who had not yet decided on their future direction [4].

Mental health status was assessed using the 12-item General Health Questionnaire (GHQ-12) [39]. A GHQ-12 score of 4 or higher has been used in prior studies to indicate poor mental health [40]; however, we used the GHQ-2 due to space limitations on the questionnaire. The GHQ-2 has been indicated to show good sensitivity and specificity (87.0% and 85.1%, respectively) and to provide a cut-off of $\geq$1 [41]. The GHQ-2 provides one item from the depression/anxiety factor (asking whether respondents felt an anxiety and depression in the previous 30 days; response options were "not at all," "no more than usual," "more than usual," and "much more than usual") and one from the decrease in positive feelings factor (asking whether respondents could enjoy normal activities in the previous 30 days; response options were "more so than usual," "same as usual," "less than usual," and "much less than usual").

2.3. Data analysis

First, we identified participants' demographics by gender. Second, we calculated the prevalence and 95% confidence intervals (CI) of each sleep problem by gender using the χ^2 test. Third, we calculated the distribution of subjective happiness scores by gender. Fourth, we calculated the prevalence of each sleep problem in relation to subjective happiness scores. Finally, we conducted univariable and multivariable logistic regression analyses, calculating the adjusted odds ratios (ORs) of subjective happiness and its 95% CI for each sleep problem. The explanatory variables in the multivariable logistic regression analysis included basic demographic characteristics (gender and school grade), lifestyle behaviors (eating breakfast, club participation, drinking habits, smoking habits, Internet usage, and future direction), and mental health status. To determine explanatory variables, we referred to factors associated with sleep problems in previous studies [17,19,31,35,42–44]. A previous study found a weak correlation between happiness and GHQ [45]; however, multivariate analysis have shown mental health and happiness to have different psychological strains [46]. This finding have suggested that the change of happiness scores is an emotion that appears earlier than depressed mood. In addition, the relationship between sleep and mental health is important [9]. Thus, we added mental health status to the explanatory variables. Participants for whom data were missing were excluded from the analyses. We set the significance level at $p < 0.01$. All analyses were performed using SPSS Statistics 22.0 [47].

3. Results

Table 1 shows the participant demographics by gender. The lowest subjective happiness scores (0–2), were reported by 5.6% of male students and 4.4% of female students. The highest subjective happiness scores (9–10), were reported by 19.5% of male students and by 20.2% of female students. In general, female students tended to report higher subjective happiness scores than male students.

Most male and female students ate breakfast everyday (81.2% and 85.2%, respectively). Almost all male and female students did not smoke or drink (97.5% and 98.9%; 93.8% and 95.3%,

Table 1
Characteristics of the participants.

	Boys (N = 34,582)		Girls (N = 29,570)	
	N	%	N	%
Subjective happiness				
0-2	1869	5.4	1270	4.4
3-4	3739	10.8	3668	12.6
5-6	10,926	31.6	9125	31.4
7-8	10,119	29.3	9128	31.4
9-10	6447	18.6	5858	20.2
Unknown	1482	4.3	521	1.8
Grade				
Grade 7	3740	10.8	3644	12.3
Grade 8	3687	10.7	3642	12.3
Grade 9	3702	10.7	3713	12.6
Grade 10	7963	23.0	6238	21.1
Grade 11	7903	22.9	6309	21.3
Grade 12	7470	21.6	5934	20.1
Unknown	117	0.3	90	0.3
Having breakfast				
Everyday	28,070	81.2	25,192	85.2
Sometimes/Seldom	5248	15.2	3921	13.3
Unknown	1264	3.7	457	1.5
Participating in club activities				
No	8477	24.5	8646	29.2
Yes	24,773	71.6	20,368	68.9
Unknown	1332	3.9	556	1.9
Intending to study at university				
No	19,620	56.7	17,017	57.5
Yes	14,962	43.3	12,553	42.5
Presently smoking				
No	33,726	97.5	29,243	98.9
Yes	856	2.5	327	1.1
Presently drinking				
No	32,431	93.8	28,135	95.1
Yes	2151	6.2	1435	4.9
Mental health status				
Good	16,535	47.8	11,510	38.9
Poor	16,649	48.1	17,507	59.2
Unknown	1398	4.0	553	1.9
Problematic Internet use				
No	30,142	87.2	24,379	82.4
Yes	4230	12.2	5063	17.1
Unknown	210	0.6	128	0.4

Table 2
Prevalence of each sleep problem.

		Insomnia	SSD	Poor sleep quality
Total	N	62,018	62,299	62,192
	%	19.3	30.1	37.3
	95% CI	19.0–19.6	29.7–30.4	36.9–37.7
Males	N	33,079	33,249	33,173
	%	18.7	28.4	36.3
	95% CI	18.3–19.1	27.9–28.8	35.7–36.8
Females	N	28,939	29,050	29,019
	%	20.1	32.0	38.5
	95% CI	19.6–20.5	31.5–32.5	37.9–39.0
p-value		<0.001	<0.001	<0.001

p-values were calculated by X2-test (gender; male or female) ×2 (each sleep problem; yes or no).
Participants with missing data were excluded from the analysis.
Insomnia: participants who had one or more symptoms of insomnia; SSD: Short sleep duration (<6 h).

respectively). However, 48.1% of male students and 59.2% of female students reported poor mental health, while 12.2% of male students and 17.1% of female students reported problematic Internet use.

Table 2 shows the prevalence of each sleep problem by gender. The prevalence of insomnia symptoms was 19.3% (males: 18.7%, females: 20.1%), short sleep duration (SSD) was 30.1% (males: 28.4%, females: 32.0%), and poor sleep quality was 37.3% (males: 36.3%, females: 38.5%). Gender differences were observed across all sleep problems.

Fig. 1 shows the relationship between each sleep problem and subjective happiness scores. Linear relationships can be observed between sleep problems and subjective happiness scores. Among the lowest subjective happiness group (0–2), the prevalence of insomnia, SSD, and poor sleep quality were 40.0%, 49.5%, and 62.2%, respectively. However, among the highest subjective happiness group (9–10), the prevalence of insomnia, SSD, and poor sleep quality were 13.6%, 23.7%, and 23.7%, respectively.

Table 3 shows the univariate logistic regression analysis for associations between each sleep problem and subjective happiness. Compared to those students who reported the highest levels of subjective happiness, those who reported the lowest levels of subjective happiness displayed 4.25 (95% CI: 3.89–4.64, $p < 0.001$) times higher ORs for insomnia, 3.14 (95% CI: 2.90–3.41, $p < 0.001$) times higher ORs for SSD, and 5.29 (95% CI: 4.86–5.75, $p < 0.001$) times higher ORs for poor sleep quality. Thus, we found that the lower the reported subjective happiness score, the higher the unadjusted ORs for each sleep problem.

Table 4 shows the multivariable logistic regression analysis for associations between each sleep problems and subjective happiness after adjustment for variables related to demographics, lifestyle behaviors, and mental health status. Compared to students who reported the highest subjective happiness scores, those who reported the lowest subjective happiness scores had 2.64 (95% CI: 2.41–2.90, $p < 0.001$) times higher ORs for insomnia, 3.27 (95% CI: 2.99–3.57, $p < 0.001$) times higher ORs for SSD, and 2.48 (95% CI: 2.27–2.70) times higher ORs for poor sleep quality. Thus, our findings showed that the lower the reported subjective happiness score, the higher the ORs after adjusting the related factors for each sleep problem.

