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Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide cross-sectional surveys 1996–2017

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ARTICLE

Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide crosssectional surveys 1996-2017

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Objectives: This study aimed to assess the trend in the prevalence of alcohol use in non-smoking/smoking groups and that of smoking in non-drinking/drinking groups using Japanese school-based nationwide surveys.

Design: Nationwide cross-sectional surveys were conducted from 1996 to 2017. Surveyed schools, both junior and senior high schools, considered representative of the entire Japanese nation, were sampled randomly. Enrolled students completed a self-reported and anonymous questionnaire on smoking and drinking behaviour.

Results: Since 1996, the prevalence of alcohol use and smoking among adolescents has decreased in each survey. The prevalence of alcohol use in the non-smoking group was 29.0% in 1996 and 4.0% in 2017, and in the smoking group, was 73.3% in 1996 and 57.4% in 2017. The reduction rate (the difference in prevalence between 1996 and 2017 divided by the prevalence in 1996) was 0.86 in the non-smoking group and 0.22 in the smoking group. The prevalence of smoking in the non-drinking group was 6.7% in 1996 and 0.7% in 2017, while that in the drinking group was 32.5% in 1996 and 18.9% in 2017. The reduction rate was 0.90 in the non-drinking group and 0.42 in the drinking group. Therefore, downward trends differed among the groups. In a sub-analysis limited to senior high school students, we divided students into three groups according to the intention of further education. From 1996 to 2017, there was a consistent difference in the prevalence of alcohol use and/or smoking among these groups.

Conclusions: The situation of alcohol use and smoking among Japanese adolescents seems to have improved. However, specific groups showed poor improvements and that health risk behaviour disparity among Japanese adolescents exists and may be widening. We need to explore high-risk groups and appropriate approaches or interventions for such groups.

Strength and limitations of this study

- The data were collected from periodical, nationwide large-sample surveys on Japanese adolescents from 1996 to 2017, and the study contained a large sample size (n=11584-64152 per year).
- This study focused on the co-use of alcohol and tobacco and analysed its trends in the sub-groups.
- Due to ethical concerns and inconvenience, school response rates were not as high as expected; however, the student-response rate was preserved.

Keywords: alcohol use, smoking, adolescents, prevalence, Japan

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INTRODUCTION

Annually, smoking causes approximately 8 million deaths worldwide, and the harmful use of alcohol results in approximately 3 million deaths. [1, 2] Smoking and alcohol consumption usually start during adolescence, leading to the detrimental consequences of the epidemic of non-communicable diseases in adulthood. Health risk behaviours (HRBs) are shaped by social, economic, and cultural forces and are major determinants of ill health and health-related inequalities across the course of life.[3-6] Therefore, adolescence is a key period for controlling HRBs. Some studies have identified alcohol use, smoking, drug use, and risky sexual behaviours as risk behaviour clusters[7-10] and socioeconomic status as a strong predictor of engaging in multiple-risk behaviours.[11] Since 1996, our research group has been monitoring alcohol use and smoking among minors in Japan. According to a report, the prevalence of alcohol use and smoking among adolescents in Japan has continued to decline, and it is reported to be lower than that in the European countries and the United States.[12, 13] Despite the improvement in the situation of alcohol use and smoking among Japanese adolescents, health inequalities and social disparities are current public health issues in Japan.[14] It is important to examine whether an HRB disparity may exist among Japanese adolescents. Researchers from other countries have reported that the prevalence of smoking and alcohol use did not decrease in some adolescents over time[15-18]; however, a few studies have focused on the co-use of alcohol and tobacco and analysed its trend in subgroups. Hence, we focused on the co-use of alcohol and tobacco and hypothesised that some groups might have certain characteristics that would delay the reduction in the prevalence of alcohol use and smoking. To verify our hypothesis, the research population was divided into the following subgroups: smoking group/non-smoking group, drinking group/non-drinking group, and intention to further education. Next, the trend in prevalence of alcohol use and smoking in each group was examined. To further improve the status of alcohol use and smoking among adolescents, it is essential to evaluate these groups and implement interventions. Incidentally drug use among adolescents in Japan is not a major problem; the prevalence rate of drug use among teenagers was 0% in 2015.[19] Therefore, the present study aimed to evaluate the nationwide prevalence of smoking and alcohol use, as they were main substance-use problems and have been investigated as HRBs among Japanese adolescents.

METHODS

Study population

This was a cross-sectional random sampling survey that used single-stage cluster sampling.[20] Sampling was

performed by dividing Japan into regional blocks and randomly selecting schools from each block. Using the national school directory, junior high schools and senior high schools throughout Japan were randomly extracted, and all students enrolled in the sampled schools were subjects of the study. The number, selection rate, and response rate of the schools for each survey are shown in Supplementary Table 1. The response rates of schools ranged from 49.0% to 79.8%.

Data collection

The study was approved by the Ethics Review Committee of Tottori University School of Medicine. Supplementary Figure 1 shows the flowchart of data collection of the study. We sought the cooperation of the principals of all schools and sent the survey forms to all students. The teachers encouraged students to respond voluntarily and honestly. The students were given anonymised questionnaires and envelopes. The completed questionnaires were put in envelopes by the students themselves, and the envelopes were collected by the teachers in a sealed state and returned to our institute.

Measures

Alcohol use and smoking

The questionnaire focused on the students' experiences, frequency of alcohol use ('How many days have you drunk alcohol in the previous 30 days?'), and smoking ('How many days have you smoked cigarettes in the previous 30 days?'). To assess the 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'. Alcohol use and smoking were defined among those who had consumed alcohol or smoked at least once during the previous 30 days. Only the 2017 survey inquired about the frequency of smoking using three questions: 'How many days have you smoked combustible cigarettes in the previous 30 days?', 'How many days have you smoked heat-not-burn tobacco in the previous 30 days?', and 'How many days have you smoked electronic cigarettes in the previous 30 days?' Each question had seven options: '0 days', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days', or 'every day'. Thus, this analysis regarded combustible cigarette users as smokers in the 2017 survey.

Intention to pursue further education after graduating from senior high school

We assessed the intention to pursue further education after graduating from school ('What is your intention after graduating from school? Choose the option closest to your current feelings'). Seven options were given: 'senior high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', and 'unknown'. The intention to further education after graduating from school was categorised into four groups: (1) senior high school graduation, (2) junior college (2-year college/vocational school), (3) college or higher educational degree (4- or 6-year college/graduate school), and (4) unknown.

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Data analysis

Proportions and 95% confidence intervals (CI) presented in the Tables were calculated using a weighting method based on one-stage stratified cluster sampling.[20] Age-adjusted rates were described by using the number of junior high and senior high school students nationwide in the School Basic Survey conducted by the Ministry of Education, Science and Technology (2017) as a standard population. The Cochran–Armitage trend test was performed to clarify the linear trend in prevalence by year. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using JMP Pro version 13 for Windows (SAS Institute Inc., Cary, NC, USA). Missing data were excluded from the analysis. To measure the rate of change in prevalence, we calculated

the reduction rate using the following formula: reduction rate = (Prevalence in 1996 - Prevalence in 2017) / Prevalence in 1996.

RESULTS

Differences in the baseline characteristics of participating schools, students (sex and grade), alcohol use in the previous 30 days, and smoking in the previous 30 days are presented in Table 1. From 1996 to 2017 the prevalence of alcohol use and smoking decreased steadily without retardation.

Table 1. Characteristics of the study participants in 1996, 2000, 2004, 2008, 2012, and 2017

Year	- 19	1996 (n=11584)		2000		004	20	08	20	012	20	017
	(n=1			6297)	(n=10	02451)	(n=9	5680)	(n=1	0050)	(n=64	4152)
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Sex												
Boys	57116	(49.3)	54576	(51.3)	55998	(54.7)	48525	(50.7)	51587	(51.6)	34582	(53.9)
Girls	58698	(50.7)	51721	(48.7)	46453	(45.3)	47155	(49.3)	48463	(48.4)	29570	(46.1)
School grade												
Junior high school (12–15 y/o)												
Grade 7	14369	(12.4)	15372	(14.5)	13146	(12.8)	13302	(13.9)	13405	(13.4)	7384	(11.5)
Grade 8	14118	(12.2)	15916	(15.0)	13079	(12.8)	13649	(14.3)	12884	(12.9)	7329	(11.4)
Grade 9	14311	(12.4)	15958	(15.0)	13160	(12.8)	12925	(13.5)	12205	(12.2)	7415	(11.6)
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	275	(0.3)	0	(0.0)	87	(0.1)
Senior high school (15–18 y/o)												
Grade 10	24696	(21.3)	21142	(19.9)	21815	(21.3)	20157	(21.1)	21480	(21.5)	14201	(22.1)
Grade 11	25416	(21.9)	19600	(18.4)	21530	(21.0)	18328	(19.2)	20026	(20.0)	14212	(22.2)
Grade 12	22904	(19.8)	18309	(17.2)	19721	(19.2)	16785	(17.5)	20050	(20.0)	13404	(20.9)
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	259	(0.3)	0	(0.0)	120	(0.2)
Alcohol use/smoking												
Alcohol use in the previous 30 days	44545	(38.7)	39497	(37.4)	30233	(29.7)	16110	(16.9)	12034	(12.1)	3584	(5.6)
Smoking in the previous 30 days	20070	(17.9)	16237	(15.7)	9614	(9.5)	4966	(5.2)	2851	(2.9)	1183	(1.8)

y/o: years old

Table 2 shows the prevalence rates for alcohol use only (30-day use), smoking only (30-day use), no-use, and couse from 1996 to 2017. In each survey, the prevalence of co-use among boys was higher than that among girls, and a significant decrease was observed in each survey, among both boys and girls (p<0.01). Accordingly, in each

survey, the prevalence of no-use among girls was higher than that among boys, and it significantly increased in each survey for both boys and girls (p<0.01). In 2017, almost all participants recorded no-use (boys 93.3%, 95% CI: 93.5–93.0; girls 95.0%, 95% CI: 95.2–94.8). The prevalence of smoking only among boys was higher than that among girls, and it decreased in each survey for both boys and girls (p < 0.01). Conversely, from 1996 to 2012, the prevalence of alcohol use only among girls was higher than that among boys, and it among girls was lower than it among boys only in 2017. In the 2017 survey, where the analysis regarded a smoker as any tobacco product user (combustible cigarette, electronic cigarette, and heat-not-burn tobacco), the differences in the prevalence were less than 0.5%.

Protected by copyright, including 18 1996 2000 2004 2008 2012 2017 19 20 % 95% CI % 95% CI % 95% CI 95% CI % 95% CI % 95% CI Sex % 21 $2\overline{2}$ No use 50.3 (50.9, 49.7) 54.7 (55.3, 54.1) 66.4 (66.9, 65.9) 80.4 (80.8, 80.0) 86.9 (87.2, 86.6) 93.3° (93.5, 93.0) 23 24 Alcohol use only 23.9 (24.2, 23.6)24.2 (24.6, 23.9)21.5 (21.8, 21.3) 12.7 (12.8, 12.5) 9.2 (9.3, 9.0) 5.1 ° (5.3, 5.0) 26^{Boys} 25 2.3 <0.01 Smoking only 6.9 (7.1, 6.8)5.8 3.2 0.5 ° (6.0, 5.7)(3.3, 3.1)(2.4, 2.2)1.3 (1.4, 1.3)(0.5, 0.5)27 <0.01 28 Co-use 18.9 (19.5, 18.3)15.3 (15.7, 14.8)8.9 (9.1, 8.6)4.7 (4.9, 4.5)2.6 (2.7, 2.5)1.1 ° (1.2, 1.0)29 <0.01 30 62.8 70.3 82.8 87.3 (87.5, 87.0) 95.0^d No use 63.2 (63.6, 62.8) (63.3, 62.4)(70.7, 69.8)(83.1, 82.4)(95.2, 94.8) 31 32 <0.01**6** Alcohol use only 26.7 (25.2, 25.3)27.2 (27.5, 26.8)23.3 (23.7, 23.0)13.8 (14.1, 13.6)11.0 (11.2, 10.8)4.3^d (4.4, 4.1)33_{Girls} <0.01 and 34 Smoking only 2.3 (2.3, 2.2)2.3 (2.4, 2.2)1.5 (1.5, 1.4)0.9 (0.9, 0.8)0.4 (0.4, 0.3)0.2^d (0.2, 0.1)35 36 <0.01**data** 7.8 7.7 0.6^{d} Co-use (8.0, 7.6) (7.9, 7.5) 5.1 (5.1, 4.8)2.5 (2.6, 2.4)1.4 (1.4, 1.3)(0.6, 0.5)3<u>7</u> <0.01 38 No use 56.8 (57.3, 56.3)58.6 (59.1, 58.2)68.1 (68.6, 67.7) 81.6 (81.9, 81.2)87.1 (87.3, 86.8) 94.1 ° (94.3, 93.9) 39 ng, Al 40 25.3 25.6 (13.4, 13.0)10.1 (10.2, 9.9) Alcohol use only (25.5, 25.1) (25.9, 25.4)22.4 (22.6, 22.1) 13.2 47° (4.9, 4.6) 41_{Both} <0.01aining, 42 Smoking only 4.6 (4.7, 4.4)4.1 (4.2, 4.0)2.4 (2.5, 2.3)1.6 (1.6, 1.5)0.9 (0.9, 0.8)0.3 e (0.4, 0.3)43 44 Co-use 13.3 (13.7, 12.9)11.6 (11.9, 11.3)7.1 (7.3, 6.9)3.6 (3.8, 3.5)2.0 (2.1, 1.9)0.9 ° (0.9, 0.8)and similar technologies. 45

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Table 2. Prevalence of alcohol use and/or smoking a in 1996, 2000, 2004, 2008, 2012, and 2017 by sex

CI, confidence interval

^a in the previous 30 days

^b based on the Cochran–Armitage trend test

^c smokers regarded as users of any tobacco products (combustible cigarette, electronic cigarette, and heat-not-burn tobacco) no use 92.8% (95% CI: 93.0, 92.5), smoking only 4.8% (95% CI: 4.9, 4.6), alcohol use only 1.0% (95% CI: 1.1, 1.0), couse 1.4% (95% CI: 1.5, 1.3)

^d smokers regarded as users of any tobacco products (combustible cigarette, electronic cigarette, and heat-not-burn tobacco) no use 94.8% (95% CI: 95.0, 94.6), smoking only 4.1% (95% CI: 4.3, 4.0), alcohol use only 0.4% (95% CI: 0.5, 0.3), couse 0.7% (95% CI: 0.6, 0.8)

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^e smokers regarded as users of any tobacco products (combustible cigarette, electronic cigarette, and heat-not-burn tobacco) no use 93.7% (95% CI: 93.9, 93.5), smoking only 4.5% (95% CI: 4.6, 4.3), alcohol use only 0.7% (95% CI: 0.8, 0.7), co-use 1.1% (95% CI: 1.2, 1.1)

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Table 3 and Figure 1 show the prevalence of alcohol use in the non-smoking and smoking groups and the prevalence of smoking in the non-drinking and drinking groups, adjusted for grade and sex. The prevalence of alcohol use in the non-smoking group was lower than that in the smoking group in each survey. In the nonsmoking group, the prevalence rates did not change in 1996 and 2000. From 2004 to 2017, it decreased in each survey among boys and girls. Conversely, it increased from 1996 to 2004 in the smoking group, and it subsequently decreased from 2004 to 2008 among boys and girls. Among boys it decreased in 2017, whereas among girls, it increased in 2012 and decreased in 2017. In the smoking group, it was higher among boys than among girls in each survey. Furthermore, the reduction rates in the non-smoking group were lower than that in the smoking group, and the reduction rate among girls in the smoking group was 0.19, which was the lowest. Similarly, the prevalence of smoking was lower in the non-drinking group than that in the drinking group. In the non-drinking group, the prevalence of smoking decreased from 1996 to 2000 among boys, whereas it increased among girls. From 2000 to 2017, it halved in each survey among boys and girls. However, in the drinking group, it decreased from 1996 to 2000 among boys, whereas it increased among girls. From 2000 to 2012 it decreased, and it slightly increased from 2012 to 2017 among boys and girls. Moreover, the reduction rates in the none drinkm_b drinking group were lower than that in the drinking group.

		Year		1996		2000		2004		2008				2017	
	Sex	Group	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	sess r	%	95% CI	Reduction rate
	D	Non-smoking	30.4	(30.3, 30.5)	30.1	(30.1, 30.2)	23.0	(22.9, 23.0)	12.7	(12.7, 12.8)	9.0	2021. igner elate	4.3	(4.3, 4.3)	0.86
Alcohol use	Boys	Smoking	72.0	(71.9, 72.1)	72.0	(71.9, 72.1)	72.5	(72.4, 72.7)	66.3	(66.1, 66.5)	64.8	(60.55600)	55.3	(54.9, 55.7)	0.23
in the	0.1	Non-smoking	27.8	(27.7, 27.8)	29.1	(29.1, 29.2)	23.7	(23.7, 23.8)	13.8	(13.8, 13.8)	10.7		3.7	(3.7, 3.8)	0.87
previous 30	Giris	Smoking	76.7	(76.5, 76.9)	76.3	(76.2, 76.5)	77.0	(76.8, 77.2)	73.7	(73.5, 74.0)	79.5	(7 9.20 17) (7 9.20 17)	62.0	(61.5, 62.5)	0.19
days		Non-smoking	29.0	(29.0, 29.0)	29.6	(29.6, 29.6)	23.4	(23.3, 23.4)	13.3	(13.2, 13.3)	9.9	ata (AB	4.0	(4.0, 4.0)	0.86
	Both	Smoking	73.3	(73.2, 73.4)	73.3	(73.2, 73.4)	74.1	(74.0, 74.2)	68.7	(68.6, 68.9)	69.2		57.4	(57.1, 57.7)	0.22
	D	Non-drinking	10.6	(10.6, 10.7)	9.2	(9.1, 9.2)	4.0	(4.0, 4.1)	2.5	(2.5, 2.5)	1.4	(⊉ 4, 1 5)	1.0	(1.0, 1.0)	0.91
	Boys	Drinking	41.2	(41.1, 41.3)	37.6	(37.5, 37.7)	27.1	(27.0, 27.2)	25.8	(25.7, 25.9)	21.3	(21) (22) (20) (20) (20) (20) (20) (20) (20	22.1	(21.9, 22.3)	0.46
Smoking in	Cirla	Non-drinking	3.1	(3.1, 3.1)	3.4	(3.3, 3.4)	1.9	(1.8, 1.9)	1.0	(1.0, 1.0)	0.4	ng .4, 0	0.4	(0.4, 0.4)	0.87
30 days	Giris	Drinking	21.4	(21.3, 21.5)	21.4	(21.3, 21.5)	17.0	(16.9, 17.1)	15.1	(15.0, 15.2)	11.2	(194.1, 1943)	14.8	(14.6, 15.0)	0.31
50 u uys	Dath	Non-drinking	6.7	(6.7, 6.7)	6.2	(6.2, 6.2)	3.0	(2.9, 3.0)	1.8	(1.8, 1.8)	0.9	00) (10)	0.7	(0.7, 0.7)	0.90
	Бош	Drinking	32.5	(32.4, 32.5)	30.2	(30.1, 30.2)	22.2	(22.2, 22.3)	20.6	(20.5, 20.7)	16.2	(16.1, 16.3)	18.9	(18.8, 19.0)	0.42
I, confider	nce inter	rval										11, 2 hnol			
adjusted fo	or age a	nd sex										2025 ogie			
reduction r	rate = (I	Prevalence in 1	996 – P	revalence in 2	2017)/	Prevalence in	n 1996					s.			
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nd 2017 by	y sex											blio			
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Table 5. Frevalence of alconol use by smoking status and prevalence of smo	oking by alcohol use among students (- <u>1</u> 2	years) in 199	0, 2000,	2004, 2	000, 2012

3 4

Table 4 shows the prevalence of smoking and/or alcohol use among senior high school students (aged 15-18 years) by sex and intention to further education, adjusted for grade and sex. The prevalence of smoking and/or alcohol use increased from 1996 to 2000 in each group. Subsequently, the prevalence has decreased since 2000. In 2012 and 2017, the prevalence was almost the same in the senior high school graduation group and junior college degree group; however, in the college and higher education degree group, prevalence was the lowest and reduction rate the highest among the three groups.