4. Discussion

The present study is the first nationwide, representative cross-sectional study to examine the association between subjective happiness and sleep problems among Japanese adolescents. Specifically, we found that adolescents who reported lower levels of subjective happiness also reported a higher prevalence of sleep disturbances, including insomnia, SSD, and poor sleep quality, compared to adolescents who reported higher levels of subjective happiness. This association was consistent in the fully adjusted model, which controlled for the variables of demographics, lifestyle behaviors, and mental health status. Linear relationships were

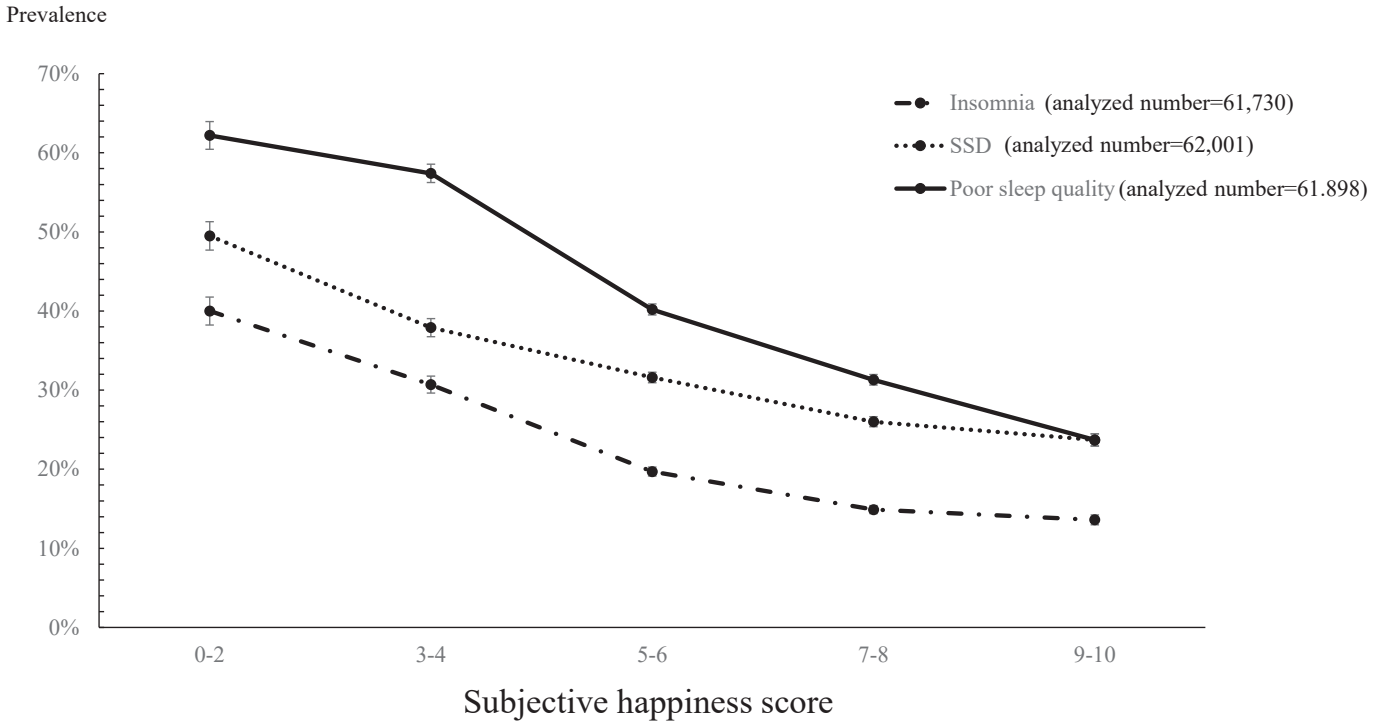

Fig. 1. Prevalence of each sleep problem by subjective happiness score.

Table 3
Univariate logistic regression analysis for association between subjective happiness and sleep problems in Japanese adolescents.

Subjective happiness	Insomnia				SSD				Poor sleep quality			
	N	Crude OR	95% CI	p-value	N	Crude OR	95% CI	p-value	N	Crude OR	95% CI	p-value
0–2	3120	4.25	3.89–4.64	<0.001	3126	3.14	2.90–3.41	<0.001	3121	5.29	4.86–5.75	<0.001
3–4	7349	2.83	2.63–3.04	<0.001	7388	1.96	1.84–2.09	<0.001	7378	4.33	4.07–4.61	<0.001
5–6	19,920	1.56	1.47–1.66	<0.001	20,003	1.49	1.41–1.57	<0.001	19,966	2.16	2.06–2.28	<0.001
7–8	19,122	1.12	1.05–1.20	0.001	19,202	1.13	1.07–1.19	<0.001	19,177	1.46	1.39–1.54	<0.001
9–10	12,219	Ref.			12,282	Ref.			12,256	Ref.		

Abbreviations: OR = odds ratio, CI = confidence interval, SIS: Subjectively insufficient sleep, SSD: short sleep duration (<6 h).
Insomnia: Participants who had one or more symptoms of insomnia (DIS or DMS or EMA).
Participants for whom data were missing were excluded from the analyses.

indicated between subjective happiness level and sleep problems. These findings have important implications for public health, as they show the magnitude of the association between subjective happiness and sleep problems.

As hypothesized, lower subjective happiness scores were significantly related to insomnia, SSD, and poor sleep quality. Previous cross-sectional studies showed that lower subjective happiness was associated with a higher risk for sleep problems [24–26,48]. For example, those with insomnia are 3.27 times more likely to describe themselves as being unhappy compared to those who do not have insomnia [48]. In contrast, a cross-sectional study of 750 American adolescents revealed that subjective happiness had a significant correlation with sleep duration, but not with sleep deprivation [49]. With regard to the association between bedtime and feeling unhappy at school, a cross-sectional study of Japanese adolescents found the adjusted odds ratios (AORs) for those with a late bedtime (after midnight) to be 1.45 times that of adolescents with an early bedtime [50]. As SSD is frequently linked to a delay in bedtime [51], these results are similar our findings.

Notably, adjusted ORs for SSD were higher than unadjusted ORs in all subjective happiness variables. The reason for this difference was the confounding factors that influenced the relationship between subjective happiness and SSD [52]. That is, the statistical control of a third variable altered the strength of association between SSD and subjective happiness. Thus, the strength of the relationship between subjective happiness and SSD may be stronger than between subjective happiness and either insomnia or poor sleep quality.

Our results showed further evidence that linear relationships such as the dose–response subjective happiness score are associated with sleep problems. That is, the lower the subjective happiness score, the higher the ORs for sleep problems. This finding was important because subjective happiness has been reported to be associated with adverse health outcomes in areas such as cardiovascular functioning [20], immune system strength [21], survival rate [22], and quality of life [53]. Furthermore, subjective happiness has been widely studied due to its interactive effects on mental health [54]. For example, higher levels of subjective happiness may serve as a protective factor for depression [55]. As the findings of the present study suggest, subjective happiness is a major public health concern related to the goal of life. Furthermore, awareness among educators and policy makers in Japan on the importance of subjective happiness is low. Therefore, public health interventions to raise awareness of the benefits of increased levels of subjective happiness may play an important role in promoting the improvement of sleep hygiene and other positive physical and mental health outcomes for adolescents.

The causal pathways linking sleep problems with subjective happiness are still not clear. As in the present study, previous studies have cited subjective happiness to be a sleep-related factor [21,25,28]. There are two possible mechanisms by which subjective happiness can promote higher sleep quality [21]. One is that subjective happiness can directly influence overall health-related behavior regardless of its impact on responses to stress. Thus, adolescents with high levels of subjective happiness may be more likely to engage in maintaining good sleep hygiene [28]. The second is that subjective happiness may help to reduce negative feelings and promote better adaptive coping skills. Adolescents with higher levels of subjective happiness may then cope more effectively with stressors. Thus, they may not experience the effects of stress in a way that leads to sleep problems. The strong associations found in our study between subjective happiness levels and sleep problems independent of poor mental health support this second method.

Some studies have further examined the influence of sleep problems on subjective happiness [23,24,27]. In one study, insomnia symptoms were inversely related to subjective happiness, when adjusted for emotional disorders [27]. A longitudinal study conducted with adult females in the UK found a J-shaped relationship between subjective happiness and sleep duration, indicating that subjective happiness decreased along with either shorter or longer sleep duration [23]. These finding suggested that getting adequate sleep was associated with increased subjective happiness. There are some theories to explain the connection between sleep deprivation and subjective happiness. One study

Table 4
Multivariate logistic regression analysis for association between subjective happiness and sleep problems in Japanese adolescents.