Table 4. Prevalence of smoking and/or alcohol use a among senior high school students (aged 15–18 years) in 1996, 2000, 2004, 2008, 2012, and 2017 by sex and the intention to further education ^b

	Tab	le 4. l	Prevalence	of sm	oking and/o	or alco	ohol use ^a ar	nong	senior high	schoo	ol students	(aged	15–18 years)	
	in 19 Year	996, 2	000, 2004, 2	2008,	2012, and 2 2000	2017 b	y sex and th	he into	ention to fu	rther	education ^h)	2017	
Intention fo	or	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	Reduction rate ^c
Senior high graduation	school	61.1	(61.0, 61.2)	61.7	(61.5, 61.8)	49.2	(49.1, 49.4)	33.6	(33.5, 33.8)	22.4	(22.3, 22.5)	10.9	(10.8, 10.9)	0.82
Junior colle degree	ege	52.0	(51.9, 52.1)	52.1	(52.0, 52.2)	46.0	(45.9, 46.1)	31.6	(31.5, 31.7)	22.6	(22.5, 22.7)	10.7	(10.6, 10.8)	0.79
College or l educational	higher degree	43.3	(43.2, 43.4)	45.0	(44.9, 45.1)	31.0	(31.0, 31.1)	17.8	(17.7, 17.8)	11.1	(11.1, 11.2)	5.5	(5.4, 5.5)	0.87
	CI, c	confid	ence interva	al										
	^a in t	the pro	evious 30 da	ays										
	^b adj	usted	for age and	sex										
	° red	luction	n rate = (Pre	walan	aa in 1006	ъ	1		marial amon in	1006				
				valen	ce in 1990 –	Preva	alence in 20.	I /) / P	revalence if	1 1 9 9 0	•			
			Trate (Tre	valen	ce in 1990 –	- Preva	alence in 20.	I /) / P	revalence in	1 1 9 9 0				
			Trace (Tre	valen	ce in 1990 –	- Preva	alence in 20.	[/) / P	revalence in	11990				
				valen	ce in 1990 –	- Preva	alence in 20.	I /) / P	revalence in	1 1 9 9 0				
				valen	ce in 1996 –	- Preva	alence in 20.	I /) / P		11990				
			frace (Free	evalen	ce in 1996 –	- Preva	alence in 20.	I /) / P						
				evalen	ce in 1996 –	- Preva	alence in 20.	I /) / P						
				evalen	ce ili 1996 –	Preva	alence in 20.	I /) / P						
				evalen	ce ili 1996 –	Preva	alence in 20.	I /) / P			1			
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DISCUSSION

In this study, we found a decrease in the prevalence of alcohol use and smoking among representative samples of Japanese adolescents from 1996 to 2017. Moreover, the prevalence decreased to levels lower than those in the European countries[21] and the United States.[22] We hypothesised that some people groups with certain characteristics may exhibit a delay in reducing the prevalence of alcohol use and smoking. To examine this, we compared the trend of alcohol use by dividing the students into two groups: smoking group/non-smoking group and similarly, the trend of smoking by creating two groups: drinking group/non-drinking group. The prevalence of alcohol use in the smoking group was consistently higher than that in the non-smoking group from 1996 to 2017, and the reduction rate in the smoking group decreased at a rate slower than that in the non-smoking group. Moreover, we compared the trend of smoking. The prevalence of smoking in the drinking group was consistently higher than that in the non-smoking group and examined the overall trend in the prevalence of smoking. The prevalence of smoking in the drinking group was consistently higher than that in the non-smoking group was consistently higher than that in the drinking group was consistently higher than that in the non-smoking group. Moreover, we compared the trend of smoking between the non-drinking and drinking groups and examined the overall trend in the prevalence of smoking. The prevalence of smoking in the drinking group was lower than that in the non-drinking group. In other words, the prevalence of smoking in the drinking group was lower than that in the non-drinking group. In other words, the prevalence of smoking in the drinking group was lower than that in the non-drinking group. In other words, the prevalence of smoking in the drinking group was lower than that in the non-drinking group. In other words, the prevalence of smoking in the drinking group was lower than that in the non-drinking group. These findings suggest that HRB disparity among J

The trends in alcohol and tobacco use among adults may explain our results. Adolescents' smoking behaviour is related to their parents, older brothers, older sisters, and friends.[23] In particular, boys are influenced by their fathers, and girls by their mothers.[12] In Japan, the prevalence of smoking among adults is decreasing annually for both men and women.[24] A decrease in smoking among adults may be attributed to smoking behaviour among adolescents. Adolescents' drinking behaviours are also related to their family and friends. In particular, an adolescent's drinking behaviour is more influenced by their mother's drinking behaviour than those of other family members.[13] In Japan, the prevalence of alcohol use among men is not increasing significantly, whereas it is among women.[24] This drinking behaviour among women may affect adolescents' drinking behaviour. The prevalence of alcohol use among girls in the smoking group was consistently higher than that among boys in the same group, and the reduction rate was the lowest. A probable reason for these trends is that the prevalence of alcohol use in the parents' generation, especially in women, did not decrease, unlike that of smoking. Further, girls have received considerable influence from their mothers.

Furthermore, the reduction rate in the prevalence of smoking by the drinking and non-drinking groups was higher than that in the prevalence of alcohol use by the smoking and non-smoking groups. This might have resulted from the different political measures instituted against tobacco and alcohol in Japan. Since the tobacco tax was implemented in Japan, the tobacco and consumer taxes have increased several times. Therefore, the price of a pack of 20 of the most popular brands of cigarettes in Japan increased each time. The price of a pack of 20 cigarettes in 1996 was 240 yen (equivalent to 2 USD). It increased to 250 yen (4% increase), 270 yen (8% increase), 300 yen (11% increase), 410 yen (37% increase), and 420 yen (2% increase) in 1998, 2003, 2006, 2010, and 2014, respectively. Moreover, tobacco commercials have been regulated by the self-regulation of the tobacco industry

since 1998. An increase in the price and regulation of tobacco commercials might have contributed to the decrease in smoking rate among adolescents; however, the prevalence of smoking among the drinking group increased from 2012 to 2017. However, alcohol tax varies according to the type of alcohol, and the tax for beer was almost stable since 1996 to 2017. Thus, the price of alcohol increased by only 2–3% because of the consumer tax; the cheapest beer or alcopop was sold for less than 1 USD. Before 2000, students could buy alcohol from supermarkets, convenience stores, and vending machines. Japan enacted a revision of the Act to Prohibit Minors from Alcohol Use in 2000; the penalty for selling alcoholic beverages to minors was reinforced. Furthermore, the law was revised again in 2001 to reinforce age confirmation by liquor distributors. After 2000, the number of alcohol vending machines has decreased due to the self-regulation of the alcohol industry.[25] Therefore, the decrease in the prevalence of alcohol use among adolescents since 2000 may be attributable to the aforementioned policy. However, the prevalence of alcohol use among girls in the smoking group did not change from 1996 to 2004 and increased in both sexes from 2008 to 2012. Moreover, alcohol commercials remain unbanned. These policies have different effects on each subgroup. Rising tobacco prices and deferring alcohol prices may contribute to the differences in reduction rates of the prevalence of alcohol use and smoking, respectively.

Our findings revealed that the trends in alcohol and tobacco use differ between the non-smoking and smoking groups and between the non-drinking and drinking groups. These results may be partly explained by the social context of those substance users. Some Japanese researchers have reported an association between social context and HRBs. For example, the prevalence of lifetime alcohol use and smoking in adolescent youth detention centres in Japan is much higher than that outside such centres [19]; schools and neighbourhood contexts are associated with adolescent drinking, [26] and childhood poverty has a negative effect on adult HRBs. [27] This study showed different trends in the prevalence of alcohol use and smoking in each subgroup, i.e., the lifestyle of non-drinkers and non-smokers has becoming healthier, whereas that of drinkers and smokers has not changed despite the decrease in the number of adolescent drinkers and smokers. Additionally, we observed that there were differences in the trend of prevalence of alcohol use and/or smoking with the intention of further education; the group that had the highest academic intention had the highest reduction rate, i.e., students who had higher academic intentions reduced more than those who had lower academic intentions. Students' choices after graduating from senior high school influence their future socioeconomic status and lifestyle. Some researchers have reported that HRBs, such as alcohol use and smoking, are associated with lower academic performance.[28, 29] This observation is consistent with our findings, in which there were differences in the trend of prevalence of alcohol use and/or smoking and reduction rate with intention of further education. This implies that adolescents' HRBs could be a driving factor later in their life. In order not to widen the inequality gap, the results highlight that it is important to focus on the high-risk group that delays reduction in the prevalence and find an appropriate way to approach or intervene in the group, for example, school-based interventions.

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The data were collected from periodical, nationwide large-sample surveys, which is the strength of our study. This methodology enabled us to minimize sampling bias.[16] Hence, the results of this study can potentially be generalised nationwide for Japanese adolescents. However, our study has several limitations. First, the sample of

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the subjects was possibly biased, as 30–50% of the sampled schools did not respond to these surveys. Despite the effort made by the research team, ethical concerns and inconvenience due to the need for elaborate explanations may have caused the lower rate of cooperation among schools. Concerning this, the greatest ethical issue was the requirement to meet the criteria for ethical approval. However, the characteristics of the schools that responded did not significantly differ from those of the non-responding schools. Since this tendency was consistent over the surveys, a major problem did not occur in interpreting trends in this study. Second, the fact that class teachers distributed the forms may have influenced the results. As stated above, to address the students' concerns about privacy, student questionnaires were anonymous, and the students put them into private envelopes themselves. Moreover, the explanatory document given to the class teachers explained that they must ensure the students' privacy. Notwithstanding, it is important and significant to continue conducting periodic nationwide surveys, even if they have some methodological problems.

CONCLUSION

Since 1996, the prevalence rates of drinking and smoking among Japanese adolescents have decreased. However, the trend was different between the non-drinking group/drinking group and the non-smoking group/smoking group. In other words, HRB disparity among Japanese adolescents exists and has been widening. From a sub-analysis, students who had higher academic intentions presented the greater reduction in the prevalence of alcohol use and smoking among adolescents, it is imperative to comprehensively adapt interventions, enlighten adults and parents, raise the prices of tobacco and alcohol, and regulate sale promotions. Furthermore, in order to not widen the inequality gap, the results highlight that it is important to focus on the high-risk group that delays improvement, considers social contexts, and finds a good way to approach or intervene in the group.

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Authors' contributions

YoO, 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, YuK, and AI carried out the statistical analyses. MF wrote the first draft of the manuscript. All authors have read and approved the manuscript.

Competing interest statement

The authors declare that they have no competing interests.

Data availability

The data are owned by research group and cannot be shared by the authors.

Ethic approval and consent to participate

The participants were older than 12 years of age. Before the survey, the school principals provided the 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).

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Year	19	96	200	2000		2004		2008		2012		17
	n ('	%)	n (9	%)								
Junior high school												
(A) Number of schools in Japan	11194		11153		11060		10882		10018		10325	
(B) Number of schools sampled (%)	122	(1.1)	132	(1.2)	131	(1.2)	130	(1.2)	140	(1.4)	98	(0.9)
(C) Number of schools which took part	80		99		92		92		94		48	
Response rate	65.6		75.0		70.2		70.8		67.1		49.0	
Senior high school												
(D) Number of schools in Japan	5330		5315		5193		5115		4603		4907	
(E) Number of schools sampled (%)	109	(2.0)	102	(1.9)	109	(2.1)	110	(2.2)	124	(2.7)	86	(1.8)
(F) Number of schools which took part	73		77		87		80		85		55	
Response rate	67.0		75.5		79.8		72.7		68.5		64.0	

Supplementary Table 1. Sampling of the study-participating schools in 1996, 2000, 2004, 2008, 2012, and 2017

Supplementary Figure 1. Flowchart of data collection





Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below. Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation. Upload your completed checklist as an extra file when you submit to a journal. In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as: von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Page Reporting Item Number Title and abstract Title Indicate the study's design with a commonly used term in the #1a title or the abstract

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1 2	Abstract	<u>#1b</u>	Provide in the abstract an informative and balanced summary	2
3 4 5			of what was done and what was found	
6 7 8	Introduction			
9 10 11	Background /	<u>#2</u>	Explain the scientific background and rationale for the	3
12 13 14	rationale		investigation being reported	
15 16 17	Objectives	<u>#3</u>	State specific objectives, including any prespecified	3
18 19			hypotheses	ļ
20 21 22	Methods			g
23 24 25	Study design	<u>#4</u>	Present key elements of study design early in the paper	3
26 27 28	Setting	<u>#5</u>	Describe the setting, locations, and relevant dates, including	3-4
29 30			periods of recruitment, exposure, follow-up, and data	
31 32 33			collection	
34 35	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of	3-4
36 37 38			selection of participants.	
39 40 41		<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential	4 4
41 42 43			confounders, and effect modifiers. Give diagnostic criteria, if	
44 45 46			applicable	
40 47 48	Data sources /	<u>#8</u>	For each variable of interest give sources of data and details	3-4
49 50	measurement		of methods of assessment (measurement). Describe	9
51 52 53			comparability of assessment methods if there is more than	
54 55			one group. Give information separately for for exposed and	
56 57 58			unexposed groups if applicable.	
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2	Bias	<u>#9</u>	Describe any efforts to address potential sources of bias	ана 3 сре
3 4 5	Study size	<u>#10</u>	Explain how the study size was arrived at	3-5 st
6 7 8	Quantitative	<u>#11</u>	Explain how quantitative variables were handled in the	4 ee
9 10	variables		analyses. If applicable, describe which groupings were	ras io Pr
11 12 13			chosen, and why	otected
14 15 16	Statistical	<u>#12a</u>	Describe all statistical methods, including those used to	by copy 4
17 18 19	methods		control for confounding	right, in
20 21	Statistical	<u>#12b</u>	Describe any methods used to examine subgroups and	cluding 4
22 23 24	methods		interactions	4 Augus for uses
25 26 27	Statistical	<u>#12c</u>	Explain how missing data were addressed	sr 2021. s relatec 4
28 29 30	methods			to text
30 31 32	Statistical	<u>#12d</u>	If applicable, describe analytical methods taking account of	perieur and da 4
33 34 35	methods		sampling strategy	(ABES) ta minin
36 37 38	Statistical	<u>#12e</u>	Describe any sensitivity analyses	n/a H
39 40	methods			aining, a
41 42 43	Results			and simi
44 45 46	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg	lar tech
47 48			numbers potentially eligible, examined for eligibility,	nologi
49 50			confirmed eligible, included in the study, completing follow-	es. Al Al
51 52			up, and analysed. Give information separately for for	gence
53 54 55			exposed and unexposed groups if applicable.	
56 57 58	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	n/a qu
59 60		For pee	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	edei

1 2 3	Participants	<u>#13c</u>	Consider use of a flow diagram	n/a
4 5	Descriptive data	<u>#14a</u>	Give characteristics of study participants (eg demographic,	5
6 7			clinical, social) and information on exposures and potential	
8 9 10			confounders. Give information separately for exposed and	
10 11 12 13			unexposed groups if applicable.	Protected
14 15	Descriptive data	<u>#14b</u>	Indicate number of participants with missing data for each	5 by co
16 17 18			variable of interest	pyrignt, i
19 20	Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures.	6-9 Includ
21 22 22			Give information separately for exposed and unexposed	ng tor
23 24 25 26			groups if applicable.	uses reia
27 28	Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-	6-9 to
29 30			adjusted estimates and their precision (eg, 95% confidence) text a
31 32			interval). Make clear which confounders were adjusted for	ind dat
33 34 35 36			and why they were included	ta mining,
37 38	Main results	<u>#16b</u>	Report category boundaries when continuous variables were	n/a tra
39 40 41			categorized	ining, an
42 43	Main results	<u>#16c</u>	If relevant, consider translating estimates of relative risk into	n/a Simi
44 45 46			absolute risk for a meaningful time period	lar techno
47 48 40	Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups	6-9 gie
49 50 51 52			and interactions, and sensitivity analyses	ņ
53 54 55	Discussion			
56 57 58	Key results	<u>#18</u>	Summarise key results with reference to study objectives	10
59 60		For pee	r review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

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Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources	11-12
		of potential bias or imprecision. Discuss both direction and	
		magnitude of any potential bias.	
Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives,	12
		limitations, multiplicity of analyses, results from similar	IOlect
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Generalisability	<u>#21</u>	Discuss the generalisability (external validity) of the study	n/a
		results	
Other Information			
Funding	<u>#22</u>	Give the source of funding and the role of the funders for the	13
		present study and, if applicable, for the original study on	
		which the present article is based	ופאו מי
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Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide cross-sectional surveys 1996–2017

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1 ARTICLE 2 Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide cross-3 sectional surveys 1996-2017 4

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32 ABSTRACT 33 Objectives: This study aimed to assess the trend in the prevalence of alcohol use in non-smokers' and smokers' 34 groups and that of smoking in non-drinkers' and drinkers' groups using Japanese school-based nationwide surveys. 35 Design: Nationwide cross-sectional surveys were conducted between 1996 and 2017. 36 Setting: Surveyed schools, both junior and senior high schools, considered representative of the entire Japanese nation, were sampled randomly. 37 Participants: Enrolled students completed a self-reported and anonymous questionnaire on smoking and drinking behaviour. 40 Results: Since 1996, the prevalence of alcohol use and smoking among adolescents decreased in each survey. 41 The prevalence of alcohol use in the non-smokers' group was 29.0% in 1996 and 4.0% in 2017, and in the smokers' group, was 73.3% in 1996 and 57.4% in 2017. The reduction rate (the difference in prevalence between 1996 and 2017 divided by the prevalence in 1996) was 0.86 in the non-smokers' group and 0.22 in the smokers' group. The prevalence of smoking in the non-drinkers' group was 6.7% in 1996 and 0.7% in 2017, while that in the drinkers' group. The refore, downward trends differed among the groups. In a sub-analysis limited to senior high school students, we divided students in three groups according to the intention to pursue further education. 74 Between 1996 and 2017, there was a consistent difference in the prevalence of alcohol use and smoking among Japanese adolescents seems to have improved. 75 Metrefore, specific groups showed	2		
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69 INTRODUCTION

Smoking causes approximately eight million deaths worldwide annually, and the harmful use of alcohol results in approximately three million deaths. [1, 2] Smoking and alcohol consumption usually start during adolescence, leading to the detrimental consequences of an epidemic of non-communicable diseases in adulthood. Health risk behaviours (HRBs) are shaped by social, economic, and cultural forces and are major determinants of ill health and health-related inequalities across the course of life.[3–5] Therefore, adolescence is a key period for controlling HRBs. Some studies have identified alcohol use, smoking, drug use, and risky sexual behaviours as risk behaviour clusters[6-9] and socioeconomic status as a strong predictor of engaging in multiple-risk behaviours.[10] Since 1996, our research group has been monitoring alcohol use and smoking among adolescents in Japan. According to reports, the prevalence of alcohol use and smoking among adolescents in Japan has continued to decline and is reported to be lower than that in the European countries and the United States.[11, 12] Researchers from other countries have reported a different trend in the prevalence of smoking and alcohol use in some adolescents over time. For instance, socioeconomic backgrounds had the shortest transition period to daily smokers in France [13] higher educational aspiration was negatively associated with alcohol use behaviour in Finland, [14] and adolescents who were not in school were inclined to smoke in China.[15] Moreover, some studies have reported on alcohol consumption and health inequality, and higher rates of morbidity and mortality in adults with a lower socioeconomic status.[16–19] In Japan, despite the improvement in the situation on alcohol use and smoking among Japanese adolescents, the prevalence of alcohol use and smoking have not reached the goal of 0% that Japanese government had established. Furthermore, because health inequalities and social disparities are current public health issues in Japan, [20] there may be groups that have not improved. Therefore, it is important to examine whether an HRB disparity exists among Japanese adolescents. Few studies have focused on the co-use of alcohol and tobacco and the analysis of trends in subgroups. Hence, we focused on the co-use of alcohol and tobacco and hypothesised that some groups may have certain characteristics that can reduce the prevalence of alcohol use and smoking. To further improve the status of alcohol use and smoking among adolescents, it is essential to evaluate these groups and implement interventions. Incidentally, drug use among adolescents in Japan is not a major problem; the prevalence rate of drug use among teenagers was 0% in 2015.[21] Therefore, the present study aimed to evaluate the nationwide prevalence of smoking and alcohol use, as they were main substance-use problems and have been investigated as HRBs among Japanese adolescents.