Subjective happiness	Insomnia				SSD				Poor sleep quality			
	N	AOR	95% CI	p-value	N	AOR	95% CI	p-value	N	AOR	95% CI	p-value
0–2	3077	3.45	3.14–3.78	<0.001	3084	2.69	2.47–2.93	<0.001	3078	4.31	3.96–4.71	<0.001
3–4	7269	2.44	2.27–2.63	<0.001	7310	1.66	1.56–1.77	<0.001	7301	3.63	3.40–3.87	<0.001
5–6	19,705	1.48	1.39–1.58	<0.001	19,788	1.32	1.25–1.39	<0.001	19,753	1.96	1.86–2.07	<0.001
7–8	18,966	1.11	1.04–1.18	0.003	19,044	1.03	0.98–1.09	0.242	19,021	1.38	1.31–1.46	<0.001
9–10	12,094	Ref.			12,156	Ref.			12,132	Ref.		

Abbreviations: AOR = adjusted odds ratio, CI = confidence interval, SSD = short sleep duration (<6 h).
Insomnia: Participants who had one or more symptoms of insomnia (DIS or DMS or EMA).
Participants for whom data were missing were excluded from the analyses.
Adjusted for gender, grade, club activity, problematic Internet use, having breakfast, drinking, smoking, and intending to study at university by multivariate logistic regression.

proposed that sleep deprivation affects positive emotions such as subjective happiness through networks in the brain related to emotion, rapid eye movement (REM) sleep, emotional information processing, and the cognitive-energy model [56]. From the above findings, it can be posited that a bidirectional relationship exists between sleep problems and subjective happiness [28,29,54,56].

However, the relationship between sleep problems and subjective happiness may also be influenced by several confounding factors, such as cultural differences and socioeconomic status (SES). Adolescents in East Asia generally have lower subjective happiness levels and shorter sleep durations compared to adolescents in other parts of the word (eg, Australia and Scandinavia) where adolescents tend to have higher subjective happiness levels and longer sleep durations [16,57]. Moreover, a study of adolescents in Portugal reported SES was modestly associated with subjective happiness [58]. Mezick et al. [59], reported that lower SES was associated with poor sleep quality in American adults. Thus, we consider it a possibility for future research to conduct a high-quality longitudinal study to ascertain the causal relationship between subjective happiness and sleep quality in adolescents.

The present study showed that female students report more depressive symptoms but also tend to report higher subjective happiness levels than male students. Previous studies have reported that females are superior to males in expressing emotions. For example, LaFrance et al. [60], reported that women use emotional expressions more often than men. In subjective emotional experiments involving looking at facial expression stimuli, females were shown to be more strongly rated as expressing pleasant emotions than males [61]. In addition, gender differences in depressive symptoms have been reported, and males are less likely than females to notice depressive symptoms in themselves [62]. These findings suggest that females experience emotions more strongly than males and express them more frequently or richly.

Based on our findings, we propose the following measures for improving happiness among adolescents, by improving their sleep. School teachers, administrators, and parents must consider the status and importance of adolescents' subjective happiness when providing them with education or discipline. Specifically, we believe it would be effective to educate children on cultivating a sense of happiness by conducting classes that consider the mechanism of happiness and the practice of happy life design in school education. For example, such a lecture could include an overview of the scientific evidence showing that happiness improves sleep problems. Further, if educators and parents do not understand happiness, they will not be effective in teaching children, and we therefore consider it important for them to understand happiness.

This study had three main strengths. First, it is a nationwide survey. Thus, the results of this study can be considered as highly representative of adolescents in Japan. Second, the study had a sample population appropriately large enough for us to establish strong results. This also increased credibility by minimizing the impact of potential random errors in self-reporting, especially among adolescents. Third, it has a survey response rate over 50%, which is high for this type of epidemiological study [63].

Some limitations of this study should also be acknowledged. First, because this was a cross-sectional study, we cannot determine the causal relationships between sleep problems and subjective happiness, or how these relationships might change over time. Thus, future studies should use a longitudinal design. Second, we had to adjust for several potential confounding variables. No data were obtained on factors related to participants' SES (eg, family income or parental educational levels) despite some studies reporting an association between sleep problems and SES [59,64]. Thus, future research should include factors related to SES. Third, due to limited space on the questionnaire, insomnia in this study could not include the entire clinical diagnostic criteria found in the International Classification of Sleep Disorders (ICSD-3) [65]. Therefore, insomnia as presented in this study may have differed from clinical insomnia. Fourth, objective data could not be used for the present evaluation of sleep habits. A previous study reported that self-reported sleep durations were systematically biased by gender and race when compared with those measured objectively using an actigraph [66]. In addition, according to general recommendations, the average sleep duration for adolescents should be around 8–10 h. However, Japanese adolescents are characterized by taking little time for sleep, and many sleep under 6 h on average per night. Therefore, we considered that measurements of this group with high health risks were important, and defined less than 6 h as SSD. Finally, a non-response bias existed, as over 40% schools and students did not participate. This could be due to some schools refusing to participate in the survey at the discretion of the school principals.

In conclusion, this large-scale cross-sectional study of adolescents in Japan showed that low subjective happiness was strongly associated with sleep problems such as insomnia and poor sleep quality. Considering this association, educators and policymakers should promote the importance of subjective happiness and sleep hygiene education for adolescents. Longitudinal research is needed to further identify the mechanism regulating the relationship between subjective happiness and sleep problems.

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CRediT authorship contribution statement

Yuichiro Otsuka: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing - original draft. **Yoshitaka Kaneita:** Conceptualization, Data curation, Investigation, Resources, Writing - review & editing. **Osamu Itani:** Data curation, Investigation, Resources, Software. **Maki Jike:** Data curation. **Yoneatsu Osaki:** Conceptualization, Data curation, Funding acquisition, Resources, Supervision. **Susumu Higuchi:** Conceptualization, Data curation, Resources. **Hideyuki Kanda:** Conceptualization, Data curation, Resources. **Aya Kinjo:** Data curation. **Yuki Kuwabara:** Data curation. **Hisashi Yoshimoto:** Data curation.

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Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2020.01.008.

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Heated Tobacco Product Smokers in Japan Identified by a Population-Based Survey

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ABSTRACT

Background: In this study, we aim to estimate the prevalence of heated tobacco product (HTP) smokers 3 years after the launch of HTPs in Japan.

Methods: Our study, performed in February 2018 in Japan, had a cross-sectional population-based design. A total of 4,628 adult participants (2,121 men and 2,507 women) were randomly sampled from all regions of Japan. The response rate was 57.9%. Interviews were conducted by trained investigators who visited participants' homes. A survey on current (past 30 days) and lifetime tobacco use (including e-cigarettes and HTPs), as well as numerous sociodemographic factors, was conducted.

Results: The age-adjusted rates and estimated number of lifetime-HTP smokers were 14.1% (95% confidence interval [CI], 12.5–15.6%; 7.11 million men) and 3.7% (95% CI, 2.9–4.4%; 1.99 million women). The age-adjusted rates for current HTP smokers were 8.3% (95% CI, 7.1–9.6%; 4.21 million men) and 1.9% (95% CI, 1.3–2.4%; 1.02 million women). Multiple variables were found to be associated with a higher prevalence of current HTP use, including being male, aged 20–39 years, a current Internet user, a risky drinker, or a heavy episodic drinker. HTP use was also higher among men with 10 years or more of education, women with 15 years or less of education, and men with middle- or high-level household incomes.

Conclusion: We concluded that HTP use has increased substantially in Japan. However, regulations for HTPs are weaker than those for combustible cigarettes in Japan. Thus, HTPs should be subjected to the same regulations as combustible tobacco products.