98 METHODS

99 Study population

This was a cross-sectional random sampling survey that used single-stage cluster sampling.[22] Sampling was performed by dividing Japan into regional blocks and randomly selecting schools from each block. Using the national school directory, junior high schools and senior high schools throughout Japan were randomly extracted, and all students enrolled in the sampled schools were participants of the study. The number, selection rate, and response rate of the schools for each survey are shown in Supplementary Table 1. The response rates of schools ranged between 49.0% and 79.8%.

59 106 To verify our hypothesis, the research population was divided into the following subgroups: smokers' group/non-

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smokers' group, drinkers' group/non-drinkers' group, and the intention to pursue further education. Next, the
trend in prevalence of alcohol use and smoking in each group was examined
Data collection
The study was approved by the Ethics Review Committee of Tottori University School of Medicine.
Supplementary Figure 1 shows the flowchart of data collection of the study. We obtained the cooperation of the
principals of all the schools and sent the survey forms to all the students. The teachers encouraged the students
to respond voluntarily and honestly. The students were given anonymised questionnaires and envelopes. The
completed questionnaires were placed in envelopes by the students themselves, and the envelopes were
collected by the teachers in a sealed state and returned to our institute.
Patient and Public Involvement
No patients were involved in this study.
Measures
Alcohol use and smoking
Alcohol users and smokers were defined as those who had consumed alcohol or smoked at least once during the
previous 30 days. The questionnaire focused on the students' experiences, frequency of alcohol use ('How many
days have you drunk alcohol in the previous 30 days?') and smoking ('How many days have you smoked
cigarettes in the previous 30 days?'), amount of alcohol use ('How much have you drunk alcohol on the drinking
day?') and smoking ('How many cigarettes have you smoked cigarettes on average per day in the previous 30
days?').
To assess the frequency of alcohol use, seven options were provided: '0 days', '1-2 days', '3-5 days', '6-9 days',
'10-19 days', '20-29 days', or 'every day'. To assess the amount of alcohol use, seven options were provided:
'No glass', 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3-5 glasses', 'More than 6 glasses', or 'Until
get drunk'.
In the 1996 and 2000 surveys, to assess smoking, seven options were provided: 'Have not smoked in previous 30
days', 'Less than 1 cigarette per day', '1-4 cigarettes', '5-9 cigarettes', '10-14 cigarettes', '15-19 cigarettes', or
'More than 20 cigarettes'; while in the 2004 to 2017 surveys eight options were provided: 'Have not smoked in
previous 30 days', 'Less than 1 cigarette per day', '1 cigarette', '2-5 cigarettes', '6-10 cigarettes', '11-15
cigarettes', '16-20 cigarettes' or 'more than 21 cigarettes'. In only the 2017 survey, the questions about cigarettes
were divided into three categories: combustible cigarette, heat-not-burn tobacco, and electronic cigarettes. Thus,
in the 2017 survey, this analysis regarded combustible cigarette users as smokers. (Supplementary File1.)
Intention to pursue further education after graduating from senior high school
We assessed the intention to pursue further education after graduating from school ('What is your intention after
graduating from school? Choose the option closest to your current feelings'). Seven options were provided: 'senior
high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', and 'unknown'.

145 The intention to further education after graduating from school was categorised into four groups: (1) senior high 146 school graduation, (2) junior college (2-year college/vocational school), (3) college or higher educational degree 147 (4- or 6-year college/graduate school), and (4) unknown.

⁹ 149 Data analysis

The proportions and 95% confidence intervals (CI) presented in the Tables were calculated using a weighting method and based on one-stage stratified cluster sampling.[22] The proportions were adjusted for grade and sex using the number of junior high and senior high school students nationwide as a standard population, from the School Basic Survey conducted by the Ministry of Education, Science and Technology (2017). A Cochran-Armitage trend test was performed to clarify the linear trend in prevalence by year. A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using JMP Pro version 13 for Windows (SAS Institute Inc., Cary, NC, USA). The participants did not include answers on their sex, grade, or age; therefore, the data were excluded from the analysis. Hence, there were no missing data in our analysis. To measure the rate of change in the prevalence, we calculated the reduction rate using the following formula: reduction rate = (Prevalence in 1996 - Prevalence in 2017) / Prevalence in 1996.

161 RESULTS

162 The differences in the baseline characteristics of participating schools, students (sex and grade), alcohol use in the 163 previous 30 days, and smoking in the previous 30 days are presented in Table 1. Between 1996 and 2017 the 164 prevalence of alcohol use and smoking decreased steadily.

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Year	19	996	2000		2004		20	08	2012		2017	
	(n=115814)		(n=106297)		(n=102451)		(n=95680)		(n=100050)		(n=64152)	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Sex												
Boys	57116	(49.3)	54576	(51.3)	55998	(54.7)	48525	(50.7)	51587	(51.6)	34582	(53.9
Girls	58698	(50.7)	51721	(48.7)	46453	(45.3)	47155	(49.3)	48463	(48.4)	29570	(46.1
School grade												
Junior high school (12-15 y/o)												
Grade 7	14369	(12.4)	15372	(14.5)	13146	(12.8)	13302	(13.9)	13405	(13.4)	7384	(11.5
Grade 8	14118	(12.2)	15916	(15.0)	13079	(12.8)	13649	(14.3)	12884	(12.9)	7329	(11.4
Grade 9	14311	(12.4)	15958	(15.0)	13160	(12.8)	12925	(13.5)	12205	(12.2)	7415	(11.6
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	275	(0.3)	0	(0.0)	87	(0.1)
Senior high school (15-18 y/o)												
Grade 10		(21.3)	21142	(19.9)	21815	(21.3)	20157	(21.1)	21480	(21.5)	14201	(22.1
Grade 11	25416	(21.9)	19600	(18.4)	21530	(21.0)	18328	(19.2)	20026	(20.0)	14212	(22.2
Grade 12	22904	(19.8)	18309	(17.2)	19721	(19.2)	16785	(17.5)	20050	(20.0)	13404	(20.9
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	259	(0.3)	0	(0.0)	120	(0.2)
Alcohol use/smoking												
Alcohol use in the previous 30 days	44545	(38.7)	39497	(37.4)	30233	(29.7)	16110	(16.9)	12034	(12.1)	3584	(5.6)
Smoking in the previous 30 days	20070	(17.9)	16237	(15.7)	9614	(9.5)	4966	(5.2)	2851	(2.9)	1183	(1.8)
67 y/o: years old												
68												
69 Supplementary Figure 2 sho	ws the ch	nange in	the pro	evalenc	e of alc	ohol us	e from	1996 to	0 2012 1	betweer	n the 7tl	h
70 grade and 11th grade and be	tween the	e 8th gr	ade and	l 12th g	rade in	every f	four-yea	ır surve	y; and l	between	n the 7tl	h
71 grade in 2012 and the 12th gr	ade in 20	17. Sup	plemen	tary Fig	gure 3 sl	hows th	e chang	e in the	prevale	ence of	smoking	g
in the same groups described	in Suppl	ementa	ry Figu	re 2. Bo	oth the p	orevaler	nce of a	lcohol ı	ise and	that of	smoking	g
among the same grade showe	ed a redu	ction ov	ver time									
74												
75 Table 2 shows the prevalence	rates for	alcoho	l use on	ly, smo	king on	lv. no-ı	use, and	co-use	in the n	revious	30 dav	S

between 1996 and 2017. In each survey, the prevalence of co-use among boys was higher than that among girls, while a significant decrease was observed in each survey, for both boys and girls (p < 0.01). Accordingly, in each survey, the prevalence of no-use among girls was higher than that among boys and was significantly increased in each survey for both boys and girls (p < 0.01). In 2017, almost all of the participants recorded no-use (boys 93.3%, 95% CI: 93.5-93.0; girls 95.0%, 95% CI: 95.2-94.8). The prevalence of smoking only among boys was higher than that among girls, and it decreased in each survey for both boys and girls (p < 0.01). Conversely, between 1996 and 2012, the prevalence of alcohol use only among girls was higher than that among boys, while in 2017,

it was lower than among boys.

Table 2. Prevalence of alcohol use and/or smoking in 1996, 2000, 2004, 2008, 2012, and 2017 by sex

0 1 2 3 4 5 6Boys	No use		0/											
2 3 4 5 6 _{Boys}	No use		70	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
4 5 б _{Воуз}		b	50.3	(50.9, 49.7)	54.7	(55.3, 54.1)	66.4	(66.9, 65.9)	80.4	(80.8, 80.0)	86.9	(87.2, 86.6)	93.3	(93.5, 93.0)
6 Boys	Alcoho	ol use only ^b	23.9	(24.2, 23.6)	24.2	(24.6, 23.9)	21.5	(21.8, 21.3)	12.7	(12.8, 12.5)	9.2	(9.3, 9.0)	5.1	(5.3, 5.0)
7 7	Smoki	ng only ^b	6.9	(7.1, 6.8)	5.8	(6.0, 5.7)	3.2	(3.3, 3.1)	2.3	(2.4, 2.2)	1.3	(1.4, 1.3)	0.5	(0.5, 0.5)
8 9	Co-use	, b	18.9	(19.5, 18.3)	15.3	(15.7, 14.8)	8.9	(9.1, 8.6)	4.7	(4.9, 4.5)	2.6	(2.7, 2.5)	1.1	(1.2, 1.0)
0 1 2	No use	b	63.2	(63.6, 62.8)	62.8	(63.3, 62.4)	70.3	(70.7, 69.8)	82.8	(83.1, 82.4)	87.3	(87.5, 87.0)	95.0	(95.2, 94.8)
2 3	Alcoho	ol use only ^b	26.7	(25.2, 25.3)	27.2	(27.5, 26.8)	23.3	(23.7, 23.0)	13.8	(14.1, 13.6)	11.0	(11.2, 10.8)	4.3	(4.4, 4.1)
4Girls 5	Smoki	ng only ^b	2.3	(2.3, 2.2)	2.3	(2.4, 2.2)	1.5	(1.5, 1.4)	0.9	(0.9, 0.8)	0.4	(0.4, 0.3)	0.2	(0.2, 0.1)
6 7	Co-use	;	7.8	(8.0, 7.6)	7.7	(7.9, 7.5)	5.1	(5.1, 4.8)	2.5	(2.6, 2.4)	1.4	(1.4, 1.3)	0.6	(0.6, 0.5)
8 9	No use	b	56.8	(57.3, 56.3)	58.6	(59.1, 58.2)	68.1	(68.6, 67.7)	81.6	(81.9, 81.2)	87.1	(87.3, 86.8)	94.1	(94.3, 93.9)
0 1	Alcoho	ol use only ^b	25.3	(25.5, 25.1)	25.6	(25.9, 25.4)	22.4	(22.6, 22.1)	13.2	(13.4, 13.0)	10.1	(10.2, 9.9)	4.7	(4.9, 4.6)
2Both 3	Smoki	ng only ^b	4.6	(4.7, 4.4)	4.1	(4.2, 4.0)	2.4	(2.5, 2.3)	1.6	(1.6, 1.5)	0.9	(0.9, 0.8)	0.3	(0.4, 0.3)
4 5	Co-use	, b	13.3	(13.7, 12.9)	11.6	(11.9, 11.3)	7.1	(7.3, 6.9)	3.6	(3.8, 3.5)	2.0	(2.1, 1.9)	0.9	(0.9, 0.8)
5 7 18	86	CI, confic	lence ii	nterval					L					
3 18	87	^a based or	the Co	ochran-Arm	itage t	rend test								
) 18	88	^b in the pr	evious	30days										
, 18	89													
19	90	Suppleme	entary [Fable 2 and	Table	3 shows th	e amo	ount of alcol	10l us	e among alc	ohol ı	users on driv	nking	day for
s 4 10	91	three grou	ıns [.] 'le	ss than 2 gl	asses'	'more than	3 ola	sses' and 'u	ntil ge	et drunk' an	d num	ber of ciga	rettes s	smoked
5 10	92	among en	nokers	on average i	ner day	y for two gr	nine.	less than Q	10) ci	garettes' and	1 'mor	than $10(1)$	1) cios	arettes'
5 ¹ 7 10	22 03	Retween	1006	and 2017 the	nreve	lence of (1_{2})	oupo,	2 also sec^{2}	alcoh	ol usors tond	led to	increase in	avery	
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9 1	9 4 05	Generale	2004 8	anu 2017 li	ne pre				igare	ues smoke				Sunctry.
י בי ג 1	30	Suppleme	ntary 1	able 4 and	5 shov	vs the days	or alco	onoi arunk a	unong	alconol use	is for	inree group	s; 1–9	y days,
2 19	96	`10–29 da	iys', ar	nd 'every da	y', an	d days of ci	garett	e smoked ar	nong	smokers for	three	groups; '1–	9 days	s´, `10–

Between 1996 and 2017 the prevalence of 'less than 2 glasses' alcohol users tended to increase in every survey. Between 2004 and 2017 the prevalence of 'more than 11 cigarettes' smokers did not increase distinctly. Supplementary Table 4 and 5 shows the days of alcohol drunk among alcohol users for three groups; '1–9 days', '10-29 days', and 'every day', and days of cigarette smoked among smokers for three groups; '1-9 days', '10-29 days', and 'every day'. For alcohol users, it did not change distinctly, while in smokers, every day smokers tended to decrease.

Table 3 and Figure 1 show the prevalence of alcohol use in the non-smokers' and smokers' groups and the prevalence of smoking in the non-drinkers' and drinkers' groups, adjusted for grade and sex. The prevalence of

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alcohol use in the non-smokers' group was lower than that in the smokers' group in each survey. In the non-smokers' group, the prevalence rates did not change in the surveys of 1996 and 2000. However, in the 2004 to 2017 surveys, it decreased in each survey among both boys and girls. Conversely, it increased between 1996 and 2004 in the smokers' group, and subsequently decreased between 2004 and 2008 among both boys and girls. Among boys it decreased in 2017, whereas among girls, it increased in 2012 and decreased in 2017. In the smokers' group, it was higher among boys than among girls in each survey. Furthermore, the reduction rates in the non-smokers' group were lower than that in the smokers' group; the reduction rate among girls in the smokers' group was 0.19, which was the lowest. Similarly, the prevalence of smoking was lower in the non-drinkers' group than that in the drinkers' group. In the non-drinkers' group, the prevalence of smoking decreased between 1996 and 2000 among boys, whereas it increased among girls. Between 2000 and 2017, it halved in each survey among both boys and girls. However, in the drinkers' group, it decreased between 1996 and 2000 among boys, whereas it did not change among girls. Between 2000 and 2012 it decreased, and between 2012 and 2017, it increased Br.. slightly among boys and girls. Moreover, the reduction rates in the non-drinkers' group were lower than that in the drinkers' group.
and 2017 by	v sex											3 on ding			
Numerator Denominator				1996		2000		2004		2008		20 f2 Au		2017	Dadaati
Numerator	J	Denominator	⁰∕₀ ª	95% CI	⁰∕₀ a	95% CI	% ^a	95% CI	⁰∕₀ a	95% CI	% ^a	gu∐st Ense Ses	⁰∕₀ a	95% CI	Reducti
	D	Non-smokers	30.4	(30.3, 30.5)	30.1	(30.1, 30.2)	23.0	(22.9, 23.0)	12.7	(12.7, 12.8)	9.0	2021 Piggne relatu	4.3	(4.3, 4.3)	0.
Alcohol use	Boys	Smokers	72.0	(71.9, 72.1)	72.0	(71.9, 72.1)	72.5	(72.4, 72.7)	66.3	(66.1, 66.5)	64.8	(64.39.690)	55.3	(54.9, 55.7)	0.
in the	Cirla	Non-smokers	27.8	(27.7, 27.8)	29.1	(29.1, 29.2)	23.7	(23.7, 23.8)	13.8	(13.8, 13.8)	10.7		3.7	(3.7, 3.8)	0
previous 30	GIrls	Smoker	76.7	(76.5, 76.9)	76.3	(76.2, 76.5)	77.0	(76.8, 77.2)	73.7	(73.5, 74.0)	79.5	and (70 c	62.0	(61.5, 62.5)	0
days	Dath	Non-smokers	29.0	(29.0, 29.0)	29.6	(29.6, 29.6)	23.4	(23.3, 23.4)	13.3	(13.2, 13.3)	9.9	frôm r (AE lata r	4.0	(4.0, 4.0)	0
	Бош	Smokers	73.3	(73.2, 73.4)	73.3	(73.2, 73.4)	74.1	(74.0, 74.2)	68.7	(68.6, 68.9)	69.2		57.4	(57.1, 57.7)	0
	Boys	Non-drinkers	10.6	(10.6, 10.7)	9.2	(9.1, 9.2)	4.0	(4.0, 4.1)	2.5	(2.5, 2.5)	1.4	g,4 ,1 <mark>0</mark>)	1.0	(1.0, 1.0)	0
a 1	Boys	Drinkers	41.2	(41.1, 41.3)	37.6	(37.5, 37.7)	27.1	(27.0, 27.2)	25.8	(25.7, 25.9)	21.3	(2 4 , 2 4 , 2 6 , 5)	22.1	(21.9, 22.3)	0
Smoking in the previous 30 days	Girls	Non-drinkers	3.1	(3.1, 3.1)	3.4	(3.3, 3.4)	1.9	(1.8, 1.9)	1.0	(1.0, 1.0)	0.4	(4 , 0 4)	0.4	(0.4, 0.4)	0
	Girls	Drinkers	21.4	(21.3, 21.5)	21.4	(21.3, 21.5)	17.0	(16.9, 17.1)	15.1	(15.0, 15.2)	11.2		14.8	(14.6, 15.0)	0
2	Both	Non-drinkers	6.7	(6.7, 6.7)	6.2	(6.2, 6.2)	3.0	(2.9, 3.0)	1.8	(1.8, 1.8)	0.9	(19, 00)	0.7	(0.7, 0.7)	0
	Both	Drinkers	32.5	(32.4, 32.5)	30.2	(30.1, 30.2)	22.2	(22.2, 22.3)	20.6	(20.5, 20.7)	16.2		18.9	(18.8, 19.0)	0
CI, confiden ^a adjusted fo	ce inter r age ar	rval nd sex										• 11, 2025 chnologie			
° reduction r	ate = (1	revalence in 1	996 - PT	evalence in 2	017)71	Prevalence in	1996					at Agence Bibliographiqu			
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Table 4 shows the prevalence of alcohol use and smoking among senior high school students (aged 15–18 years) by the intention to pursue further education, adjusted for grade and sex. The prevalence of alcohol use decreased in each survey among the three groups, except for the junior college degree group between 1996 and 2000. The prevalence of smoking decreased in each survey among the three groups, except for the three groups, except for the high school graduation group and college or the higher educational degree group between 1996 and 2000. Both the prevalence of alcohol use and smoking in the college or higher educational degree groups were the lowest in each survey, with the reduction rate being the highest among the three groups.