Key words: heated tobacco products; heat-not-burn tobacco; tobacco; population-based study; Japan

INTRODUCTION

Heated tobacco products (HTPs) are relatively new, sold by several tobacco companies, and are used with electronic devices that, without combustion, allow smokers to inhale aerosols produced by heated tobacco leaves.[1–3] Tobacco companies advertise HTPs as being relatively less harmful than other forms of tobacco, yet HTP aerosols contain nicotine and other chemicals,[4–6] and the potential harm of secondhand exposure to HTPs has been reported.[7,8] In 2014, the first HTP, IQOS, was created in Japan. By 2018, the IQOS market share of tobacco sales in Japan reached 15.5%.[9] Thus, it is necessary to understand the present increase in HTP use from a public health perspective by conducting an empirical investigation into potential harmful effects of HTPs. Given their efficient implementation, Internet-based surveys have predominantly been used to provide current estimates of the prevalence of HTP use in three countries.[8,10,11] However, to the best of our knowledge, no population-based studies on HTP prevalence have yet been reported. The participants sampled in web-based surveys may be potentially biased in terms of age and high familiarity with information technology, as participants are typically recruited from a voluntary registered pool. Therefore, the current study was conducted to provide a more accurate estimate of HTP users in Japan by utilizing a nationwide population-based survey.

METHODS

Design

In this cross-sectional study, adults were randomly sampled from all regions of Japan. The respondents were visited at home and interviewed by trained investigators.

Participants

Participants were recruited using a stratified, two-stage random sampling approach. The strata were determined by first dividing the survey districts into eleven areas (Hokkaido, Tohoku, Kanto, Hokuriku, Tosan [Yamanashi, Nagano, and Gifu], Tokai, Kinki, Chugoku, Shikoku, Northern Kyushu, and Southern Kyushu) and then into five groups classified by municipality size (large cities,

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$n = 14$; cities with populations ≥300,000, ≥100,000, <100,000, and smaller towns and villages). The survey districts were selected from each stratum in proportion to the adult (≥20 years old) population. Survey data were collected from participants during the years of 2003 ($n = 3,500$), 2008 ($n = 7,500$), 2013 ($n = 7,500$), and 2018 ($n = 8,000$). This study utilized the 2018 survey dataset, as it included questions on HTPs. The datasets from 2003, 2008, and 2013 were utilized to calculate percentages of tobacco users.

Survey procedures and response rates

The 2018 survey was conducted in February and March of that year. A survey request document was sent to the municipal office after the surveying district was randomly selected. Participants were then randomly selected by the investigator from the resident register at the municipal office. To ensure that participants provided informed consent, they were asked whether or not they would participate in the survey and, if they voluntarily agreed, the investigator visited their residence and conducted the interview. The number of participants and response rate were 4,628 and 57.9%, respectively. The details of previous surveys have been reported.[12]

Indicators of tobacco use

The question on general tobacco use was, "Have you smoked any tobacco often or daily within the past 30 days? (Yes/No)". The following question on HTPs was answered by any current (ie, past 30 days) tobacco user: "Have you ever used heated tobacco products such as iQOS, glo, or Ploom TECH?". The question regarding e-cigarettes asked: "Have you ever used e-cigarettes such as FLEVO, EMILI, VITAFUL, or VITACIG?". The answer choices for those two questions were: "never used", "have used before, but not within the past 30 days", and "currently use". These items identified "any tobacco smoker, past 30 days", "HTP smoker, lifetime", "HTP smoker past 30 days", "e-cigarette smoker, lifetime", and "e-cigarette smoker, past 30 days". In addition, participants were categorized into four groups: "non-smoker", "only smokes combustible tobacco", "HTP smoker or dual smoker", and "other".

Socio-demographic, Internet use, and alcohol use indicators

Participants were classified into the following age groups: 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and older. Educational attainment was classified into four categories: ≤9 years of education (junior high school level), 10–12 years of education (senior high school level), 13–15 years of education (technical school level or current university students), and ≥16 years of education (university and graduate school level). Marital status was classified into three categories: married or living with a partner, bereaved or divorced, and unmarried. Household size was classified into three categories: living alone, two persons, and three persons or more. Working status was classified according to six categories: regular employee, self-employed, non-regular employee, student, housework, and unemployed. There was no housework status classification for men. Household income was classified into three categories: <4,000,000 yen per year, 4,000,000–8,000,000 yen per year, and ≥8,000,000 yen per year (100 yen = 0.92 dollars as of February 1, 2018). In 2016, the median and average household incomes in Japan were approximately 4,420,000 and 5,602,000 yen, respectively.[13] Individuals who used the Internet within the past 30 days were defined as current Internet users. Risky drinkers were defined by daily alcohol consumption (≥40 g for men or ≥20 g for women), which were the levels adopted in the second term of the National Health Promotion Movement of the 21st century (Health Japan 21).[14] Heavy episodic drinking was defined as drinking ≥60 g of alcohol on a single occasion within the past 30 days.[15]

Statistical analyses

The age-adjusted rates and estimated numbers of HTP users were weighted based on the population of Japan in October 1, 2017. To calculate lower and upper 95% confidence intervals (CIs) regarding any tobacco, HTP, and e-cigarette smokers, the following formula was used: age-adjusted point estimate ± 1.96 × standard error of age-adjusted rate. Regarding the proportion of any tobacco, HTP, and e-cigarette users by sociodemographic background, crude rates were used, and 95% CIs were calculated, without adjusting for age. Individuals who did not respond to questions were included in the analysis as non-respondents. Statistical analyses were performed using Microsoft Excel 2016 software for Windows (Microsoft Corp., Redmond, WA, USA).

Ethical considerations

The study protocol was approved by the ethics committee at the Kurihama Medical and Addiction Centre. During the visit for the interview, the investigator obtained informed consent from participants after providing a comprehensive explanation of the purpose of the investigation, its content, and how personal information would be protected. Researchers did not collect any personally identifiable information from the respondents, as it was excluded from the survey data.

RESULTS

A total of 2,121 men and 2,507 women participated in the 2018 nationwide survey. Participant characteristics are shown in Table 1. Almost 70% of participants were current Internet users. The prevalence of any current tobacco use had steadily decreased between 2003 and 2013, but plateaued between 2013 and 2018.

Table 2 shows the estimates of various tobacco product smokers. The age-adjusted rate and estimated number of current HTP smokers in the Japanese population was 5.23 million, with 4.21 million men (8.3%; 95% CI, 7.1–9.6%) and 1.02 million women (1.9%; 95% CI, 1.3–2.4%). The age-adjusted rate of current users of any type of tobacco was 30.8% (95% CI, 28.8–32.8%) among men and 9.4% (95% CI, 8.3–10.5%) among women. Almost one-third of men and one-fifth of women were HTP smokers in the tobacco-user population. The age-adjusted rate of current e-cigarette smokers was 1.6% (95% CI, 1.0–2.2%) among men and 0.5% (95% CI, 0.2–0.7%) among women, and the number of HTP smokers was higher than e-cigarette smokers. The age adjusted rate estimates were calculated for "non-smoker" (men = 69.2%; women = 90.6%), "only smoke combustible tobacco" (men = 22.0%; women = 7.5%), "HTP smoker or dual smoker" (men = 7.2%; women = 1.4%), and "other" (men = 1.7%; women = 0.5%) groups (see Figure 1).