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						BN	ЛJ Open				mjopen-202 1 by copyrigt			
231	Table 4. Prevalence of alcohol use a	nd the	prevalence	of smo	king among	senior	high school	studen	ts (aged 15-	18 year	0-0450996, ht, includi	2000,	2004, 2008, 2	2012, and 2017
232	the intention to pursue further educ	ation									on 4			
			1996		2000		2004		2008				2017	Reduction rat
		0∕0 a	95%CI	% ^a	95%CI	0∕0 a	95%CI	0∕0 a	95%CI	% a	esrei;	0∕0 a	95%CI	
	Alcohol use in the previous 30 days										021. gnen late			
	High school graduation	52.7	(52.6, 52.9)	53.1	(52.9, 53.2)	43.7	(43.6, 43.9)	29.2	(29.0, 29.3)	19.9		9.4	(9.4, 9.5)	0.82
	Junior college degree	46.7	(46.6, 46.8)	47.1	(47.0, 47.2)	42.8	(42.6, 42.9)	28.8	(28.7, 29.0)	21.6		9.8	(9.7, 9.8)	0.79
	College or higher educational degree	18.0	(17.9, 18.1)	16.6	(16.5, 16.6)	10.1	(10.1, 10.2)	5.7	(5.7, 5.8)	3.2	anceric	1.8	(1.8, 1.8)	0.90
	Smoking in the previous 30 days										d fro 9ur (I dat			
	High school graduation	36.8	(36.7, 36.9)	37.7	(37.5, 37.8)	23.7	(23.6, 23.8)	15.5	(15.4, 15.7)	7.6		4.0	(3.9, 4.0)	0.89
	Junior college degree	23.4	(23.3, 23.5)	22.6	(22.5, 22.7)	15.3	(15.2, 15.4)	10.2	(10.1, 10.3)	5.0	n.(4.905.0)	3.0	(3.0, 3.1)	0.87
	College or higher educational degree	13.1	(13.0, 13.2)	14.6	(14.6, 14.7)	6.7	(6.6, 6.7)	3.1	(3.1, 3.1)	1.4	A (1.3 - 1.4)	1.0	(1.0, 1.0)	0.92
233	CI, confidence interval										jope trair			
234	^a adjusted for grade and sex										n.brr ning,			
235	^b reduction rate = (Prevalence in 1996)	- Preva	alence in 201	7) / Pre	evalence in 19	996.					nj.co			
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DISCUSSION

In this study, we found a decrease in the prevalence of alcohol use and smoking among the representative samples of Japanese adolescents between 1996 and 2017. Moreover, the prevalence decreased to levels lower than those in the European countries [23] and the United States. [24] Japan and other countries have shown a declining trend in alcohol and tobacco.[23-26] which may have been due to the influence of the devaluation of alcohol and tobacco, as well as socio- economic changes. In terms of alcohol, reports have indicated that the global decline in youth drinking behaviour may have been due to a change in the societal and economic devaluation of alcohol.[27-29] Regarding the frequencies of alcohol use and smoking, the results of this study have indicated that among alcohol users and smokers the prevalence of frequent users and greater users did not show an increase. Tobacco control activity may have influenced those smokers who found it easier to quit while the remaining smokers were those who were less likely to stop smoking [30,31] In moving towards the goal of the prevalence of smoking being zero among adolescents, the numbers are reducing; however, close attention needs to be paid to existing smokers who cannot quit smoking. We hypothesised that some groups with certain characteristics may exhibit a delay in reducing the prevalence of alcohol use and smoking. To examine this, we compared the trend of alcohol use by dividing the students into two groups: the smokers' and non-smokers' groups and similarly, the trend of smoking by creating two groups: the drinkers' group and non-drinkers' groups. Between 1996 and 2017, the prevalence of alcohol use in the smokers' group was consistently higher than that in the non-smokers' group, and the reduction rate in the smokers' group was lower than that in the non-smokers' group. In other words, the prevalence of alcohol use in the smokers' group decreased at a rate slower than that in the non-smokers' group. Moreover, we compared the trend of smoking between the non-drinkers' and drinkers' groups and examined the overall trend in the prevalence of smoking. Between 1996 and 2017, the prevalence of smoking in the drinkers' group was consistently higher than that in the non-drinkers' group, and the reduction rate in the drinkers' group was lower than that in the non-drinkers' group. In other words, the prevalence of smoking in the drinkers' group decreased at a rate slower than that in the non-drinkers' group. These findings suggest that not only does an HRB disparity exist among Japanese adolescents but that it may be widening. The trends in alcohol and tobacco use among the people around adolescents may explain our results. Adolescents' smoking behaviour is related to their parents, older brothers, older sisters, and friends.[32] In terms of their friends, the school environment influenced their alcohol use and smoking behaviour.[33,34] Of the 153 schools that participated in the 1996 survey, the prevalence of alcohol use in every participating school ranged from 12.1% to

76.0% and that of smoking from 0.7% to 50.5%. All these participating schools had at least one student who drank alcohol and smoked tobacco. Of the 103 schools that participated in the 2017 survey, the prevalence of alcohol use in every participating school ranged from 0% to 13.8% and that of smoking from 0% to 8.8%. There were two schools (1.9%) where no student did use alcohol in previous 30 days, and 17 schools (16.5%) where no student did smoke in previous 30 days. Although the differences in prevalence between schools were reducing, they still existed. Adolescent drinking and smoking prevention efforts should include enhancing the collective efficacy of schools. In terms of their families, boys are influenced by their fathers and girls by their mothers.[11] In Japan, the prevalence of smoking among adults was shown to have decreased annually for both men and women, [35] which may be the reason for the smoking behaviour among adolescents. Adolescents' drinking behaviours are

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also related to their family and friends. In particular, an adolescent's drinking behaviour is more influenced by their mother's drinking behaviour than those of other family members.[12] In Japan, the prevalence of alcohol use among men has not increased significantly, whereas among women, it has.[35] This drinking behaviour among women may affect adolescents' drinking behaviour. The prevalence of alcohol use among girls in the smokers' group was consistently higher than that among boys in the same group, and the reduction rate was the lowest. A probable reason for these trends is that the prevalence of alcohol use in the parents' generation, especially in women, did not decrease, unlike that of smoking. Further, girls were influenced, considerably, by their mothers. Furthermore, the reduction rate in the prevalence of smoking by the drinkers' and non-drinkers' groups was higher than the prevalence of alcohol use in the smokers' and non-smokers' groups. This may have been the result of the different political measures instituted against tobacco and alcohol use in Japan. Since implementation of tobacco tax in Japan, tobacco and consumer taxes have increased several times, with the price of a pack of 20 of the most popular brands of cigarettes in Japan increasing each time. The price of a pack of 20 cigarettes in 1996 was 240 yen (equivalent to 2 USD). It increased to 250 yen (4% increase), 270 yen (8% increase), 300 yen (11% increase), 410 yen (37% increase), and 420 yen (2% increase) in 1998, 2003, 2006, 2010, and 2014, respectively. Self-regulation of the tobacco industry from 1998 has resulted in the regulation of tobacco commercials. An increase in the price and regulation of tobacco commercials may have contributed to the decrease in the rate of smoking among adolescents; however, the prevalence of smoking among the drinkers' group increased between 2012 and 2017. Moreover, the alcohol tax varied according to type of alcohol, and the tax on beer was stable between 1996 and 2017. Thus, the price of alcohol increased by only 2-3% because of the consumer tax; the cheapest beer or alcopop was sold for less than 1 USD. Prior to 2000, students could buy alcohol from supermarkets, convenience stores, and vending machines. In 2000, Japan enacted a revision of the Act to Prohibit Minors from using alcohol with a reinforcement of the penalty for selling alcoholic beverages to minors. Furthermore, the law was revised again in 2001 to reinforce age confirmation by liquor distributors. After 2000, the number of alcohol vending machines also decreased due to the self-regulation of the alcohol industry.[36] Therefore, the decrease in the prevalence of alcohol use among adolescents since 2000 may be attributed to the aforementioned policy. However, from 2004, a bigger decrease was shown among both the smokers' and non-smokers' groups, suggesting that although alcohol policies were changed in 2000, their effect was delayed as the policies were spread widely and slowly. Moreover, alcohol commercials remained unbanned. These policies had different effects on each subgroup. Rising tobacco prices and deferring alcohol prices may have contributed to the differences in the reduction rates of the prevalence of alcohol use and smoking, respectively. Our findings revealed that the trends in alcohol use and smoking differed between the non-smokers' and smokers' groups and between the non-drinkers' and drinkers' groups. These results may be partly explained by the social

context of those substance users. Some Japanese researchers have reported an association between the social context and HRBs. For example, the prevalence of lifetime alcohol use and smoking in adolescent youth detention centres in Japan was found to be much higher than that outside such centres, [21] schools and neighbourhood contexts were also found to be associated with adolescent drinking,[33] and childhood poverty had a negative effect on adult HRBs.[37] This study showed different trends in the prevalence of alcohol use and smoking in each subgroup, i.e., the lifestyle of non-drinkers and non-smokers has become healthier, whereas that of drinkers

 and smokers has not changed despite the decrease in the number of adolescent drinkers and smokers. Additionally, we observed that there were differences in the trends of the prevalence of alcohol use and the prevalence of smoking by what their intentions were with regards to pursuing further education: the group that had the highest academic intention had the highest reduction rate, i.e., students who had higher academic intentions showed a greater decrease in prevalence compared with those who had lower academic intentions. Students' choices after graduating from senior high school influenced their future socioeconomic status and lifestyle. Some researchers have reported that HRBs, such as alcohol use and smoking, were associated with lower academic performances.[38, 39] This observation was consistent with our findings, where there were differences in the trends of prevalence of alcohol use and smoking and reduction rate with the intention to pursue further education. This implied that adolescents' HRBs could be a driving factor later in their life. In order to not widen the inequality gap, these results highlighted the importance of focusing on the high-risk groups that delay the reduction in the prevalence and develop appropriate strategies to approach or intervene in this group, for example, school-based interventions.

The strength of our study is that the data were collected from periodical, nationwide large-sample surveys. This methodology enabled us to minimize any sampling bias.[22] Hence, the results of this study can potentially be generalised nationwide for Japanese adolescents. However, our study also had several limitations. First, the sample of the participants was possibly biased, as 30–50% of the sampled schools did not respond to the surveys. Despite the effort made by the research team, ethical concerns and inconvenience due to the need for elaborate explanations may have been reasons for the lower rate of cooperation among schools. Concerning this, the greatest ethical issue was the requirement to meet the criteria required for ethical approval. However, the characteristics of the schools that responded did not differ significantly from those of the non-responding schools. Since this tendency was consistent across the surveys, the trends in this study were interpreted easily. Second, although student questionnaires were anonymous and the students put them into private envelopes themselves, the distribution of the forms by class teachers may have influenced the results. Moreover, the explanatory document given to the class teachers explained that they had to ensure the students' privacy. Notwithstanding these limitations, it is important to continue conducting periodic nationwide surveys, even if some methodological problems exist.

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342 CONCLUSION

Since 1996, the prevalence rates of drinking and smoking among Japanese adolescents have decreased. However, the trend was different between the non-drinkers' and drinkers' groups and the non-smokers' group and smokers' groups. In other words, not only does an HRB disparity exist among Japanese adolescents but it may be widening. The results from the sub-analysis indicated that students who had higher academic intentions presented a greater reduction in the prevalence of alcohol use and smoking, a trend associated with their future socioeconomic status. To further improve the status of alcohol use and smoking among adolescents, it is imperative to comprehensively adapt interventions, enlighten adults and parents, raise the prices of tobacco and alcohol, and regulate sale promotions. Furthermore, in order to not widen the inequality gap, the results highlight that it is important to focus

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on the high-risk group that delays improvement, consider social contexts, and develop an appropriate strategy to

approach or intervene in this group. Acknowledgements We would like to thank Editage for English language editing. Authors' contributions YoO, SH, and YoK designed the study and devised the study protocols. OI, YuO, MJ, and HY reviewed the literature and helped summarise previous research studies. HK, AK, YuK, RM, HM and AI carried out the statistical analyses. MF wrote the first draft of the manuscript. All authors have read and approved the manuscript. **Competing interest statement** The authors declare that they have no competing interests. Data availability The data are owned by research group and cannot be shared by the authors. Ethic approval and consent to participate The participants were older than 12 years of age. Before the survey, the school principals provided the 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). Funding This study was supported by a grant for Comprehensive Research on Lifestyle-Related Diseases, including cardiovascular diseases and diabetes mellitus, from the Ministry of Health and Welfare Health Science Research Fund in Japan (grant no. 29060801). The funding body did not have any role in the design of the study; collection, analysis, and interpretation of data; or in writing the manuscript. REFERENCES Word Health Organization. WHO report on global tobacco epidemic. Available online: https://www.who.int/tobacco/global_report/en// 2019 (accessed 30 Aug 2020).

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FIGURE LEGENDS

1 2 3 4 5 6 7 8 9 10 11 12	511 512 513 514	Figure 1. Prevalence of alcohol use by smoking status and prevalence of smoking by alcohol use among students (aged 12–18 years) in 1996, 2000, 2004, 2008, 2012, and 2017 by sex ** [colour image] Figure1
 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 		
27 28 29 30 31 32 33 34 35 36 37 38 39 40		
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55		
56 57 58 59 60		19

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Supplementary File 1. The list of questions from the survey questionnaire

Students were asked to select one option in each question.

English version

1. Demographic data

- (1) Are you male or female?
 - 'Male' or 'Female'
- (2) What is your grade in school?
 - 'Grade 1', 'Grade 2', or 'Grade 3'

2. Use of Alcohol

- (1) How many days have you drunk alcohol in the previous 30 days?
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'every day'

(2) How much have you drunk alcohol on the drinking day?

'No glass' 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3--5 glasses', 'More than 6 glasses', 'Until get drunk'

3. Use of cigarettes

- (1) How many days have you smoked cigarettes in the previous 30 days?(In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'every day'
- (2) How many cigarettes have you smoked cigarettes on average per day in the previous 30 days? (In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')
 - (1996 and 2000 survey)
 - 'Have not smoked in previous 30days', 'Less than 1 cigarette per day', '1–4 cigarettes', '5–9 cigarettes', '10–14 cigarettes', '15–19 cigarettes', 'More than 20 cigarettes'
 - (From the 2004 to 2017 survey)
 - 'Have not smoked in previous 30days', 'Less than 1 cigarette per day', '1 cigarette', '2–5 cigarettes', '6–10 cigarettes', '11–15 cigarettes', '16–20 cigarettes', 'More than 21 cigarettes'

4. Intention to pursue future education

- (1) What is your intention after graduating from school? Choose the option closest to your current feelings?
 - 'senior high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', 'unknown'

Japanese version	
1. あなた自身のことについて質問します。	
(1)あなたは男性ですか、女性ですか?あてはまる数字に○をつけてください。	
1. 男性 2. 女性	
(2) あなたの学年は何年生ですか?あてはまる数字に〇をつけてください。	
1.1年生 2.2年生 3.3年生	
2. ここからはお酒についての質問です。	
(1) この 30 日間に、少しでもお酒を飲んだ日は合計何日になりますか?	
1.0日 3.3~5日 5.10~19日 7.毎日(30日)	
2. 1 か 2 日 4. 6 ~ 9 日 6. 20~29 日	
(2) お酒を飲むときにはどのくらいの量を飲みますか?	
1. 飲まない 5. コップに 3 ~ 5杯	
2.コップ1杯未満(ほんの少しの量) 6.コップに6杯以上	
3. コップに1杯 7. 酔いつぶれるまで	
4. コップに2杯	
3. ここからはタバコについての質問です。	
(1) この 30 日間に、何日、タバコを吸いましたか?	
(2017 年調査のみ「タバコ」を「紙巻きタバコ」に変更)	
1.0日 3.3~5日 5.10~19日 7.毎日(30日)	
2. $1 \Rightarrow 2 \square$ 4. $6 \sim 9 \square$ 6. $20 \sim 29 \square$	
(2) この 30 日間に、1日平均どのくらいの本数のタバコを吸いましたか?	
(2017 年調査のみ「タバコ」を「紙巻きタバコ」に変更)	
(1996年と2000年の調査)	
1. この間、吸っていない 4. 5~9本 7. 20本以上	
2.1日1本に満たない 5.10~14本	
3.1~4本 6.15~19本	
(2004年から2017年の調査)	
1. この間、吸っていない 4. 2~5本 7. 16~20本	
2.1日1本に満たない 5.6~10本 8.21本以上	
3.1本 6.11~15本	
4. あなたの将来の進学希望についてお聞きします。	
(1) 将来の進路をどのように考えていますか?今の気持ちに近いもの1つに○をつけてください	<i>, </i>
1. 高等学校 3. 短大 5. 大学院 7. わからない	
2. 専門学校 4. 大学 6. 今の学校卒業後の就職	
	Japanese version





59

60

0

2008

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Prevalence of alcohol use between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



Prevalence of smoking between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



Page 24 of 28

2012, and 2017

Supplementary Table 1. Sampling of the study-participating schools in 1996, 2000, 2004, 2008,

Year n (%) n (%) n (%) n (%) n (%) n (%) Junior high school (A) Number of schools in Japan (1.2) (B) Number of schools sampled (%) (1.1) (1.2)(1.2)(1.4) (0.9)(C) Number of schools which took part Response rate 65.6 75.0 70.2 70.8 67.1 49.0 Senior high school (D) Number of schools in Japan (E) Number of schools sampled (%) (2.0)(1.8) (1.9)(2.1)(2.2)(2.7)(F) Number of schools which took part 67.0 Response rate 75.5 79.8 72.7 68.5 64.0

Supplementary Figure 1. Flowchart of data collection





Supplementary Table 2. Amount of alcohol drunk among alcohol users on drinking day

	1996			2000		2004		2008		2012	2017		
	n=44545		n=39497		r	1=30233	r	n=16110	r	1=12034	n=3584		
	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	
Less than 2 glasses	42.1	(41.7, 42.6)	60.3	(59.9, 60.8)	60.9	(60.4, 61.5)	61.6	(60.9, 62.4)	63.8	(62.9, 64.6)	65.2	(63.6, 66.7)	
More than 3 glasses	39.4	(39.0, 39.9)	31.3	(30.9, 31.8)	32.2	(31.7, 32.7)	31.3	(30.6, 32.0)	30.2	(29.3, 31.0)	27.2	(25.7, 28.7)	
Until get drunk	10.6	(10.3, 10.9)	6.8	(6.6, 7.1)	5.9	(5.7, 6.2)	5.8	(5.4, 6.2)	4.4	(4.1, 4.8)	5.6	(4.8, 6.3)	

Cl, confidence interval

Supplementary Table 3. Number of cigarettes smoked among smokers on average per day

	1996			2000		2004		2008		2012	2017		
	n=20070		n=16237		ı	n=9614		n=4966		n=2851		n=769	
	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	
Less than 9 cigarettes	60.2	(59.5, 60.9)	74.0	(73.2, 74.5)									
More than 10 cigarettes	35.9	(35.2, 36.5)	23.0	(21.9, 23.2)	0	_		_		_		_	
Less than 10 cigarettes					67.4	(66.4, 68.3)	67.3	(66.0, 68.6)	73.2	(71.5, 74.8)	69.1	(65.8, 72.3)	
More than 11 cigarettes		—		—	29.3	(28.4, 30.2)	28.4	(27.2, 29.7)	23.1	(21.6, 24.7)	25.0	(21.9, 28.0)	

Cl, confidence interval

Supplementary Table 4. Days of alcohol drunk among alcohol users

		1996		2000		2004		2008		2012	2017		
	n=44545		n=39497		n=30233		n=16110		n=12034		n=3584		
	%	95%CI	%	95%CI									
1-9 days	91.5	(91.3, 91.8)	91.1	(90.9, 91.4)	90.1	(89.8, 90.5)	89.6	(89.2, 90.1)	90.6	(90.1, 91.1)	89.3	(88.3, 90.3)	
10-29 days	7.1	(6.8, 7.3)	8.0	(7.7, 8.3)	8.7	(8.4, 9.0)	8.9	(8.5, 9.4)	8.3	(7.8, 8.8)	9.1	(8.1, 10.0)	
every day	1.4	(1.3, 1.5)	0.9	(0.8, 1.0)	1.2	(1.1, 1.3)	1.4	(1.2, 1.6)	1.1	(1.0, 1.3)	1.6	(1.2, 2.0)	