Table 3 shows the crude rate of various types of tobacco smokers among men by sociodemographic factors. The prevalence of HTP smokers was highest among the following groups:

Table 1. Participant characteristics

	Men		Women		Total	
	n	(%)	*N*	(%)	*n*	(%)
Total	2,121	45.8	2,507	54.2	4,628	100.0
Age groups, years						
20–29	167	7.9	197	7.9	364	7.9
30–39	262	12.4	316	12.6	578	12.5
40–49	362	17.1	476	19.0	838	18.1
50–59	310	14.6	398	15.9	708	15.3
60–69	426	20.1	490	19.5	916	19.8
70–79	422	19.9	411	16.4	833	18.0
80 years and older	172	8.1	219	8.7	391	8.4
Areas						
Hokkaido	103	4.9	109	4.3	212	4.6
Tohoku	182	8.6	193	7.7	375	8.1
Kanto	623	29.4	751	30.0	1,374	29.7
Hokuriku	103	4.9	130	5.2	233	5.0
Tosan	107	5.0	109	4.3	216	4.7
Tokai	242	11.4	257	10.3	499	10.8
Kinki	326	15.4	388	15.5	714	15.4
Chugoku	124	5.8	179	7.1	303	6.5
Shikoku	67	3.2	77	3.1	144	3.1
Northern Kyushu	135	6.4	169	6.7	304	6.6
Southern Kyushu	109	5.1	145	5.8	254	5.5
Municipality size						
Large cities	512	24.1	609	24.3	1,121	24.2
Cities with populations ≥300,000	349	16.5	416	16.6	765	16.5
Cities with populations ≥100,000	544	25.6	679	27.1	1,223	26.4
Cities with populations <100,000	507	23.9	564	22.5	1,071	23.1
Smaller towns and villages	209	9.9	239	9.5	448	9.7
Educational attainment						
1–9 years	232	10.9	297	11.8	529	11.4
10–12 years	797	37.6	1,092	43.6	1,889	40.8
13–15 years	289	13.6	681	27.2	970	21
16 years	798	37.6	435	17.4	1,233	26.6
No response	5	0.2	2	0.1	7	0.2
Marital status						
Married	1,573	74.2	1,730	69.0	3,303	71.4
Bereaved or divorced	139	6.6	433	17.3	572	12.4
Unmarried	404	19.0	339	13.5	743	16.1
No response	5	0.2	5	0.2	10	0.2
Number of cohabitants						
Alone	202	9.5	246	9.8	448	9.7
2 persons	695	32.8	703	28.0	1,398	30.2
3 or more persons	1,221	57.6	1,558	62.2	2,779	60.0
No response	3	0.1	0	0.0	3	0.1
Working status						
Employee (regular)	939	44.3	477	19.0	1,416	30.6
Employee (non-regular)	218	10.3	670	26.7	888	19.2
Self-employed	296	14.0	195	7.8	491	10.6
Student	40	1.9	37	1.5	77	1.7
Housework	0	0.0	865	34.5	865	18.7
Unemployed	624	29.4	256	10.2	880	19.0
Others	4	0.2	7	0.3	11	0.2
Annual household income						
<4,000,000 yen	732	34.5	819	32.7	1,551	33.5
4,000,000–8,000,000 yen	652	30.7	593	23.7	1,245	26.9
≥8,000,000 yen	368	17.4	389	15.5	757	16.4
No response	369	17.4	706	28.2	1,075	23.2

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	Men		Women		Total	
	n	(%)	*N*	(%)	*n*	(%)
Internet user, past 30 days	1,499	70.7	1,632	65.1	3,131	67.7
Risky drinker (male 40 g/day, female 20 g/day or more)	316	14.9	169	6.7	485	10.5
Heavy episodic drinker, past 30 days	649	30.6	205	8.2	854	18.5
Any tobacco use, past 30 days						
Year 2003	555	46.9	198	14.5	753	29.6
Year 2008	761	40.5	258	11.5	1,019	24.7
Year 2013	570	30.5	206	9.0	776	18.7
Year 2018	637	30.0	242	9.4	879	19.0
Use of new tobacco products						
HTP[a] smoker, lifetime (Year 2018)	264	12.4	90	3.6	354	7.6
HTP[a] smoker, past 30 days (Year 2018)	131	7.3	55	1.8	186	4.3
E-cigarette smoker, lifetime (Year 2018)	155	6.2	45	2.2	200	4.0
E-cigarette smoker, past 30 days (Year 2018)	31	1.5	11	0.4	42	0.9
Smoking patterns						
Non-smoker	1,484	70.0	2,265	90.3	3,749	81.0
Only smoke combustible tobacco	473	22.3	197	7.9	670	14.5
HTP[a] smoker or dual smoker	133	6.3	34	1.4	167	3.6
Other	31	1.4	11	0.4	42	0.9

[a]HTP, heated tobacco products.

Table 2. Frequency and estimates of tobacco product use

		Men	Women	Total
Any tobacco use, past 30 days	Crude rate (%)	30.0	9.7	19.0
	Age-adjusted rate[a] (%)	30.8	9.4	19.7
	95% CI of the proportion (%)	28.8–32.8	8.3–10.5	18.6–20.8
	Estimated number (in millions)	15.57	5.13	20.70
	95% CI of the estimated number (in millions)	14.56–16.58	4.51–5.75	19.52–21.89
HTP smoker, lifetime	Crude rate (%)	12.4	3.6	7.6
	Age-adjusted rate[a] (%)	14.1	3.7	8.7
	95% CI of the proportion (%)	12.5–15.6	2.9–4.4	7.8–9.5
	Estimated number (in millions)	7.11	1.99	9.10
	95% CI of the estimated number (in millions)	6.32–7.90	1.59–2.40	8.21–9.99
HTP smoker, past 30 days	Crude rate (%)	7.3	1.8	4.3
	Age-adjusted rate[a] (%)	8.3	1.9	5.0
	95% CI of the proportion (%)	7.1–9.6	1.3–2.4	4.3–5.6
	Estimated number (in millions)	4.21	1.02	5.23
	95% CI of the estimated number (in millions)	3.58–4.84	0.73–1.32	4.54–5.93
E-cigarette smoker, lifetime	Crude rate (%)	6.2	2.2	4.0
	Age-adjusted rate[a] (%)	6.8	2.3	4.4
	95% CI of the proportion (%)	5.6–7.9	1.7–2.9	3.8–5.1
	Estimated number (in millions)	3.42	1.23	4.65
	95% CI of the estimated number (in millions)	2.84–4.00	0.91–1.56	3.99–5.32
E-cigarette smoker, past 30 days	Crude rate (%)	1.5	0.4	0.9
	Age-adjusted rate[a] (%)	1.6	0.5	1.0
	95% CI of the proportion (%)	1.0–2.2	0.2–0.7	0.7–1.3
	Estimated number (in millions)	0.82	0.25	1.07
	95% CI of the estimated number (in millions)	0.53–1.11	0.10–0.40	0.74–1.40

CI, confidence interval. HTP, heated tobacco products.
[a]The 2017 population data vital statistics were used to adjust for age.