CI, confidence interval

Supplementary Table 5. Days of cigarettes smoked among smokers

		1996 2000			2004		2008		2012	2017			
	n=20070		n=16237			n=9614	n=4966			n=2851	n=769		
	%	95%CI	%	% 95%CI		95%CI	%	95%CI	%	95%CI	%	95%CI	
 1-9 days	33.0	(32.4, 33.7)	32.3	(31.6, 33.0)	35.0	(34.0, 35.9)	38.4	(37.1, 39.8)	38.0	(36.2, 39.7)	47.2	(43.7, 50.7)	
10-29 days	19.2	(18.6, 19.7)	19.0	(18.4, 19.6)	21.0	(20.2, 21.9)	20.7	(19.6, 21.8)	23.7	(22.2, 25.3)	21.2	(18.3, 24.1)	
every day	47.8	(47.1, 48.5)	1, 48.5) 48.7 (47.9, 49.		44.0	(43.0, 45.0)	40.9	(39.5, 42.2)	38.3	(36.5, 40.1)	31.6	(28.3, 34.9)	

CI, confidence interval

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1			recruitment, exposure, follow-up, and data collection	BMJ
2 3 4 5	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of selection of participants.	3-4 n: Tirst
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9 10 11 12 13 14 15	Data sources / measurement	<u>#8</u>	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	Protected by cop
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32 33 34 35	Statistical methods	<u>#12c</u>	Explain how missing data were addressed	ur (ABES) data mining 5°
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46 47 48 49 50 51 52 53 54	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	s 11, 2025 at Agence Bib Shnologies.
55 56	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	n/a gra
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<u>#14a</u>	Give characteristics of study participants (eg demographic, clinical,	6
	social) and information on exposures and potential confounders. Give	
	information separately for exposed and unexposed groups if applicable.	
<u>#14b</u>	Indicate number of participants with missing data for each variable of	n/a
	interest	
#15	Report numbers of outcome events or summary measures. Give	6-11
$\frac{\pi 1 J}{2}$	information separately for exposed and unexposed groups if applicable	0-11
	information separately for exposed and unexposed groups if applicable.	
<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-adjusted	7-9
	estimates and their precision (eg, 95% confidence interval). Make clear	
	which confounders were adjusted for and why they were included	
#16b	Report category boundaries when continuous variables were categorized	7_9
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<u>#16c</u>	If relevant, consider translating estimates of relative risk into absolute	n/a
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#17	Report other analyses done—e.g., analyses of subgroups and	10-11
	interactions, and sensitivity analyses	
<u>#18</u>	Summarise key results with reference to study objectives	12
#19	Discuss limitations of the study, taking into account sources of potential	14
	bias or imprecision. Discuss both direction and magnitude of any	
	potential bias.	
<u>#20</u>	Give a cautious overall interpretation considering objectives,	12-14
	limitations, multiplicity of analyses, results from similar studies, and	
	other relevant evidence.	
#21	Discuss the generalisability (external validity) of the study results	n/a
<u>#22</u>	Give the source of funding and the role of the funders for the present	15
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	#14a #14b #15 #16a #16c #16c #17 #18 #19 #20 #21 #22	 #14a Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable. #14b Indicate number of participants with missing data for each variable of interest #15 Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. #16a Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included #16b Report category boundaries when continuous variables were categorized #16 If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period #17 Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses #18 Summarise key results with reference to study objectives #19 Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. #20 Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. #21 Discuss the generalisability (external validity) of the study results #22 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based eklist is distributed under the terms of the Creative Commons Attribution License CCC completed on 22. December 2020 using https://www.goodreports.org/, a tool made for the prevent with <u>Penelopeai</u>.

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Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide cross-sectional surveys 1996–2017

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1 ARTICLE 2 Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide cross-3 sectional surveys 1996-2017 4

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 - 29 Word count: 3929

3 4	32	ABSTRACT
5	33	Objectives: This study aimed to assess the trend in the prevalence of alcohol use in non-smokers' and smokers'
6 7	34	groups and that of smoking in non-drinkers' and drinkers' groups using Japanese school-based nationwide surveys.
8	35	Design: Nationwide cross-sectional surveys were conducted between 1996 and 2017.
9 10	36	Setting: Surveyed schools, both junior and senior high schools, considered representative of the entire Japanese
11	37	nation, were sampled randomly.
12 13	38	Participants: We enrolled 11,584–64,152 students from 179–103 schools yearly. They completed a self-reported
14	39	and anonymous questionnaire on smoking and drinking behaviour.
15 16	40	Results: Since 1996, the prevalence of alcohol use and smoking among adolescents decreased in each survey
17	41	(p<0.01). The prevalence of alcohol use in the non-smokers' group was 29.0% in 1996 and 4.0% in 2017, and in
18 10	42	the smokers' group, it was 73.3% in 1996 and 57.4% in 2017. The reduction rate (the difference in prevalence
20	43	between 1996 and 2017 divided by the prevalence in 1996) was 0.86 in the non-smokers' group and 0.22 in the
21 22	44	smokers' group. The prevalence of smoking in the non-drinkers' group was 6.7% in 1996 and 0.7% in 2017, while
23	45	that in the drinkers' group was 32.5% in 1996 and 18.9% in 2017. The reduction rate was 0.90 in the non-drinkers'
24 25	46	group and 0.42 in the drinkers' group. Therefore, downward trends differed among the groups. In a sub-analysis
26	47	of senior high school students, we divided students into three groups according to the intention to pursue further
27 28	48	education. Between 1996 and 2017, there was a consistent difference in the prevalence of alcohol use and smoking
28 29	49	among these groups.
30 31	50	Conclusions: The situation of alcohol use and smoking among Japanese adolescents seems to have improved.
32	51	However, specific groups showed poor improvements, and health risk behaviour disparity exists, which may
33 34	52	widen. We need to focus on high-risk groups and appropriate approaches or interventions for such groups.
35	53	
36 37	54	STRENGTHS AND LIMITATIONS OF THIS STUDY
38	55	• The data were collected from a periodical, nationwide large-sample surveys on Japanese adolescents
39 40	56	between 1996 and 2017, and the study contained a large sample size (n=11,584-64,152 per year).
41	57	• This study focused on the co-use of alcohol and tobacco and analysed its trends in the sub-groups.
42 43	58	• Due to ethical concerns and inconvenience, school response rates were not as high as expected; however,
44	59	the student-response rate was consistent.
45 46	60	• Due to the ethical concerns, we did not ask students their social and economic status and instead analysed
47	61	the trends by the students' intention to pursue further education.
48 49	62	• The study used a self-reporting questionnaire; hence further studies to examine the accuracy of its findings
50	63	are required.
51 52	64	
53 54	65	Keywords: alcohol use, smoking, adolescents, prevalence, Japan
55	66	
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68 INTRODUCTION

Smoking causes approximately eight million deaths worldwide annually, and the harmful use of alcohol results in approximately three million deaths. [1, 2] Smoking and alcohol consumption usually start during adolescence, leading to the detrimental consequences of an epidemic of non-communicable diseases in adulthood. Health risk behaviours (HRBs) are shaped by social, economic, and cultural forces and are major determinants of ill health and health-related inequalities across the course of life.[3–5] Therefore, adolescence is a key period for controlling HRBs. Some studies have identified alcohol use, smoking, drug use, and risky sexual behaviours as risk behaviour clusters[6-9] and socioeconomic status as a strong predictor of engaging in multiple-risk behaviours.[10] Since 1996, our research group has been monitoring alcohol use and smoking among adolescents in Japan. According to reports, the prevalence of alcohol use and smoking among adolescents in Japan has continued to decline and is reported to be lower than that in the European countries and the United States.[11, 12] Researchers from other countries have reported a different trend in the prevalence of smoking and alcohol use in some adolescents over time. For instance, socioeconomic backgrounds had the shortest transition period to daily smokers in France [13] higher educational aspiration was negatively associated with alcohol use behaviour in Finland, [14] and adolescents who were not in school were inclined to smoke in China.[15] Moreover, some studies have reported on alcohol consumption and health inequality and higher rates of morbidity and mortality in adults with a lower socioeconomic status.[16–19] In Japan, despite the improvement in the situation on alcohol use and smoking among Japanese adolescents, the prevalence of alcohol use and smoking have not reached the goal of 0% that Japanese government had established. Furthermore, because health inequalities and social disparities are current public health issues in Japan, [20] there may be groups that have not improved. Therefore, it is important to examine whether an HRB disparity exists among Japanese adolescents. Few studies have focused on the co-use of alcohol and tobacco and the analysis of trends in subgroups. Hence, we focused on the co-use of alcohol and tobacco and hypothesised that some groups may have certain characteristics that can reduce the prevalence of alcohol use and smoking. To further improve the status of alcohol use and smoking among adolescents, it is essential to evaluate these groups and implement interventions. Incidentally, drug use among adolescents in Japan is not a major problem; the prevalence rate of drug use among teenagers was 0% in 2015.[21] Therefore, the present study aimed to evaluate the nationwide prevalence of smoking and alcohol use, as they were main substance-use problems and have been investigated as HRBs among Japanese adolescents.

97 METHODS

98 Study population

This was a cross-sectional random sampling survey that used single-stage cluster sampling.[22] Sampling was performed by dividing Japan into regional blocks and randomly selecting schools from each block. Using the national school directory, junior high schools and senior high schools throughout Japan were randomly extracted, and all students enrolled in the sampled schools were participants of the study. The number, selection rate, and response rate of the schools for each survey are shown in Supplementary Table 1. The response rates of schools ranged between 49.0% and 79.8%.

59 105 To verify our hypothesis, the research population was divided into the following subgroups: smokers' group/non-

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3 4	106	smokers' group, drinkers' group/non-drinkers' group, and the intention to pursue further education. Next, the
5	107	trend in prevalence of alcohol use and smoking in each group was examined.
6 7	108	
8	109	Data collection
9 10	110	The study was approved by the Ethics Review Committee of Tottori University School of Medicine.
11	111	Supplementary Figure 1 shows the flowchart of data collection of the study. We obtained the cooperation of the
12 13	112	principals of all the schools and sent the survey forms to all the students. The teachers encouraged the students
14	113	to respond voluntarily and honestly. The students were given anonymised questionnaires and envelopes. The
15 16	114	completed questionnaires were placed in envelopes by the students themselves, and the envelopes were
17	115	collected by the teachers in a sealed state and returned to our institute.
18 10	116	
20	117	Patient and Public Involvement
21	118	No patients were involved in this study.
22	119	
24 25	120	Measures
25 26	121	Alcohol use and smoking
27 20	122	Alcohol users and smokers were defined as those who had consumed alcohol or smoked at least once during the
28 29	123	previous 30 days. The questionnaire focused on the students' experiences, frequency of alcohol use ('How many
30 21	124	days have you drunk alcohol in the previous 30 days?') and smoking ('How many days have you smoked
32	125	cigarettes in the previous 30 days?'), amount of alcohol use ('How much have you drunk alcohol on the drinking
33 34	126	day?') and smoking ('How many cigarettes have you smoked cigarettes on average per day in the previous 30
35	127	days?').
36 27	128	To assess the frequency of alcohol use, seven options were provided: '0 days', '1–2 days', '3–5 days', '6–9 days',
38	129	'10-19 days', '20-29 days', or 'every day'. To assess the amount of alcohol use, seven options were provided:
39 40	130	'No glass', 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3-5 glasses', 'More than 6 glasses', or 'Until
40 41	131	get drunk'.
42 42	132	In the 1996 and 2000 surveys, to assess smoking, seven options were provided: 'Have not smoked in previous 30
43 44	133	days', 'Less than 1 cigarette per day', '1-4 cigarettes', '5-9 cigarettes', '10-14 cigarettes', '15-19 cigarettes', or
45 46	134	'More than 20 cigarettes'; while in the 2004 to 2017 surveys eight options were provided: 'Have not smoked in
40 47	135	previous 30 days', 'Less than 1 cigarette per day', '1 cigarette', '2-5 cigarettes', '6-10 cigarettes', '11-15
48 40	136	cigarettes', '16-20 cigarettes' or 'more than 21 cigarettes'. (Supplementary File1.) In only the 2017 survey, the
49 50	137	questions about cigarettes were divided into three categories: combustible cigarette, heat-not-burn tobacco, and
51 52	138	electronic cigarettes. Thus, in the 2017 survey, this analysis regarded combustible cigarette users as smokers.
52 53	139	
54 55	140	Intention to pursue further education after graduating from senior high school
55 56	141	We assessed the intention to pursue further education after graduating from school ('What is your intention after
57 58	142	graduating from school? Choose the option closest to your current feelings'). Seven options were provided: 'senior
50 59 60	143	high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', and 'unknown'.

144 The intention to further education after graduating from school was categorised into four groups: (1) senior high 145 school graduation, (2) junior college (2-year college/vocational school), (3) college or higher educational degree 146 (4- or 6-year college/graduate school), and (4) unknown.

⁹ 148 Data analysis

The proportions and 95% confidence intervals (CI) presented in the Tables were calculated using a weighting method and based on one-stage stratified cluster sampling.[22] The proportions were adjusted for grade and sex using the number of junior high and senior high school students nationwide as a standard population, from the School Basic Survey conducted by the Ministry of Education, Science and Technology (2017). A Cochran-Armitage trend test was performed to clarify the linear trend in prevalence by year. A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using JMP Pro version 13 for Windows (SAS Institute Inc., Cary, NC, USA). Data of the participants that did not have information on sex, grade, or age were regarded as discrepant data and excluded from the analysis. To measure the rate of change in the prevalence, we calculated the reduction rate using the following formula: reduction rate = (Prevalence in 1996 - Prevalence in 2017) / Prevalence in 1996.

160 RESULTS

161 The differences in the baseline characteristics of participating schools, students (sex and grade), alcohol use in the 162 previous 30 days, and smoking in the previous 30 days are presented in Table 1. Between 1996 and 2017, the 163 prevalence of alcohol use and smoking decreased steadily.

	19	96	20	000	20	04	20	08	20	012	20	17
	(n=11	5814)	(n=10)6297)	(n=10	2451)	(n=9:	5680)	(n=10	00050)	(n=64	4152
	n	(%)	n	(%								
Sex												
Boys	57116	(49.3)	54576	(51.3)	55998	(54.7)	48525	(50.7)	51587	(51.6)	34582	(53
Girls	58698	(50.7)	51721	(48.7)	46453	(45.3)	47155	(49.3)	48463	(48.4)	29570	(46
School grade												
Junior high school (12-15 y/o)												
Grade 7	14369	(12.4)	15372	(14.5)	13146	(12.8)	13302	(13.9)	13405	(13.4)	7384	(11
Grade 8	14118	(12.2)	15916	(15.0)	13079	(12.8)	13649	(14.3)	12884	(12.9)	7329	(11
Grade 9	14311	(12.4)	15958	(15.0)	13160	(12.8)	12925	(13.5)	12205	(12.2)	7415	(11
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	275	(0.3)	0	(0.0)	87	(0
Senior high school (15-18 y/o)												
Grade 10	24696	(21.3)	21142	(19.9)	21815	(21.3)	20157	(21.1)	21480	(21.5)	14201	(22
Grade 11	25416	(21.9)	19600	(18.4)	21530	(21.0)	18328	(19.2)	20026	(20.0)	14212	(22
Grade 12	22904	(19.8)	18309	(17.2)	19721	(19.2)	16785	(17.5)	20050	(20.0)	13404	(20
Unknown	0	(0.0)	0	(0.0)	0	(0.0)	259	(0.3)	0	(0.0)	120	(0
Alcohol use/smoking												
Alcohol use in the previous 30 days	44545	(38.7)	39497	(37.4)	30233	(29.7)	16110	(16.9)	12034	(12.1)	3584	(5
Smoking in the previous 30 days	20070	(17.9)	16237	(15.7)	9614	(9.5)	4966	(5.2)	2851	(2.9)	1183	(1
166 y/o: years old												
167												

Supplementary Figure 2 shows the change in the prevalence of alcohol use from 1996 to 2012 between the 7th grade and 11th grade and between the 8th grade and 12th grade in every four-year survey, and between the 7th grade in 2012 and the 12th grade in 2017. Supplementary Figure 3 shows the change in smoking prevalence in the same groups described in Supplementary Figure 2. Both the prevalence of alcohol use and that of smoking among the same grade showed a reduction over time.

Table 2 shows the prevalence rates for alcohol use only, smoking only, no-use, and co-use in the previous 30 days between 1996 and 2017. In each survey, the prevalence of co-use among boys was higher than that among girls, while a significant decrease was observed in each survey for both boys and girls (p < 0.01). Accordingly, in each survey, the prevalence of no-use among girls was higher than that among boys and was significantly increased in each survey for both boys and girls (p < 0.01). In 2017, almost all the participants recorded no-use (boys 93.3%, 95% CI: 93.5-93.0; girls 95.0%, 95% CI: 95.2-94.8). The prevalence of smoking only among boys was higher than that among girls, and it decreased in each survey for both boys and girls (p < 0.01). Conversely, between 1996 and 2012, the prevalence of alcohol use only among girls was higher than that among boys, while in 2017,

it was lower than among boys.

Table 2. Prevalence of alcohol use and/or smoking in 1996, 2000, 2004, 2008, 2012, and 2017 by sex

, }	104	i adie 2.	rreva		:0101	use and/or	SINOK	2004	2000,	2008	, 2012	2012	by se	2017
,) 				1996		2000		2004		2008		2012		2017
0 1			%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
2	No use ^b		50.3	(50.9, 49.7)	54.7	(55.3, 54.1)	66.4	(66.9, 65.9)	80.4	(80.8, 80.0)	86.9	(87.2, 86.6)	93.3	(93.5, 93.0)
5 4 5	Alcohol	use only ^b	23.9	(24.2, 23.6)	24.2	(24.6, 23.9)	21.5	(21.8, 21.3)	12.7	(12.8, 12.5)	9.2	(9.3, 9.0)	5.1	(5.3, 5.0)
boys 6	Smoking	only ^b	6.9	(7.1, 6.8)	5.8	(6.0, 5.7)	3.2	(3.3, 3.1)	2.3	(2.4, 2.2)	1.3	(1.4, 1.3)	0.5	(0.5, 0.5)
3	Co-use ^b		18.9	(19.5, 18.3)	15.3	(15.7, 14.8)	8.9	(9.1, 8.6)	4.7	(4.9, 4.5)	2.6	(2.7, 2.5)	1.1	(1.2, 1.0)
,)	No use ^b		63.2	(63.6, 62.8)	62.8	(63.3, 62.4)	70.3	(70.7, 69.8)	82.8	(83.1, 82.4)	87.3	(87.5, 87.0)	95.0	(95.2, 94.8)
<u>!</u> 	Alcohol	use only ^b	26.7	(25.2, 25.3)	27.2	(27.5, 26.8)	23.3	(23.7, 23.0)	13.8	(14.1, 13.6)	11.0	(11.2, 10.8)	4.3	(4.4, 4.1)
411s 1	Smoking	only ^b	2.3	(2.3, 2.2)	2.3	(2.4, 2.2)	1.5	(1.5, 1.4)	0.9	(0.9, 0.8)	0.4	(0.4, 0.3)	0.2	(0.2, 0.1)
5 5	Co-use		7.8	(8.0, 7.6)	7.7	(7.9, 7.5)	5.1	(5.1, 4.8)	2.5	(2.6, 2.4)	1.4	(1.4, 1.3)	0.6	(0.6, 0.5)
	No use ^b		56.8	(57.3, 56.3)	58.6	(59.1, 58.2)	68.1	(68.6, 67.7)	81.6	(81.9, 81.2)	87.1	(87.3, 86.8)	94.1	(94.3, 93.9)
	Alcohol	use only ^b	25.3	(25.5, 25.1)	25.6	(25.9, 25.4)	22.4	(22.6, 22.1)	13.2	(13.4, 13.0)	10.1	(10.2, 9.9)	4.7	(4.9, 4.6)
th	Smoking	only ^b	4.6	(4.7, 4.4)	4.1	(4.2, 4.0)	2.4	(2.5, 2.3)	1.6	(1.6, 1.5)	0.9	(0.9, 0.8)	0.3	(0.4, 0.3)
	Co-use ^b		13.3	(13.7, 12.9)	11.6	(11.9, 11.3)	7.1	(7.3, 6.9)	3.6	(3.8, 3.5)	2.0	(2.1, 1.9)	0.9	(0.9, 0.8)
	185	CI, conf	idence	interval										
	186	^a based o	on the	Cochran-Ar	nitage	e trend test								
	187	^b in the p	oreviou	ıs 30days										
	188													
	189	Supplen	nentary	Table 2 and	d Tab	le 3 show th	ie prev	valence of th	ne amo	ount of alco	hol us	ed among a	lcohol	users on
	190	drinking	day fo	or three grou	ps; 'le	ess than 2 gla	asses'.	, 'more than	3 glas	ses' and 'un	til get	drunk', and	the p	revalence
	191	of the av	verage	number of c	igare	ttes smoked	amon	ig smokers r	er dav	y for two gr	oups;	'less than 9	(10) c	igarettes'
	192	and 'mo	re thar	10(11) cig	arettes	s.' Between	1996	and 2017 th	e prev	valence of 'l	ess th	an 2 glasses	s' alco	hol users
	193	tended t	o incre	ase in everv	surve	ev. Between	2004	and 2017 th	e prev	valence of '1	more t	han 11 ciga	rettes'	smokers
	194	did not i	ncreas	e distinctly	Sunn	lementary T	able 4	and 5 show	the n	revalence of	f the n	umber of da	ivs alc	cohol was
	195	used in f	he last	30 days am	onga	lcohol users	for th	ree groups.	۹ د	lavs', '10–2	9 dav	s', and 'ever	v dav	' and the
	196	nrevaler	ce of t	he number o	of day	s of smoking	o cioa	rettes in the	< last 3() davs amon	o smc	kers for the	e oro	, uns: '1_9
	107	dave? '1		hous' and w	voru	day' Ear al	o o nga	usara it did	not al	ango distin	othy	while in amo	kora s	ups, 1-7

Supplementary Table 2 and Table 3 show the prevalence of the amount of alcohol used among alcohol users on drinking day for three groups; 'less than 2 glasses', 'more than 3 glasses' and 'until get drunk', and the prevalence of the average number of cigarettes smoked among smokers per day for two groups; 'less than 9(10) cigarettes' and 'more than 10(11) cigarettes.' Between 1996 and 2017 the prevalence of 'less than 2 glasses' alcohol users tended to increase in every survey. Between 2004 and 2017 the prevalence of 'more than 11 cigarettes' smokers did not increase distinctly. Supplementary Table 4 and 5 show the prevalence of the number of days alcohol was used in the last 30 days among alcohol users for three groups; '1–9 days', '10–29 days', and 'every day', and the prevalence of the number of days of smoking cigarettes in the last 30 days among smokers for three groups; '1–9 days', '10-29 days', and 'every day'. For alcohol users, it did not change distinctly, while in smokers, every day smokers tended to decrease.

Table 3 and Figure 1 show the prevalence of alcohol use in the non-smokers' and smokers' groups and the prevalence of smoking in the non-drinkers' and drinkers' groups, adjusted for grade and sex. The prevalence of

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alcohol use in the non-smokers' group was lower than that in the smokers' group in each survey. In the non-smokers' group, the prevalence rates did not change in the surveys of 1996 and 2000. However, in the 2004 to 2017 surveys, it decreased in each survey among both boys and girls. Conversely, it increased between 1996 and 2004 in the smokers' group and subsequently decreased between 2004 and 2008 among both boys and girls. Among boys, it decreased in 2017, whereas among girls, it increased in 2012 and decreased in 2017. The reduction rates in the non-smokers' group were lower than that in the smokers' group; the reduction rate among girls in the smokers' group was 0.19, which was the lowest. Similarly, the prevalence of smoking was lower in the non-drinkers' group than that in the drinkers' group. In the non-drinkers' group, the prevalence of smoking decreased between 1996 and 2000 among boys, whereas it increased among girls. Between 2000 and 2017, it halved in each survey among both boys and girls. However, in the drinkers' group, it decreased between 1996 and 2000 among boys, whereas it did not change among girls. Between 2000 and 2012, it decreased, and between 2012 and 2017, yys and g..

 p. it increased slightly among boys and girls. Moreover, the reduction rates in the non-drinkers' group were lower than that in the drinkers' group.

and 2017 by	sex /											3 on 4			
				1996		2000		2004		2008		20 f2 Au		2017	Paduatia
			⁰∕₀ ª	95% CI	% a	95% CI	⁰∕o ª	95% CI	⁰∕o a	95% CI	⁰⁄0 a	guist Egse	⁰∕₀ a	95% CI	Keducii
	D	Non-smokers	30.4	(30.3, 30.5)	30.1	(30.1, 30.2)	23.0	(22.9, 23.0)	12.7	(12.7, 12.8)	9.0	2021 >iggne relati	4.3	(4.3, 4.3)	0.8
Alcohol use	Boys	Smokers	72.0	(71.9, 72.1)	72.0	(71.9, 72.1)	72.5	(72.4, 72.7)	66.3	(66.1, 66.5)	64.8		55.3	(54.9, 55.7)	0.2
in the	0.1	Non-smokers	27.8	(27.7, 27.8)	29.1	(29.1, 29.2)	23.7	(23.7, 23.8)	13.8	(13.8, 13.8)	10.7		3.7	(3.7, 3.8)	0.3
previous 30	Girls	Smokers	76.7	(76.5, 76.9)	76.3	(76.2, 76.5)	77.0	(76.8, 77.2)	73.7	(73.5, 74.0)	79.5	and (7d c	62.0	(61.5, 62.5)	0.
days	Deth	Non-smokers	29.0	(29.0, 29.0)	29.6	(29.6, 29.6)	23.4	(23.3, 23.4)	13.3	(13.2, 13.3)	9.9	frôm r (AE lata r	4.0	(4.0, 4.0)	0.
	Both	Smokers	73.3	(73.2, 73.4)	73.3	(73.2, 73.4)	74.1	(74.0, 74.2)	68.7	(68.6, 68.9)	69.2		57.4	(57.1, 57.7)	0.
	Dava	Non-drinkers	10.6	(10.6, 10.7)	9.2	(9.1, 9.2)	4.0	(4.0, 4.1)	2.5	(2.5, 2.5)	1.4		1.0	(1.0, 1.0)	0.
Smoking in the previous 30 days	Boys	Drinkers	41.2	(41.1, 41.3)	37.6	(37.5, 37.7)	27.1	(27.0, 27.2)	25.8	(25.7, 25.9)	21.3	(2 4 .2, 20.5)	22.1	(21.9, 22.3)	0.
	Cirla	Non-drinkers	3.1	(3.1, 3.1)	3.4	(3.3, 3.4)	1.9	(1.8, 1.9)	1.0	(1.0, 1.0)	0.4	(4 , 1111111111111	0.4	(0.4, 0.4)	0.
	Giris	Drinkers	21.4	(21.3, 21.5)	21.4	(21.3, 21.5)	17.0	(16.9, 17.1)	15.1	(15.0, 15.2)	11.2		14.8	(14.6, 15.0)	0.
	Both	Non-drinkers	6.7	(6.7, 6.7)	6.2	(6.2, 6.2)	3.0	(2.9, 3.0)	1.8	(1.8, 1.8)	0.9	sig (9, 0 0)	0.7	(0.7, 0.7)	0.
	Бош	Drinkers	32.5	(32.4, 32.5)	30.2	(30.1, 30.2)	22.2	(22.2, 22.3)	20.6	(20.5, 20.7)	16.2		18.9	(18.8, 19.0)	0.
CI, confiden	ce inte	rval										e 11, chno			
^a adjusted fo	r grade	and sex										202! logi			
^b reduction r	ate = $(]$	Prevalence in 1	996 - Pr	evalence in 2	017)/3	Prevalence in	1996					es.			
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3	222	Table 4 shows the prevalence of alcohol use and smoking among senior high school students (aged 15–18 years)
4 5	223	by the intention to pursue further education, adjusted for grade and sex. The prevalence of alcohol use decreased
6 7	224	in each survey among the three groups, except for the junior college degree group between 1996 and 2000. The
8	225	prevalence of smoking decreased in each survey among the three groups, except for the high school graduation
9 10	226	group and college or the higher educational degree group between 1996 and 2000. Both the prevalence of
11	227	alcohol use and smoking in the college or higher educational degree groups were the lowest in each survey, with
12	228	the reduction rate being the highest among the three groups.
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230	Table 4. Prevalence of alcohol use a	nd the	prevalence	of smo	king among	senior	high school	studen	ts (aged 15-	18 year	0-0450996	, 2000,	2004, 2008,	2012, and 2017
231	the intention to pursue further educ	ation									3 on ding			
			1996		2000		2004		2008		2012 A		2017	
		⁰∕₀ a	95%CI	% a	95%CI	⁰⁄₀ a	95%CI	⁰∕₀ a	95%CI	% a		⁰∕₀ a	95%CI	Reduction rate
	Alcohol use in the previous 30 days										202 eigno relat			
	High school graduation	52.7	(52.6, 52.9)	53.1	(52.9, 53.2)	43.7	(43.6, 43.9)	29.2	(29.0, 29.3)	19.9) 9.4	(9.4, 9.5)	0.82
	Junior college degree	46.7	(46.6, 46.8)	47.1	(47.0, 47.2)	42.8	(42.6, 42.9)	28.8	(28.7, 29.0)	21.6	o ກະວ ຜູ້ຜູ້ຜູ້ກາງ 1.7) 9.8	(9.7, 9.8)	0.79
	College or higher educational degree	18.0	(17.9, 18.1)	16.6	(16.5, 16.6)	10.1	(10.1, 10.2)	5.7	(5.7, 5.8)	3.2		1.8	(1.8, 1.8)	0.90
	Smoking in the previous 30 days										eur d da			
	High school graduation	36.8	(36.7, 36.9)	37.7	(37.5, 37.8)	23.7	(23.6, 23.8)	15.5	(15.4, 15.7)	7.6	ta (ABS) m(BBS),7.6)	4.0	(3.9, 4.0)	0.89
	Junior college degree	23.4	(23.3, 23.5)	22.6	(22.5, 22.7)	15.3	(15.2, 15.4)	10.2	(10.1, 10.3)	5.0	ini(4.95.0)	3.0	(3.0, 3.1)	0.87
	College or higher educational degree	13.1	(13.0, 13.2)	14.6	(14.6, 14.7)	6.7	(6.6, 6.7)	3.1	(3.1, 3.1)	1.4	A (1.3	1.0	(1.0, 1.0)	0.92
232	CI, confidence interval										train			
33	^a adjusted for grade and sex										ing,			
234	^b reduction rate = (Prevalence in 1996	- Preva	alence in 201	7) / Pre	evalence in 1	996.					j.con and			
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In this study, we found a decrease in the prevalence of alcohol use and smoking among the representative samples

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DISCUSSION

of Japanese adolescents between 1996 and 2017. Moreover, the prevalence decreased to levels lower than those in the European countries [23] and the United States. [24] Japan and other countries have shown a declining trend in alcohol and tobacco.[23-26] which may have been due to the influence of the devaluation of alcohol and tobacco, as well as socio-economic changes. In terms of alcohol, reports have indicated that the global decline in youth drinking behaviour may have been due to a change in the societal and economic devaluation of alcohol.[27-29] Tobacco control activity may have influenced those smokers who found it easier to guit while the remaining smokers were those who were less likely to stop smoking.[30,31] However, regarding the frequencies of alcohol use and smoking, the results of this study have indicated that among alcohol users and smokers, the prevalence of frequent and greater users did not show an increase. The situation of alcohol use and smoking among Japanese adolescents seems to have improved, while the prevalence of alcohol use and smoking have not reached the goal of 0% established by Japanese government. In this study, we hypothesised that some groups with certain characteristics may exhibit a delay in decreasing the prevalence of alcohol use and smoking. To examine this, we compared the trend of alcohol use by dividing the students into two groups: the smokers' and non-smokers' groups and similarly, the trend of smoking by creating two groups: the drinkers' group and non-drinkers' groups. Between 1996 and 2017, the prevalence of alcohol use in the smokers' group was consistently higher than that in the non-smokers' group, and the reduction rate in the smokers' group was lower than that in the non-smokers' group. In other words, the prevalence of alcohol use in the smokers' group decreased at a rate slower than that in the non-smokers' group. Moreover, we compared the trend of smoking between the non-drinkers' and drinkers' groups and examined the overall trend in the prevalence of smoking. Between 1996 and 2017, the prevalence of smoking in the drinkers' group was consistently higher than that in the non-drinkers' group, and the reduction rate in the drinkers' group was lower than that in the non-drinkers' group. In other words, the prevalence of smoking in the drinkers' group decreased at a rate slower than that in the non-drinkers' group. These findings suggest that not only does an HRB disparity exist among Japanese adolescents but that it may be widening. The trends in alcohol and tobacco use among the people around adolescents may explain our results. Adolescents' smoking behaviour is related to their parents, older brothers, older sisters, and friends.[32] In terms of their friends, the school environment influenced their alcohol use and smoking behaviour.[33,34] Of the 153 schools that participated in the 1996 survey, the prevalence of alcohol use in every participating school ranged from 12.1% to 76.0% and that of smoking from 0.7% to 50.5%. All these participating schools had at least one student who drank alcohol and smoked tobacco. Of the 103 schools that participated in the 2017 survey, the prevalence of alcohol use in every participating school ranged from 0% to 13.8% and that of smoking from 0% to 8.8%. There were two schools (1.9%) where no student did use alcohol in previous 30 days, and 17 schools (16.5%) where no student did smoke in previous 30 days. Although the differences in prevalence between schools were reducing, they still existed. Adolescent drinking and smoking prevention efforts should include enhancing the collective efficacy of

schools. In terms of their families, boys are influenced by their fathers and girls by their mothers.[11] In Japan, the prevalence of smoking among adults was shown to have decreased annually for both men and women, [35] which may be the reason for the smoking behaviour among adolescents. Adolescents' drinking behaviours are

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also related to their family and friends. In particular, an adolescent's drinking behaviour is more influenced by their mother's drinking behaviour than those of other family members.[12] In Japan, the prevalence of alcohol use among men has not increased significantly, whereas among women, it has.[35] This drinking behaviour among women may affect adolescents' drinking behaviour. The prevalence of alcohol use among girls in the smokers' group was consistently higher than that among boys in the same group, and the reduction rate was the lowest. A probable reason for these trends is that the prevalence of alcohol use in the parents' generation, especially in women, did not decrease, unlike that of smoking. Further, girls were influenced, considerably, by their mothers. Furthermore, the reduction rate in the prevalence of smoking by the drinkers' and non-drinkers' groups was higher than the prevalence of alcohol use in the smokers' and non-smokers' groups. This may have been the result of the different political measures instituted against tobacco and alcohol use in Japan. Since implementation of tobacco tax in Japan, tobacco and consumer taxes have increased several times, with the price of a pack of 20 of the most popular brands of cigarettes in Japan increasing each time. The price of a pack of 20 cigarettes in 1996 was 240 yen (equivalent to 2 USD). It increased to 250 yen (4% increase), 270 yen (8% increase), 300 yen (11% increase), 410 yen (37% increase), and 420 yen (2% increase) in 1998, 2003, 2006, 2010, and 2014, respectively. Self-regulation of the tobacco industry from 1998 has resulted in the regulation of tobacco commercials. An increase in the price and regulation of tobacco commercials may have contributed to the decrease in the rate of smoking among adolescents; however, the prevalence of smoking among the drinkers' group increased between 2012 and 2017. Moreover, the alcohol tax varied according to type of alcohol, and the tax on beer was stable between 1996 and 2017. Thus, the price of alcohol increased by only 2-3% because of the consumer tax; the cheapest beer or alcopop was sold for less than 1 USD. Prior to 2000, students could buy alcohol from supermarkets, convenience stores, and vending machines. In 2000, Japan enacted a revision of the Act to Prohibit Minors from using alcohol with a reinforcement of the penalty for selling alcoholic beverages to minors. Furthermore, the law was revised again in 2001 to reinforce age confirmation by liquor distributors. After 2000, the number of alcohol vending machines also decreased due to the self-regulation of the alcohol industry.[36] Therefore, the decrease in the prevalence of alcohol use among adolescents since 2000 may be attributed to the aforementioned policy. However, from 2004, a bigger decrease was shown among both the smokers' and non-smokers' groups, suggesting that although alcohol policies were changed in 2000, their effect was delayed as the policies were spread widely and slowly. Moreover, alcohol commercials remained unbanned. These policies had different effects on each subgroup. Rising tobacco prices and deferring alcohol prices may have contributed to the differences in the reduction rates of the prevalence of alcohol use and smoking, respectively. Our findings revealed that the trends in alcohol use and smoking differed between the non-smokers' and smokers'

groups and between the non-drinkers' and drinkers' groups. These results may be partly explained by the social context of those substance users. Some Japanese researchers have reported an association between the social context and HRBs. For example, the prevalence of lifetime alcohol use and smoking in adolescent youth detention centres in Japan was found to be much higher than that outside such centres, [21] schools and neighbourhood contexts were also found to be associated with adolescent drinking,[33] and childhood poverty had a negative effect on adult HRBs.[37] This study showed different trends in the prevalence of alcohol use and smoking in each subgroup, i.e., the lifestyle of non-drinkers and non-smokers has become healthier, whereas that of drinkers

 and smokers has not changed despite the decrease in the number of adolescent drinkers and smokers. Additionally, we observed that there were differences in the trends of the prevalence of alcohol use and the prevalence of smoking by what their intentions were with regards to pursuing further education: the group that had the highest academic intention had the highest reduction rate, i.e., students who had higher academic intentions showed a greater decrease in prevalence compared with those who had lower academic intentions. Students' choices after graduating from senior high school influenced their future socioeconomic status and lifestyle. Some researchers have reported that HRBs, such as alcohol use and smoking, were associated with lower academic performances.[38, 39] This observation was consistent with our findings, where there were differences in the trends of prevalence of alcohol use and smoking and reduction rate with the intention to pursue further education. This implied that adolescents' HRBs could be a driving factor later in their life. In order to not widen the inequality gap, these results highlighted the importance of focusing on the high-risk groups that delay the reduction in the prevalence and develop appropriate strategies to approach or intervene in this group, for example, school-based interventions.

The strength of our study is that the data were collected from periodical, nationwide large-sample surveys. This methodology enabled us to minimize any sampling bias.[22] Hence, the results of this study can potentially be generalised nationwide for Japanese adolescents. However, our study also had several limitations. First, the sample of the participants was possibly biased, as 30–50% of the sampled schools did not respond to the surveys. Despite the effort made by the research team, ethical concerns, and inconvenience due to the need for elaborate explanations may have been reasons for the lower rate of cooperation among schools. Concerning this, the greatest ethical issue was the requirement to meet the criteria required for ethical approval. However, the characteristics of the schools that responded did not differ significantly from those of the non-responding schools. Since this tendency was consistent across the surveys, the trends in this study were interpreted easily. Second, although student questionnaires were anonymous and the students put them into private envelopes themselves, the distribution of the forms by class teachers may have influenced the results. Moreover, the explanatory document given to the class teachers explained that they had to ensure the students' privacy. Notwithstanding these limitations, it is important to continue conducting periodic nationwide surveys, even if some methodological problems exist.