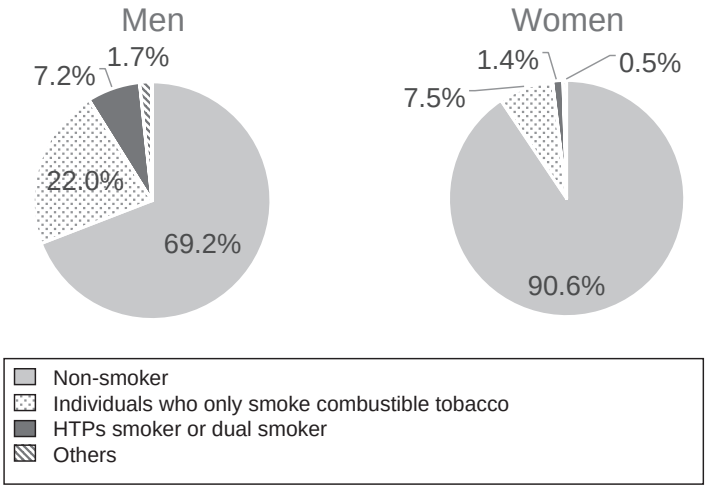

Figure 1. Proportions of tobacco smoking habits in Japan

Table 3. Male tobacco smoker types by sociodemographic characteristics

	Any tobacco use, past 30 days		HTP smoker, lifetime		HTP smoker, past 30 days		E-cigarette smoker, lifetime		E-cigarette smoker, past 30 days	
	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)
Total	30.0	(28.0–32.0)	12.4	(11.0–13.8)	7.3	(6.2–8.4)	6.2	(5.2–7.2)	1.5	(1.0–2.0)
Age groups, years										
20–29	26.3	(24.4–28.2)	22.2	(20.4–24.0)	12.6	(11.2–14.0)	10.8	(9.5–12.1)	2.4	(1.7–3.1)
30–39	31.7	(29.7–33.7)	20.6	(18.9–22.3)	13.4	(12.0–14.8)	9.9	(8.6–11.2)	3.1	(2.4–3.8)
40–49	41.7	(39.6–43.8)	21.0	(19.3–22.7)	13.3	(11.9–14.7)	7.2	(6.1–8.3)	1.7	(1.1–2.3)
50–59	37.4	(35.3–39.5)	14.2	(12.7–15.7)	7.7	(6.6–8.8)	7.1	(6.0–8.2)	1.3	(0.8–1.8)
60–69	32.6	(30.6–34.6)	8.9	(7.7–10.1)	5.6	(4.6–6.6)	5.2	(4.3–6.1)	1.9	(1.3–2.5)
70–79	20.6	(18.9–22.3)	3.1	(2.4–3.8)	0.7	(0.3–1.1)	3.3	(2.5–4.1)	0.2	(0.0–0.4)
80 years and elder	9.9	(8.6–11.2)	1.2	(0.7–1.7)	0.0	(0.0–0.0)	1.7	(1.1–2.3)	0.0	(0.0–0.0)
Area										
Hokkaido	32.0	(30.0–34.0)	10.7	(9.4–12.0)	5.8	(4.8–6.8)	10.7	(9.4–12.0)	4.9	(4.0–5.8)
Tohoku	31.9	(29.9–33.9)	10.4	(9.1–11.7)	8.2	(7.0–9.4)	3.8	(3.0–4.6)	1.1	(0.7–1.5)
Kanto	28.4	(26.5–30.3)	12.4	(11.0–13.8)	6.7	(5.6–7.8)	6.3	(5.3–7.3)	1.3	(0.8–1.8)
Hokuriku	36.9	(34.8–39.0)	16.5	(14.9–18.1)	9.7	(8.4–11.0)	11.7	(10.3–13.1)	2.9	(2.2–3.6)
Tosan	38.3	(36.2–40.4)	20.6	(18.9–22.3)	15.9	(14.3–17.5)	9.3	(8.1–10.5)	3.7	(2.9–4.5)
Tokai	31.8	(29.8–33.8)	13.6	(12.1–15.1)	8.3	(7.1–9.5)	5.0	(4.1–5.9)	0.4	(0.1–0.7)
Kinki	26.4	(24.5–28.3)	12.3	(10.9–13.7)	8.3	(7.1–9.5)	4.3	(3.4–5.2)	1.5	(1.0–2.0)
Chugoku	25.8	(23.9–27.7)	8.9	(7.7–10.1)	3.2	(2.5–3.9)	4.0	(3.2–4.8)	0.8	(0.4–1.2)
Shikoku	20.9	(19.2–22.6)	7.5	(6.4–8.6)	3.0	(2.3–3.7)	4.5	(3.6–5.4)	0.0	(0.0–0.0)
Northern Kyushu	32.6	(30.6–34.6)	12.6	(11.2–14.0)	5.2	(4.3–6.1)	5.9	(4.9–6.9)	0.0	(0.0–0.0)
Southern Kyushu	33.9	(31.9–35.9)	11.0	(9.7–12.3)	4.6	(3.7–5.5)	9.2	(8.0–10.4)	1.8	(1.2–2.4)
Municipality size										
Large cities	25.4	(23.5–27.3)	11.1	(9.8–12.4)	7.0	(5.9–8.1)	6.1	(5.1–7.1)	1.6	(1.1–2.1)
Cities with populations ≥300,000	28.1	(26.2–30.0)	12.0	(10.6–13.4)	6.3	(5.3–7.3)	6.0	(5.0–7.0)	1.4	(0.9–1.9)
Cities with populations ≥100,000	32.2	(30.2–34.2)	12.9	(11.5–14.3)	7.2	(6.1–8.3)	5.7	(4.7–6.7)	1.3	(0.8–1.8)
Cities with populations <100,000	33.1	(31.1–35.1)	14.0	(12.5–15.5)	8.7	(7.5–9.9)	6.5	(5.5–7.5)	1.4	(0.9–1.9)
Smaller towns and villages	31.6	(29.6–33.6)	11.5	(10.1–12.9)	6.7	(5.6–7.8)	7.2	(6.1–8.3)	1.9	(1.3–2.5)
Educational attainment										
1–9 years	29.3	(27.4–31.2)	6.9	(5.8–8.0)	3.9	(3.1–4.7)	3.9	(3.1–4.7)	0.4	(0.1–0.7)
10–12 years	35.0	(33.0–37.0)	13.6	(12.1–15.1)	7.9	(6.8–9.0)	8.0	(6.8–9.2)	1.8	(1.2–2.4)
13–15 years	31.5	(29.5–33.5)	15.6	(14.1–17.1)	9.3	(8.1–10.5)	7.6	(6.5–8.7)	1.7	(1.1–2.3)
≥16 years	24.7	(22.9–26.5)	11.9	(10.5–13.3)	7.0	(5.9–8.1)	4.5	(3.6–5.4)	1.4	(0.9–1.9)
No response	40.0	(37.9–42.1)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Marital status										
Married	28.8	(26.9–30.7)	12.0	(10.6–13.4)	7.2	(6.1–8.3)	5.5	(4.5–6.5)	1.4	(0.9–1.9)
Bereaved or divorced	39.6	(37.5–41.7)	9.4	(8.2–10.6)	5.0	(4.1–5.9)	7.2	(6.1–8.3)	2.2	(1.6–2.8)