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341 CONCLUSION

Since 1996, the prevalence rates of drinking and smoking among Japanese adolescents have decreased. However, the trend was different between the non-drinkers' and drinkers' groups and the non-smokers' group and smokers' groups. In other words, not only does an HRB disparity exist among Japanese adolescents but it may be widening. The results from the sub-analysis indicated that students who had higher academic intentions presented a greater reduction in the prevalence of alcohol use and smoking, a trend associated with their future socioeconomic status. To further improve the status of alcohol use and smoking among adolescents, it is imperative to comprehensively adapt interventions, enlighten adults and parents, raise the prices of tobacco and alcohol, and regulate sale promotions. Furthermore, in order to not widen the inequality gap, the results highlight that it is important to focus
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4	350	on the high-risk group that delays improvement, consider social contexts, and develop an appropriate strategy to
5 6	351	approach or intervene in this group.
7	352	
8 0	353	
J 10	354	Acknowledgements
11	355	We would like to thank Editage for English language editing.
12 13	356	
14	357	Authors' contributions
15 16	358	YoO, SH, and YoK designed the study and devised the study protocols. OI, YuO, MJ, and HY reviewed the
17	359	literature and helped summarise previous research studies. HK, AK, YuK, RM, HM and AI carried out the
18 19	360	statistical analyses. MF wrote the first draft of the manuscript. All authors have read and approved the manuscript.
20	361	
21 22	362	Competing interest statement
22	363	The authors declare that they have no competing interests.
24	364	
25 26	365	Data availability
27	366	The data are owned by research group and cannot be shared by the authors.
28 29	367	
30	368	Ethic approval and consent to participate
31 32	369	The participants were older than 12 years of age. Before the survey, the school principals provided the participants'
33	370	parents with the details of the survey. The parents were advised that they were allowed to refuse participation if
34 25	371	they were reluctant to allow their children to take part in the survey. In other words, the parents were given the
36	372	opportunity to opt their children out of the survey, if they were not comfortable with them participating in the
37	373	survey. The students whose parents refused permission for the survey were not included. This survey and opt out
38 39	374	parental consent procedure were approved by the Ethics Review Committee of Tottori University Faculty of
40	375	Medicine (reference no. 17A078).
41 42	376	
43	377	Funding
44 45	378	This study was supported by a grant for Comprehensive Research on Lifestyle-Related Diseases, including
46	379	cardiovascular diseases and diabetes mellitus, from the Ministry of Health and Welfare Health Science Research
47 19	380	Fund in Japan (grant no. 29060801). The funding body did not have any role in the design of the study; collection,
49	381	analysis, and interpretation of data; or in writing the manuscript.
50	382	
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1 2 3 4 5 6 7 8 9 10	510 511 512 513	Figure 1. Prevalence of alcohol use by smoking status and prevalence of smoking by alcohol use among students (aged 12–18 years) in 1996, 2000, 2004, 2008, 2012, and 2017 by sex ** [colour image] Figure1
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 435 36 37 38 39 40 41 42		
43 44 45 46		
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Supplementary Table 1. Sampling of the study-participating schools in 1996, 2000, 2004, 2008, 2012, and 2017

n 11194 122 80 65.6 5330 109 73 67.0	(%) (1.1) (2.0)	n 11153 132 99 75.0 5315 102 77	(%) (1.2) (1.9)	n 11060 131 92 70.2 5193 109	(%)	n 10882 130 92 70.8 5115	(%)	n 10018 140 94 67.1 4603	(%)	n 10325 98 48 49.0	(%)
11194 122 80 65.6 5330 109 73 67.0	(1.1)	11153 132 99 75.0 5315 102 77	(1.2)	11060 131 92 70.2 5193 109	(1.2)	10882 130 92 70.8 5115	(1.2)	10018 140 94 67.1 4603	(1.4)	10325 98 48 49.0	(0.9)
11194 122 80 65.6 5330 109 73 67.0	(1.1)	11153 132 99 75.0 5315 102 77	(1.2)	11060 131 92 70.2 5193 109	(1.2)	10882 130 92 70.8 5115	(1.2)	10018 140 94 67.1 4603	(1.4)	10325 98 48 49.0	(0.9)
122 80 65.6 5330 109 73 67.0	(1.1)	132 99 75.0 5315 102 77	(1.2)	131 92 70.2 5193 109	(1.2)	130 92 70.8 5115	(1.2)	140 94 67.1 4603	(1.4)	98 48 49.0	(0.9)
80 65.6 5330 109 73 67.0	(2.0)	99 75.0 5315 102 77	(1.9)	92 70.2 5193 109	(2.1)	92 70.8 5115		94 67.1 4603		48 49.0	
65.6 5330 109 73 67.0	(2.0)	75.0 5315 102 77	(1.9)	70.2 5193 109	(2.1)	70.8 5115		67.1 4603		49.0	
5330 109 73 67.0	(2.0)	5315 102 77	(1.9)	5193 109	(2.1)	5115		4603			
5330 109 73 67.0	(2.0)	5315 102 77	(1.9)	5193 109	(2.1)	5115		4603			
109 73 67.0	(2.0)	102 77	(1.9)	109	(2.1)	110				4907	
73 67.0		77				110	(2.2)	124	(2.7)	86	(1.8)
67.0				87		80		85		55	
Ò,		75.5		79.8		72.7		68.5		64.0	

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Supplementary Table 2. Prevalence of the amount of alcohol used among alcohol users on drinking day

		1996		2000		2004		2008		2012		2017
	r	1=44545	r	=39497	r	1=30233	r	n=16110	r	1=12034		n=3584
	%	95%CI										
Less than 2 glasses	42.1	(41.7, 42.6)	60.3	(59.9, 60.8)	60.9	(60.4, 61.5)	61.6	(60.9, 62.4)	63.8	(62.9, 64.6)	65.2	(63.6, 66.7)
More than 3 glasses	39.4	(39.0, 39.9)	31.3	(30.9, 31.8)	32.2	(31.7, 32.7)	31.3	(30.6, 32.0)	30.2	(29.3, 31.0)	27.2	(25.7, 28.7)
Until get drunk	10.6	(10.3, 10.9)	6.8	(6.6, 7.1)	5.9	(5.7, 6.2)	5.8	(5.4, 6.2)	4.4	(4.1, 4.8)	5.6	(4.8, 6.3)

Cl, confidence interval

Supplementary Table 3. Prevalence of the average number of cigarettes smoked among smokers per day

		1996		2000		2004		2008		2012		2017
	r	1=20070		=16237		n=9614		n=4966		n=2851		n=769
	%	95%CI										
Less than 9 cigarettes	60.2	(59.5, 60.9)	74.0	(73.2, 74.5)								
More than 10 cigarettes	35.9	(35.2, 36.5)	23.0	(21.9, 23.2)	0	_		_		_		_
Less than 10 cigarettes					67.4	(66.4, 68.3)	67.3	(66.0, 68.6)	73.2	(71.5, 74.8)	69.1	(65.8, 72.3)
More than 11 cigarettes					29.3	(28.4, 30.2)	28.4	(27.2, 29.7)	23.1	(21.6, 24.7)	25.0	(21.9, 28.0)

Cl, confidence interval

		1996		2000		2004		2008		2012		2017
	n	=44545	r	1=39497	r	1=30233	r	=16110	n	=12034	I	n=3584
	%	95%CI										
1-9 days	91.5	(91.3, 91.8)	91.1	(90.9, 91.4)	90.1	(89.8, 90.5)	89.6	(89.2, 90.1)	90.6	(90.1, 91.1)	89.3	(88.3, 90.3)
10-29 days	7.1	(6.8, 7.3)	8.0	(7.7, 8.3)	8.7	(8.4, 9.0)	8.9	(8.5, 9.4)	8.3	(7.8, 8.8)	9.1	(8.1, 10.0)
every day	1.4	(1.3, 1.5)	0.9	(0.8, 1.0)	1.2	(1.1, 1.3)	1.4	(1.2, 1.6)	1.1	(1.0, 1.3)	1.6	(1.2, 2.0)

Cl, confidence interval

Supplementary Table 5. Prevalence of the number of days of smoking cigarettes in the last 30 days among smokers

		1996		2000		2004		2008		2012		2017	
	n=20070		n=16237		n=9614		n=4966		n=2851		n=769		
	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	
 1-9 days	33.0	(32.4, 33.7)	32.3	(31.6, 33.0)	35.0	(34.0, 35.9)	38.4	(37.1, 39.8)	38.0	(36.2, 39.7)	47.2	(43.7, 50.7)	
10-29 days	19.2	(18.6, 19.7)	19.0	(18.4, 19.6)	21.0	(20.2, 21.9)	20.7	(19.6, 21.8)	23.7	(22.2, 25.3)	21.2	(18.3, 24.1)	
every day	47.8	(47.1, 48.5)	48.7	(47.9, 49.5)	44.0	(43.0, 45.0)	40.9	(39.5, 42.2)	38.3	(36.5, 40.1)	31.6	(28.3, 34.9)	

CI, confidence interval

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Supplementary Figure 2.

1A) Prevalence of alcohol use between the 7th grade







B) Prevalence of alcohol use between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



Prevalence of smoking between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



Supplementary File 1. The list of questions from the survey questionnaire

Students were asked to select one option in each question.

English version

1. Demographic data

- (1) Are you male or female?
 - 'Male' or 'Female'
- (2) What is your grade in school?
 - 'Grade 1', 'Grade 2', or 'Grade 3'

2. Use of Alcohol

- (1) How many days have you drunk alcohol in the previous 30 days?
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'every day'

(2) How much have you drunk alcohol on the drinking day?

'No glass' 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3--5 glasses', 'More than 6 glasses', 'Until get drunk'

3. Use of cigarettes

- (1) How many days have you smoked cigarettes in the previous 30 days?(In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'every day'
- (2) How many cigarettes have you smoked cigarettes on average per day in the previous 30 days? (In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')
 - (1996 and 2000 survey)
 - 'Have not smoked in previous 30days', 'Less than 1 cigarette per day', '1–4 cigarettes', '5–9 cigarettes', '10–14 cigarettes', '15–19 cigarettes', 'More than 20 cigarettes'
 - (From the 2004 to 2017 survey)
 - 'Have not smoked in previous 30days', 'Less than 1 cigarette per day', '1 cigarette', '2–5 cigarettes', '6–10 cigarettes', '11–15 cigarettes', '16–20 cigarettes', 'More than 21 cigarettes'

4. Intention to pursue future education

- (1) What is your intention after graduating from school? Choose the option closest to your current feelings?
 - 'senior high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', 'unknown'

Japane	se version					
1. あ	なた自身のこ	とについて質問	します。			
(1)	あなたは男性	ですか、女性で	すか?あてはま	る数字に○を	をつけてくだる	さい。
	1. 男性	2. 女性				
(2)	あなたの学年	Fは何年生ですが	·?あてはまる	汝字に○をつ	けてください	0
	1. 1年生	2.2年生	Ė 3.	3年生		
2. C	こからはお酒	についての質問	です。			
(1)	この 30 日間	に、少しでもお	酒を飲んだ日に	、合計何日にな	なりますか?	
	1.0日	3. 3~5日	5.10	~19 日	7.毎日	(30日)
:	2. 1か2日	4. 6~9日	6.20	~29 日		
(2)	お酒を飲むと	きにはどのくら	いの量を飲み	ますか?		
	1. 飲まない			5. コップに	3~5杯	
:	2. コップ1杯	「未満(ほんの少	しの量)	6. コップに	6杯以上	
	3. コップに 1	杯		7. 酔いつぶ	れるまで	
2	4. コップに 2	:杯				
3. C	こからはタバ	コについての質	問です。			
(1)	この 30 日間	に、何日、タバ	コを吸いました	か?		
	(2017年調音	査のみ「タバコ」	を「紙巻きタ	バコ」に変更	E)	
	1.0日	3. 3~5日	5.10	~19日	7.毎日	(30日)
	2. 1か2日	4. 6~9日	6.20	~29日		
(2)	アの20日間	に 1日亚街い	のくといの木粉	のタバッち	あいましたかり	0
(2)	(2017 在海)	に、1日十圴とり	りてらいの平安 ち「姙業きゟ	、 ワクハコを引		<u>'</u>
((2017 平洞)	且のみ「クハコ」	化「私仓さク	ハコ」に友史		
(1990年と2000	中の詞重	1 5~9*	7 20		
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	2004年から20	17年の調査)	0. 10 10.			
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			0. 11 10.1			
4. あ	なたの将来の	進学希望につい	てお聞きします	-		
(1)	将来の進路を	とのように考え	ていますか?	今の気持ちに	近いもの1つ	に○をつけてください
	1. 高等学校	3. 短大	5.	大学院		7. わからない
	0 审明学标	4 上兴	(ムの登場方当	となっき酸	

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Page
	Reporting Item	Number
Title and abstract	¹ ²	ata mining,
Title #1	a Indicate the study's design with a commonly used term in the title or the abstract	Al training,
Abstract #1	b Provide in the abstract an informative and balanced summary of what was done and what was found	2 and simila
Introduction		ar tech
Background / #2 rationale	Explain the scientific background and rationale for the investigation being reported	nologies.
Objectives #3	State specific objectives, including any prespecified hypotheses	3
Methods		
Study design #4	Present key elements of study design early in the paper	3-4
Setting #5	Describe the setting, locations, and relevant dates, including periods of For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	3-4

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		recruitment, exposure, follow-up, and data collection
Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of selection of participants.
	<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources / measurement	<u>#8</u>	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.
Bias	<u>#9</u>	Describe any efforts to address potential sources of bias
Study size	<u>#10</u>	Explain how the study size was arrived at
Quantitative variables	<u>#11</u>	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why
Statistical methods	<u>#12a</u>	Describe all statistical methods, including those used to control for confounding
Statistical methods	<u>#12b</u>	Describe any methods used to examine subgroups and interactions
Statistical methods	<u>#12c</u>	Explain how missing data were addressed
Statistical methods	<u>#12d</u>	If applicable, describe analytical methods taking account of sampling strategy
Statistical methods	<u>#12e</u>	Describe any sensitivity analyses
Results		
Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.
Participants	<u>#13b</u>	Give reasons for non-participation at each stage
Participants	<u>#13c</u>	Consider use of a flow diagram
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Descriptive data	<u>#14a</u>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give	6
		information separately for exposed and unexposed groups if applicable.	
Descriptive data	#14b	Indicate number of participants with missing data for each variable of	n/2
Descriptive data	<u>#140</u>	interest	11/ d
Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	6-11
Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-9
Main results	<u>#16b</u>	Report category boundaries when continuous variables were categorized	7-9
Main results	<u>#16c</u>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	<u>#18</u>	Summarise key results with reference to study objectives	12
Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-14
Generalisability	<u>#21</u>	Discuss the generalisability (external validity) of the study results	n/a
Other			
Information			
Funding	<u>#22</u>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15
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Primary Subject Heading :	Public health
Secondary Subject Heading:	Addiction, Smoking and tobacco
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, Community child health < PAEDIATRICS

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> 1 ARTICLE 2 Trends in the co-use of alcohol and tobacco among Japanese adolescents: Periodical nationwide 3 cross-sectional surveys 1996-2017 4 5 Maya Fujii¹, Yuki Kuwabara¹, Aya Kinjo¹, Aya Imamoto¹, Maki Jike², Yuichiro Otsuka³, Osamu Itani³, 6 Yoshitaka Kaneita³, Ruriko Minobe⁴, Hitoshi Maesato⁴, Susumu Higuchi⁴, Hisashi Yoshimoto⁵, Hideyuki 7 Kanda6, Yoneatsu Osaki1 8 9 ¹ Division of Environmental and Preventive Medicine, Department of Social Medicine, Faculty of Medicine, 10 Tottori University, Yonago, Tottori, Japan 11 ² Department of Food Science and Nutrition, Showa Women's University, Setagaya, Tokyo, Japan 12 ³ Department of Public Health, School of Medicine, Nihon University, Itabashi, Tokyo, Japan 13 ⁴ National Institute of Alcoholism, Kurihama National Hospital, Yokosuka, Kanagawa, Japan ⁵ Primary Care and Medical Education, Graduate School of Comprehensive Human Sciences, Majors of 14 15 Medical Science, University of Tsukuba, Tsukuba, Ibaraki, Japan 16 ⁶ Department of Public Health, Okayama University Graduate School of Medicine, Dentistry and 17 Pharmaceutical Sciences, Okayama, Okayama, Japan 18 19 **Corresponding Author:** 20 Maya Fujii 21 Division of Environmental and Preventive Medicine 22 Department of Social Medicine, Faculty of Medicine 23 Tottori University 24 Nishi-machi 86, Yonago, Tottori 683-8503, Japan 25 Tel: +81-859-38-6103 26 Fax: +81-859-38-6100

- 27 E-mail: maya15@live.jp 28
 - 29 Word count: 3916

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2		
3 4	32	
5	33	ABSTRACT
6 7	34	Objectives: This study aimed to assess trends in the prevalence of alcohol use depending on smoking
8	35	behaviours and that of smoking depending on drinking behaviours among Japanese adolescents.
9 10	36	Design: This was a retrospective study using Japanese school-based nationwide surveys conducted between
11	37	1996 and 2017.
12 13	38	Setting: Surveyed schools, both junior and senior high schools, considered representative of the entire Japanese
14	39	population, were sampled randomly.
15 16	40	Participants: We enrolled 11,584-64,152 students from 179-103 schools yearly. They completed a
17	41	self-reported and anonymous questionnaire on smoking and drinking behaviour.
18 19	42	Results: Since 1996, the prevalence of alcohol use and smoking among adolescents decreased in each survey (<i>p</i>
20	43	< 0.01). The prevalence of alcohol use in the non-smokers group was 29.0% in 1996 and 4.0% in 2017, and in
21 22	44	the smokers group, it was 73.3% in 1996 and 57.4% in 2017. The reduction rate (the difference in prevalence
23	45	between 1996 and 2017 divided by the prevalence in 1996) was 0.86 in the non-smokers group and 0.22 in the
24 25	46	smokers group. The prevalence of smoking in the non-drinkers group was 6.7% in 1996 and 0.7% in 2017,
26	47	while that in the drinkers group was 32.5% in 1996 and 18.9% in 2017. The reduction rate was 0.90 in the
27 28	48	non-drinkers group and 0.42 in the drinkers group. Therefore, downward trends differed among the groups. In a
29	49	sub-analysis of senior high school students, we divided students into three groups according to their intention to
30 31	50	pursue further education. Between 1996 and 2017, there was a consistent difference in the prevalence of alcohol
32	51	use and smoking among these groups.
33 34	52	Conclusions: Alcohol use and smoking among Japanese adolescents seem to have reduced. However, certain
35	53	groups showed poor improvements, and health risk behaviour disparity exists, which may widen further. We
36 37	54	need to focus on high-risk groups and implement appropriate measures or interventions accordingly.
38	55	
39 40	56	STRENGTHS AND LIMITATIONS OF THIS STUDY
41	57	• The data were collected from periodical, nationwide large-sample surveys on Japanese adolescents
42 43	58	between 1996 and 2017, and the study contained a large sample size ($n = 11,584-64,152$ per year).
44	59	• This study focused on the co-use of alcohol and tobacco and analysed respective trends in the sub-groups.
45 46	60	• Due to ethical concerns and inconvenience, school response rates were not as high as expected; however,
47	61	the student response rate was consistent.
48 49	62	• Due to the ethical concerns, we did not ask students about their social and economic status and instead,
50	63	analysed the trends by the students' intention to pursue further education.
51 52	64	• The study used a self-reporting questionnaire; hence, further studies to examine the accuracy of these
53	65	findings are required.
54 55	66	
56	67	Keywords: alcohol use smoking adolescents prevalence Japan
57 58	68	rey nor us, alconor use, smoking, adorescents, prevalence, sapan
59	00	
60		

INTRODUCTION

Smoking causes approximately eight million deaths worldwide annually, and the harmful use of alcohol results in approximately three million deaths. [1, 2] Smoking and alcohol consumption usually start during adolescence, leading to detrimental consequences which include an epidemic of non-communicable diseases in adulthood. Health risk behaviours (HRBs) are shaped by social, economic, and cultural forces, and are major determinants of ill health and health-related inequalities through the course of life.[3-5] Therefore, adolescence is the key period for controlling HRBs. Some studies have identified alcohol consumption, smoking, drug use, and risky sexual behaviours as risk behaviour clusters, [6-9] and socioeconomic status as a strong predictor of engaging in multiple-risk behaviours.[10] Since 1996, our research group has been monitoring alcohol use and smoking among adolescents in Japan. According to previous studies, the prevalence of alcohol use and smoking among adolescents in Japan has continued to decline and is reported to be lower than that in European countries and the United States.[11, 12] Researchers have reported differences in the smoking and drinking behaviour depending on the characteristics of the adolescent group. For instance, socioeconomic backgrounds have a profound effect on the transition period of non-smokers becoming daily smokers such that poor socio economic backgrounds caused the shortest transition period of non-smokers becoming smokers in France.[13] Higher educational aspiration was negatively associated with alcohol use in Finland, [14] and adolescents who were not in school were inclined to smoke in China.[15] Moreover, Some studies have reported on the positive relation between alcohol consumption and health inequality, and higher rates of morbidity and mortality among adults with a lower socioeconomic status. [16–19] In Japan, despite the reduction in alcohol use and smoking among Japanese adolescents, it has not reached the goal of zero prevalence, as established by the Japanese government. Furthermore, because health inequalities and social disparities are the current public health issues in Japan,[20] there may be groups of adolescents among whom smoking and alcohol use has not reduced. Therefore, it is important to examine whether an HRB disparity exists among Japanese adolescents. Very few studies have focused on the co-use of alcohol and tobacco and analysed trends in subgroups. Hence, we focused on this gap in existing research and hypothesised that some groups may have certain characteristics that demonstrate a slow rate of improvement in reducing alcohol use and smoking. To further lower alcohol use and smoking among adolescents, it is essential to evaluate these groups and implement relevant interventions. Incidentally, drug use among adolescents in Japan is not a major problem; the prevalence rate of drug use among teenagers was 0% in 2015.[21] Therefore, the present study aimed to evaluate the nationwide prevalence of smoking and alcohol use, as these were the two main substance-abuse problems and have been investigated as HRBs among Japanese adolescents.