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	Any tobacco use, past 30 days		HTP smoker, lifetime		HTP smoker, past 30 days		E-cigarette smoker, lifetime		E-cigarette smoker, past 30 days	
	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)
Unmarried	31.7	(29.7–33.7)	15.6	(14.1–17.1)	8.7	(7.5–9.9)	8.7	(7.5–9.9)	1.5	(1.0–2.0)
No response	20.0	(18.3–21.7)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Number of cohabitants										
Alone	35.1	(33.1–37.1)	12.4	(11.0–13.8)	5.9	(4.9–6.9)	8.9	(7.7–10.1)	1.5	(1.0–2.0)
2 persons	25.2	(23.4–27.0)	7.9	(6.8–9.0)	5.5	(4.5–6.5)	4.3	(3.4–5.2)	1.4	(0.9–1.9)
3 or more persons	31.9	(29.9–33.9)	15.1	(13.6–16.6)	8.6	(7.4–9.8)	6.8	(5.7–7.9)	1.5	(1.0–2.0)
No response	66.7	(64.7–68.7)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Working status										
Employee (regular)	35.6	(33.6–37.6)	18.3	(16.7–19.9)	11.4	(10.0–12.8)	8.3	(7.1–9.5)	2.3	(1.7–2.9)
Employee (non-regular)	33.5	(31.5–35.5)	11.5	(10.1–12.9)	6.9	(5.8–8.0)	6.4	(5.4–7.4)	0.5	(0.2–0.8)
Self-employed	31.4	(29.4–33.4)	13.9	(12.4–15.4)	6.1	(5.1–7.1)	7.1	(6.0–8.2)	1.0	(0.6–1.4)
Student	17.5	(15.9–19.1)	15.0	(13.5–16.5)	12.5	(11.1–13.9)	7.5	(6.4–8.6)	5.0	(4.1–5.9)
Housework										
Unemployed	20.8	(19.1–22.5)	3.2	(2.5–3.9)	1.6	(1.1–2.1)	2.4	(1.7–3.1)	0.5	(0.2–0.8)
Other	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Annual household income										
<4,000,000 yen	29.8	(27.9–31.7)	9.0	(7.8–10.2)	4.4	(3.5–5.3)	5.2	(4.3–6.1)	1.1	(0.7–1.5)
4,000,000–8,000,000 yen	36.3	(34.3–38.3)	17.0	(15.4–18.6)	11.3	(10.0–12.6)	7.7	(6.6–8.8)	2.0	(1.4–2.6)
≥8,000,000 yen	25.5	(23.6–27.4)	14.4	(12.9–15.9)	8.4	(7.2–9.6)	6.8	(5.7–7.9)	1.1	(0.7–1.5)
No response	23.8	(22.0–25.6)	9.2	(8.0–10.4)	4.9	(4.0–5.8)	4.9	(4.0–5.8)	1.6	(1.1–2.1)
Internet use, past 30 days										
Non-Internet user, past 30 days	27.3	(25.4–29.2)	3.7	(2.9–4.5)	1.1	(0.7–1.5)	3.4	(2.6–4.2)	0.5	(0.2–0.8)
Internet user, past 30 days	31.2	(29.2–33.2)	16.1	(14.5–17.7)	9.9	(8.6–11.2)	7.3	(6.2–8.4)	1.9	(1.3–2.5)
Risky drinking										
Drink alcohol less than 40 g/day	28.1	(26.2–30.0)	11.6	(10.2–13.0)	6.8	(5.7–7.9)	5.9	(4.9–6.9)	1.4	(0.9–1.9)
Drink alcohol more than 40 g/day	40.8	(38.7–42.9)	17.4	(15.8–19.0)	10.1	(8.8–11.4)	7.9	(6.8–9.0)	1.6	(1.1–2.1)
Heavy Episodic drinking										
Non-heavy episodic drinker, past 30 days	27.6	(25.7–29.5)	9.6	(8.3–10.9)	5.5	(4.5–6.5)	5.0	(4.1–5.9)	1.0	(0.6–1.4)
Heavy episodic drinker, past 30 days	35.6	(33.6–37.6)	19.0	(17.3–20.7)	11.4	(10.0–12.8)	8.9	(7.7–10.1)	2.5	(1.8–3.2)

20–49-year-olds, residents of Tosan, individuals with 10 years or more of education, individuals who were not bereaved or divorced, individuals with 4,000,000 yen or more annual household income, current Internet users, risky drinkers, and heavy episodic drinkers.

Table 4 shows the crude rate of various tobacco smoker types among women by sociodemographic factors. The prevalence of HTP smokers was highest in the following groups: 20–39-year-olds, individuals with 15 years or less of education, individuals with a household size of three or more persons, individuals who were employed or self-employed, current Internet users, risky drinkers, and heavy episodic drinkers.

DISCUSSION

This is one of the first reports to estimate the prevalence HTP smokers using a national population-based survey. The current survey indicated that the estimated number of current HTP smokers in Japan was 4.21 million (8.3%) men and 1.02 million (1.9%) women, as of February 2018. The proportion of HTP smokers is more than one-fourth of the total tobacco-user population.

Several web-based studies have reported HTP prevalence. One study from Japan observed that the prevalence of IQOS use increased from 0.4% in 2015 to 10.6% in 2018 among men and from 0.2% in 2015 to 3.1% in 2018 among women.[8,16] The 2018 follow-up survey was conducted at the same time as the current study. Considering the 2018 web-based survey was limited to IQOS, the current prevalence estimation is lower than that of the previous study. The difference could be explained by the differences in the age range of participants, the characteristics of participants between web-based surveys and face-to-face interviews, and the research design between cohort studies and cross-sectional studies.

The trend of a decline in tobacco use ceased between 2013 and 2018. While it is unclear whether the current plateau is associated with the launch of HTPs, tobacco industry marketing tactics that suggest HTPs are less harmful than traditional tobacco products may attract conscientious individuals concerned with their health.[17] Additionally, HTPs are presented as sophisticated and clean, which may appeal to young individuals with no prior interest in tobacco.[17,18] Thus, it is quite possible that the prevalence of tobacco use could have declined further if HTPs had not been introduced.

Table 4. Female tobacco smoker types by sociodemographic characteristics

	Any tobacco use, past 30 days		HTP smoker, lifetime		HTP smoker, past 30 days		E-cigarette smoker, lifetime		E-cigarette smoker, past 30 days	
	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)
Total	9.7	(8.5–10.9)	3.6	(2.9–4.3)	1.8	(1.3–2.3)	2.2	(1.6–2.8)	0.4	(0.2–0.6)
Age groups, years										
20–29	8.6	(7.5–9.7)	6.1	(5.2–7.0)	4.1	(3.3–4.9)	4.1	(3.3–4.9)	0.5	(0.2–0.8)
30–39	13.6	(12.3–14.9)	7.9	(6.8–9.0)	4.7	(3.9–5.5)	5.4	(4.5–6.3)	1.9	(1.4–2.4)
40–49	12.4	(11.1–13.7)	5.0	(4.1–5.9)	2.5	(1.9–3.1)	2.3	(1.7–2.9)	0.8	(0.5–1.1)
50–59	13.8	(12.4–15.2)	4.3	(3.5–5.1)	2.3	(1.7–2.9)	2.5	(1.9–3.1)	0.0	(0.0–0.0)
60–69	9.6	(8.4–10.8)	2.0	(1.5–2.5)	0.2	(0.0–0.4)	1.6	(1.1–2.1)	0.0	(0.0–0.0)
70–79	3.9	(3.1–4.7)	0.2	(0.0–0.4)	0.0	(0.0–0.0)	0.2	(0.0–0.4)	0.0	(0.0–0.0)
80 years and elder	2.3	(1.7–2.9)	0.5	(0.2–0.8)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Area										
Hokkaido	13.8	(12.4–15.2)	1.8	(1.3–2.3)	0.9	(0.5–1.3)	0.9	(0.5–1.3)	0.0	(0.0–0.0)
Tohoku	10.9	(9.7–12.1)	5.2	(4.3–6.1)	2.1	(1.5–2.7)	3.1	(2.4–3.8)	0.5	(0.2–0.8)
Kanto	9.9	(8.7–11.1)	4.3	(3.5–5.1)	2.5	(1.9–3.1)	2.7	(2.1–3.3)	0.5	(0.2–0.8)
Hokuriku	6.2	(5.3–7.1)	3.1	(2.4–3.8)	2.3	(1.7–2.9)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Tosan	11.0	(9.8–12.2)	2.8	(2.2–3.4)	0.9	(0.5–1.3)	2.8	(2.2–3.4)	0.9	(0.5–1.3)
Tokai	8.2	(7.1–9.3)	3.5	(2.8–4.2)	3.1	(2.4–3.8)	2.3	(1.7–2.9)	0.8	(0.5–1.1)
Kinki	10.1	(8.9–11.3)	3.6	(2.9–4.3)	1.0	(0.6–1.4)	2.1	(1.5–2.7)	0.3	(0.1–0.5)
Chugoku	10.6	(9.4–11.8)	3.4	(2.7–4.1)	0.6	(0.3–0.9)	2.8	(2.2–3.4)	0.0	(0.0–0.0)
Shikoku	11.7	(10.4–13)	3.9	(3.1–4.7)	2.6	(2.0–3.2)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Northern Kyushu	11.2	(10.0–12.4)	1.8	(1.3–2.3)	0.6	(0.3–0.9)	1.8	(1.3–2.3)	0.6	(0.3–0.9)
Southern Kyushu	3.4	(2.7–4.1)	2.8	(2.2–3.4)	0.7	(0.4–1.0)	2.1	(1.5–2.7)	0.7	(0.4–1.0)
Municipality size										
Large cities	10.5	(9.3–11.7)	3.8	(3.1–4.5)	1.8	(1.3–2.3)	2.5	(1.9–3.1)	0.8	(0.5–1.1)
Cities with populations ≥300,000	6.0	(5.1–6.9)	1.7	(1.2–2.2)	1.0	(0.6–1.4)	1.4	(0.9–1.9)	0.5	(0.2–0.8)
Cities with populations ≥100,000	10.6	(9.4–11.8)	4.1	(3.3–4.9)	1.8	(1.3–2.3)	2.8	(2.2–3.4)	0.0	(0.0–0.0)
Cities with populations <100,000	10.6	(9.4–11.8)	4.4	(3.6–5.2)	2.5	(1.9–3.1)	2.3	(1.7–2.9)	0.5	(0.2–0.8)
Smaller towns and villages	8.8	(7.7–9.9)	2.9	(2.2–3.6)	1.7	(1.2–2.2)	0.8	(0.5–1.1)	0.4	(0.2–0.6)
Educational attainment										
1–9 years	10.4	(9.2–11.6)	2.7	(2.1–3.3)	1.7	(1.2–2.2)	2.0	(1.5–2.5)	0.7	(0.4–1.0)
10–12 years	11.6	(10.3–12.9)	4.0	(3.2–4.8)	1.8	(1.3–2.3)	2.4	(1.8–3.0)	0.5	(0.2–0.8)
13–15 years	10.0	(8.8–11.2)	5.1	(4.2–6.0)	2.6	(2.0–3.2)	3.4	(2.7–4.1)	0.6	(0.3–0.9)
≥16 years	3.7	(3.0–4.4)	0.7	(0.4–1.0)	0.5	(0.2–0.8)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
No response	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Marital status										
Married	8.4	(7.3–9.5)	3.5	(2.8–4.2)	2.0	(1.5–2.5)	2.0	(1.5–2.5)	0.5	(0.2–0.8)
Bereaved or divorced	13.6	(12.3–14.9)	3.5	(2.8–4.2)	0.5	(0.2–0.8)	2.8	(2.2–3.4)	0.0	(0.0–0.0)
Unmarried	10.9	(9.7–12.1)	4.4	(3.6–5.2)	2.7	(2.1–3.3)	2.7	(2.1–3.3)	0.9	(0.5–1.3)
No response	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Number of cohabitants										
Alone	11.4	(10.2–12.6)	1.2	(0.8–1.6)	0.4	(0.2–0.6)	0.8	(0.5–1.1)	0.4	(0.2–0.6)
2 persons	10.4	(9.2–11.6)	2.8	(2.2–3.4)	1.1	(0.7–1.5)	1.7	(1.2–2.2)	0.0	(0.0–0.0)
3 or more persons	9.1	(8.0–10.2)	4.3	(3.5–5.1)	2.3	(1.7–2.9)	2.6	(2.0–3.2)	0.6	(0.3–0.9)
No response										
Working status										
Employee (regular)	12.4	(11.1–13.7)	5.5	(4.6–6.4)	2.5	(1.9–3.1)	2.7	(2.1–3.3)	0.4	(0.2–0.6)
Employee (non-regular)	13.3	(12.0–14.6)	5.1	(4.2–6.0)	2.2	(1.6–2.8)	3.6	(2.9–4.3)	0.7	(0.4–1.0)
Self-employed	12.3	(11.0–13.6)	5.1	(4.2–6.0)	3.1	(2.4–3.8)	3.1	(2.4–3.8)	1.0	(0.6–1.4)
Student	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)
Housework	5.9	(5.0–6.8)	1.6	(1.1–2.1)	1.0	(0.6–1.4)	1.3	(0.9–1.7)	0.2	(0.0–0.4)
Unemployed	7.4	(6.4–8.4)	2.3	(1.7–2.9)	1.2	(0.8–1.6)	0.4	(0.2–0.6)	0.0	(0.0–0.0)
Other	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)	0.0	(0.0–0.0)

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	Any tobacco use, past 30 days		HTP smoker, lifetime		HTP smoker, past 30 days		E-cigarette smoker, lifetime		E-cigarette smoker, past 30 days	
	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)	%	95% CI (%)
Annual household income										
<4,000,000 yen	12.5	(11.2–13.8)	3.5	(2.8–4.2)	1.6	(1.1–2.1)	2.1	(1.5–2.7)	0.2	(0.0–0.4)
4,000,000–8,000,000 yen	9.8	(8.6–11.0)	4.7	(3.9–5.5)	2.5	(1.9–3.1)	2.2	(1.6–2.8)	0.8	(0.5–1.1)
≥8,000,000 yen	7.5	(6.5–8.5)	3.1	(2.4–3.8)	1.5	(1.0–2.0)	2.8	(2.2–3.4)	0.5	(0.2–0.8)
No response	7.5	(6.5–8.5)	3.0	(2.3–3.7)	1.6	(1.1–2.1)	2.0	(1.5–2.5)	0.3	(0.1–0.5)
Internet use, past 30 days										
Non-Internet user, past 30 days	7.2	(6.1–8.3)	0.9	(0.5–1.3)	0.1	(0.0–0.2)	1.0	(0.6–1.4)	0.1	(0.0–0.2)
Internet user, past 30 days	11.0	(9.7–12.3)	5.0	(4.1–5.9)	2.7	(2.0–3.4)	2.8	(2.1–3.5)	0.6	(0.3–0.9)
Risky drinking										
Drink alcohol less than 20 g/day	8.4	(7.3–9.5)	3.0	(2.3–3.7)	1.5	(1.0–2.0)	1.9	(1.4–2.4)	0.3	(0.1–0.5)
Drink alcohol more than 20 g/day	27.2	(25.5–28.9)	12.4	(11.1–13.7)	6.5	(5.5–7.5)	6.5	(5.5–7.5)	1.8	(1.3–2.3)
Heavy Episodic drinking										
Non-heavy episodic drinker, past 30 days	8.3	(7.2–9.4)	2.5	(1.9–3.1)	1.2	(0.8–1.6)	1.5	(1.0–2.0)	0.2	(0.0–0.4)
Heavy episodic drinker, past 30 days	25.4	(23.7–27.1)	15.6	(14.2–17.0)	8.8	(7.7–9.9)	10.2	(9.0–11.4)	2.9	(2.2–3.6)

The present findings show that individuals living with three or more persons were more likely to be HTP smokers. This result may also be related to marketing campaigns from tobacco companies, as the harmful effects of tobacco smoke are well known in Japan, and smokers generally smoke outside their homes. As such, individuals concerned with second-hand smoke impacting family members might shift from cigarettes to HTPs. However, the harm incurred by HTPs cannot be ignored, and such forms of advertising by the tobacco industry arguably pose a health risk to users.[7] The percentage of HTP users is higher among individuals with risky and/or heavy episodic drinking habits. Smoking habits and drinking habits are highly related, which is likely why HTPs are positively correlated with alcohol consumption.[19] We also observed that the percentage of male HTP users was particularly high in Tosan, an area where the rate of combustible tobacco is also particularly high. However, the findings indicated that the highest percentage of female HTP users was in Tokai, the area where HTPs were first launched in Japan.

The current study has several limitations. The primary limitation is the likely bias associated with self-report measures. Biological samples were not provided by participants, and thus it is possible that participants provided inaccurate answers. To reduce response errors as much as possible, concise and easy questions were used. Additionally, the current survey was carried out in person, which may have reduced incorrect answers. The second limitation is that the sample size of each age group was too small to analyze age differences in HTP prevalence. The effect of age was strong among HTP smokers, and an age-stratified analysis should be conducted to examine related background factors. The fourth limitation is the cross-sectional study design, which does not allow for the verification of causal effects of sociodemographic and risk factors. However, the primary purpose of the current study to estimate the total percentage was not affected by this limitation. The methodology in the current study was suitable in terms of collecting highly representative samples.

In conclusion, the current survey indicated that the estimated number of current Japanese HTP smokers was 4.21 million (8.3%) men and 1.02 million (1.9%) women, as of February 2018. However, the regulations for HTPs in Japan is weaker than those for combustible cigarettes. As such, equivalent regulations should be extended to HTPs.

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