METHODS

Study population

This was a cross-sectional random sampling survey that used single-stage cluster sampling.[22] The sampling was performed by dividing Japan into regional blocks and randomly selecting schools from each block. Using the national school directory, junior high schools and senior high schools throughout Japan were randomly

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2		
3 4	108	extracted, and all students enrolled in the sampled schools were participants of the study. The number, selection
5	109	rate, and response rate of the schools in each survey are shown in Supplementary Table 1. The response rates of
6 7	110	schools ranged between 49.0% and 79.8%.
8	111	To test our hypothesis, the research population was divided into the following subgroups: smokers
9 10	112	group/non-smokers group, drinkers group/non-drinkers group, and their intention to pursue further education
11	113	fell under four categories: (1) senior high school graduation, (2) junior college (2-year college/vocational
12 13	114	school), (3) college or higher educational degree (4- or 6-year college/graduate school), and (4) unknown. Next,
14	115	trends in the prevalence of alcohol use and smoking in each group were examined.
15 16	116	
17	117	Data collection
18 10	118	This study was approved by the Ethics Review Committee of Tottori University School of Medicine.
20	119	Supplementary Figure 1 shows the flowchart of data collection in the study. We obtained the cooperation of the
21 22	120	principals of all the schools and sent the survey forms to all the students. The teachers encouraged the students
22	121	to respond voluntarily and honestly. The students were given anonymised questionnaires and envelopes. The
24 25	122	completed questionnaires were placed in envelopes and sealed by the students themselves, and these envelopes
25 26	123	were collected by the teachers and returned to our institute.
27 28	124	
28 29	125	Patient and Public Involvement
30 21	126	No patients were involved in this study.
32	127	
33 24	128	Measures
34 35	129	Alcohol use and smoking
36 27	130	Drinkers and smokers were defined as those who had consumed alcohol or smoked at least once during the past
37 38	131	30 days. The questionnaire focused on the students' experiences, frequency of alcohol use ('How many days in
39 40	132	the past 30 days have you had alcohol?") and smoking ('How many days in the past 30 days have you smoked
40 41	133	cigarettes?'), amount of alcohol use ('How much alcohol have you had on a drinking day?') and smoking ('How
42	134	many cigarettes on average per day have you smoked in the past 30 days?').
45 44	135	To assess the frequency of alcohol use, seven options were provided: '0 days', '1-2 days', '3-5 days', '6-9
45 46	136	days', '10-19 days', '20-29 days', or 'Every day'. To assess the amount of alcohol use, seven options were
40 47	137	provided: 'No glass', 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3-5 glasses', 'More than 6 glasses',
48 40	138	or 'Until I got drunk'.
49 50	139	In the 1996 and 2000 surveys, to assess smoking, seven options were provided: 'Have not smoked in past 30
51 52	140	days', 'Less than 1 cigarette per day', '1-4 cigarettes', '5-9 cigarettes', '10-14 cigarettes', '15-19 cigarettes', or
52 53	141	'More than 20 cigarettes'; in the 2004 to 2017 surveys, eight options were provided: 'Have not smoked in past
54	142	30 days', 'Less than 1 cigarette per day', '1 cigarette', '2-5 cigarettes', '6-10 cigarettes', '11-15 cigarettes',
55 56	143	'16–20 cigarettes' or 'More than 21 cigarettes' (Supplementary File 1). It was only in the 2017 survey when the
57	144	questions on cigarettes were divided into three categories: combustible cigarette, heat-not-burn tobacco, and
58 59 60	145	electronic cigarettes. Thus, in the 2017 survey, this analysis regarded combustible cigarette users as smokers.

Intention to pursue further education We assessed the intention to pursue further education after graduating from school ('What is your intention after graduating from school? Choose the option closest to your current feelings.'). Seven options were provided: 'senior high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'started working', and 'unknown'. Data analysis The proportions and 95% confidence intervals (CI) presented in the Tables were calculated using a weighting method and based on one-stage stratified cluster sampling.[22] The proportions were adjusted for grade and sex using the number of junior high and senior high school students nationwide as a standard population, from the School Basic Survey conducted by the Ministry of Education, Science and Technology (2017). A Cochran-Armitage trend test was performed to clarify the linear trend in prevalence by year. A p-value < 0.05was considered statistically significant. All statistical analyses were performed using JMP Pro version 13 for Windows (SAS Institute Inc., Cary, NC, USA). Data of the participants that did not include information on sex, grade, or age were regarded as discrepant data and excluded from the analysis. To measure the rate of change in the prevalence, we calculated the reduction rate using the following formula: reduction rate = (Prevalence in 1996 - Prevalence in 2017) / Prevalence in 1996. RESULTS The differences in the baseline characteristics of participating schools, students (sex and grade), alcohol use in the past 30 days, and smoking in the past 30 days are presented in Table 1. Between 1996 and 2017, the prevalence of alcohol use and smoking steadily decreased.

2 3 4 5	170 171 Table 1. Characteristics	of the stud	ly parti	cipants	in 1996	, 2000, 2	004, 20	08, 2012	, and 2()17			
6 ⁻ 7	Year	19	96	20	00	20	04	20	08	20	12	20	17
, 8 9	Number of participants	(n = 11	5,814)	(n = 10)6,297)	(n = 10	2,451)	(n = 9	5,680)	(n = 10	00,050)	(n = 64,152)	
10		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
11 ⁻ 12	Sex												
13	Boys	57,116	(49.3)	54,576	(51.3)	55,998	(54.7)	48,525	(50.7)	51,587	(51.6)	34,582	(53.9)
14 15	Girls	58,698	(50.7)	51,721	(48.7)	46,453	(45.3)	47,155	(49.3)	48,463	(48.4)	29,570	(46.1)
16 17	School grade												
18	Junior high school (12-15 y/o)												
19 20	Grade 7	14,369	(12.4)	15,372	(14.5)	13,146	(12.8)	13,302	(13.9)	13,405	(13.4)	7,384	(11.5)
21	Grade 8	14,118	(12.2)	15,916	(15.0)	13,079	(12.8)	13,649	(14.3)	12,884	(12.9)	7,329	(11.4)
22 23	Grade 9	14,311	(12.4)	15,958	(15.0)	13,160	(12.8)	12,925	(13.5)	12,205	(12.2)	7,415	(11.6)
24 25	Unknown	0	(0.0)	0	(0.0)	0	(0.0)	275	(0.3)	0	(0.0)	87	(0.1)
26	Senior high school (15-18 y/o)												Ċ
27 28	Grade 10	24,696	(21.3)	21,142	(19.9)	21,815	(21.3)	20,157	(21.1)	21,480	(21.5)	14,201	(22.1)
29	Grade 11	25,416	(21.9)	19,600	(18.4)	21,530	(21.0)	18,328	(19.2)	20,026	(20.0)	14,212	(22.2)
30 31	Grade 12	22,904	(19.8)	18,309	(17.2)	19,721	(19.2)	16,785	(17.5)	20,050	(20.0)	13,404	(20.9)
32 33	Unknown	0	(0.0)	0	(0.0)	0	(0.0)	259	(0.3)	0	(0.0)	120	(0.2)
34	Alcohol use/smoking in the past 30 days												
35 36	Alcohol use	44,545	(38.7)	39,497	(37.4)	30,233	(29.7)	16,110	(16.9)	12,034	(12.1)	3,584	(5.6)
37 38-	Smoking	20,070	(17.9)	16,237	(15.7)	9,614	(9.5)	4,966	(5.2)	2,851	(2.9)	1,183	(1.8)

y/o: years old

Supplementary Figure 2 and 3 shows the change in prevalence of alcohol use from 1996 to 2012 between the 7th and 11th grades and between the 8th and 12th grades in every four-year survey and between the 7th grade in 2012 and the 12th grade in 2017. Supplementary Figure 4 and 5 show the change in smoking prevalence in the same groups described in Supplementary Figure 2 and 3. Both, the prevalence of alcohol use and that of smoking among the same grade, showed a reduction over time.

Table 2 shows the prevalence rates for alcohol use only, smoking only, no-use, and co-use in the past 30 days between 1996 and 2017. In each survey, the prevalence of co-use among boys was higher than among girls, while a significant decrease was observed in each survey among both boys and girls (p < 0.01). Accordingly, in each survey, the prevalence of no-use among girls was higher than that among boys and was significantly increased in each survey among both boys and girls (p < 0.01). In 2017, almost all the participants recorded no-use (boys 93.3%, 95% CI: 93.5-93.0; girls 95.0%, 95% CI: 95.2-94.8). The prevalence of smoking only among boys was higher than that among girls, and it decreased in each survey among both boys and girls (p < p

0.01). Conversely, between 1996 and 2012, the prevalence of alcohol use only among girls was higher than that among boys, while in 2017, it was lower than that among boys.

190	Table 2. Prevalence of alcohol use and/or smoking among Japanese adolescents (aged 12-18 years) between
191	1996 and 2017 by sex

10	191	1990 and	u 2017	by sex											
₩ _{ear}				1996		2000		2004		2008		2012		2017	
12			%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value ^a
<u>14</u> 15	No use ^b		50.3	(50.9, 49.7)	54.7	(55.3, 54.1)	66.4	(66.9, 65.9)	80.4	(80.8, 80.0)	86.9	(87.2, 86.6)	93.3	(93.5, 93.0)	<0.01
16 17		1.6	22.0	(24.2.22.0)	24.2	(24 (22 0)	21.5	(21.0.21.2)	10.7	(12.0.12.5)	0.2	(0,2,0,0)	5.1	(5.2.5.0)	
17 11830ys	Alconol u	use only ⁶	23.9	(24.2, 23.6)	24.2	(24.6, 23.9)	21.5	(21.8, 21.3)	12.7	(12.8, 12.5)	9.2	(9.3, 9.0)	5.1	(5.3, 5.0)	0.01 2
19	Smoking	only ^b	6.9	(7.1, 6.8)	5.8	(6.0, 5.7)	3.2	(3.3, 3.1)	2.3	(2.4, 2.2)	1.3	(1.4, 1.3)	0.5	(0.5, 0.5)	< 0.01
20 21 - 22	Co-use ^b		18.9	(19.5, 18.3)	15.3	(15.7, 14.8)	8.9	(9.1, 8.6)	4.7	(4.9, 4.5)	2.6	(2.7, 2.5)	1.1	(1.2, 1.0)	<0.01gn
23	No use ^b		63.2	(63.6, 62.8)	62.8	(63.3, 62.4)	70.3	(70.7, 69.8)	82.8	(83.1, 82.4)	87.3	(87.5, 87.0)	95.0	(95.2, 94.8)	<0.01
24 25	Alcohol u	use only ^b	26.7	(25.2, 25.3)	27.2	(27.5, 26.8)	23.3	(23.7, 23.0)	13.8	(14.1, 13.6)	11.0	(11.2, 10.8)	4.3	(4.4, 4.1)	<0.01
26 ^{ms}	Smoking	only ^b	2.3	(2.3, 2.2)	2.3	(2.4, 2.2)	1.5	(1.5, 1.4)	0.9	(0.9, 0.8)	0.4	(0.4, 0.3)	0.2	(0.2, 0.1)	<0.01
28 29	Co-use	o-use 7.		(8.0, 7.6)	7.7	(7.9, 7.5)	5.1	(5.1, 4.8)	2.5	(2.6, 2.4)	1.4	(1.4, 1.3)	0.6	(0.6, 0.5)	<0.01S
30 31	No use ^b	ise ^b 56.8 (57.2		(57.3, 56.3)	58.6	(59.1, 58.2)	68.1	(68.6, 67.7)	81.6	(81.9, 81.2)	87.1	(87.3, 86.8)	94.1	(94.3, 93.9)	
32 33 3Both	Alcohol u	use only ^b 25.3		(25.5, 25.1)	25.6	(25.9, 25.4)	22.4	(22.6, 22.1)	13.2	(13.4, 13.0)	10.1	(10.2, 9.9)	4.7	(4.9, 4.6)	<0.01 to tex
35	Smoking	only ^b	4.6	(4.7, 4.4)	4.1	(4.2, 4.0)	2.4	(2.5, 2.3)	1.6	(1.6, 1.5)	0.9	(0.9, 0.8)	0.3	(0.4, 0.3)	<0.01
36 37	Co-use ^b		13.3	(13.7, 12.9)	11.6	(11.9, 11.3)	7.1	(7.3, 6.9)	3.6	(3.8, 3.5)	2.0	(2.1, 1.9)	0.9	(0.9, 0.8)	<0.01 ta
38 30	192	CI, confid	lence in	nterval											min
40	193	^a based or	n the Co	ochran-Armit	age tre	end test									Ing,
41 42	194	^b in the pa	1st 30 d	lays											Altr
42 43	195														alni
44	196	Supplem	entary	Tables 2 ai	nd 3 s	how the pre-	valenc	e of the am	ount o	f alcohol us	ed am	ong drinker	s on a	drinking	ng, a
45 46	197	day in th	iree gr	oups: 'less	than 2	2 glasses', 'i	more 1	than 3 glass	es', ar	nd 'until I g	ot dru	nk', and the	e prev	alence of	and
47	198	the avera	ige nu	mber of ciga	arettes	s smoked an	nong s	mokers per	day in	two groups	s: 'less	s than 9(10)	cigare	ettes' and	simi
48 49	199	'more th	an 10	(11) cigarett	tes'. E	Between 199	6 and	2017, the r	revale	ence of 'less	s than	2 glasses' a	mong	drinkers	lar t
50	200	tended to) incre	ase in everv	surve	ev. Between	2004	and 2017. th	ne prev	valence of '	more t	han 11 ciga	rettes'	smokers	ecnr
51 52	201	did not i	ncreas	e consideral	olv Si	upplementar	v Tab	les 4 and 5	show t	he prevalen	ce of t	he number	of dav	s alcohol	
53	202	was used	l in the	e nast 30 da	vs am	ong drinkers	s in th	ree groups.	·1_9 d	avs' '10-2	9 dave	and 'ever	v dav	and the	gies.

Supplementary Tables 2 and 3 show the prevalence of the amount of alcohol used among drinkers on a drinking day in three groups: 'less than 2 glasses', 'more than 3 glasses', and 'until I got drunk', and the prevalence of the average number of cigarettes smoked among smokers per day in two groups: 'less than 9(10) cigarettes' and 'more than 10(11) cigarettes'. Between 1996 and 2017, the prevalence of 'less than 2 glasses' among drinkers tended to increase in every survey. Between 2004 and 2017, the prevalence of 'more than 11 cigarettes' smokers did not increase considerably. Supplementary Tables 4 and 5 show the prevalence of the number of days alcohol was used in the past 30 days among drinkers in three groups: '1–9 days', '10–29 days', and 'every day', and the prevalence of the number of days when cigarettes were smoked in the past 30 days among smokers in three groups: '1-9 days', '10-29 days', and 'every day'. For drinkers, it did not change considerably, while among smokers, the number of every day smokers tended to decrease.

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Table 3 and Figure 1 show the prevalence of alcohol use among the non-smokers and smokers groups, and the prevalence of smoking among the non-drinkers and drinkers groups, adjusted for grade and sex. The prevalence of alcohol use in the non-smokers group was lower than that in the smokers group in each survey. In the non-smokers group, the prevalence rates did not change between the surveys of 1996 and 2000. However, in the surveys from 2004 to 2017, it decreased in each survey among both boys and girls. Conversely, it increased between 1996 and 2004 in the smokers group and subsequently decreased between 2004 and 2008 among both boys and girls. Among boys, it decreased in 2017, whereas among girls, it increased in 2012 and decreased in 2017. The reduction rates in the smokers group were lower than that in the non-smokers group; the reduction rate among girls in the smokers group was 0.19, which was the lowest. Similarly, the prevalence of smoking was lower in the non-drinkers group than in the drinkers group. In the non-drinkers group, the prevalence of smoking decreased between 1996 and 2000 among boys, whereas it increased among girls. Between 2000 and 2017, it halved in each survey among both boys and girls. However, in the drinkers group, it decreased between 1996 and 2000 among boys, whereas it did not change among girls. Between 2000 and 2012, it decreased, and between 2012 and 2017, it increased slightly among boys and girls. Moreover, the reduction rates in the drinkers group were lower than that in the non-drinkers group.

between 1	996 and	l 2017 by sex										on 4			
Year				1996 2			2000 2004			2008				2017	
			% ^a	95% CI	% ^a	95% CI	% ^a	95% CI	% ^a	95% CI	⁰∕₀ ª	S es l	⁰∕₀ ^a	95% CI	
	Dova	Non-smokers	30.4	(30.3, 30.5)	30.1	(30.1, 30.2)	23.0	(22.9, 23.0)	12.7	(12.7, 12.8)	9.0	2021) relate	4.3	(4.3, 4.3)	0.86
	Boys	Smokers	72.0	(71.9, 72.1)	72.0	(71.9, 72.1)	72.5	(72.4, 72.7)	66.3	(66.1, 66.5)	64.8	(64.0) (64.0)	55.3	(54.9, 55.7)	0.23
Alcohol use	0.1	Non-smokers	27.8	(27.7, 27.8)	29.1	(29.1, 29.2)	23.7	(23.7, 23.8)	13.8	(13.8, 13.8)	10.7		3.7	(3.7, 3.8)	0.87
in the past	GIrls	Smokers	76.7	(76.5, 76.9)	76.3	(76.2, 76.5)	77.0	(76.8, 77.2)	73.7	(73.5, 74.0)	79.5	antê (Î c	62.0	(61.5, 62.5)	0.19
50 uu j5	Deth	Non-smokers	29.0	(29.0, 29.0)	29.6	(29.6, 29.6)	23.4	(23.3, 23.4)	13.3	(13.2, 13.3)	9.9	from Inter (AE	4.0	(4.0, 4.0)	0.86
	Both	Smokers	73.3	(73.2, 73.4)	73.3	(73.2, 73.4)	74.1	(74.0, 74.2)	68.7	(68.6, 68.9)	69.2		57.4	(57.1, 57.7)	0.22
	Pour	Non-drinkers	10.6	(10.6, 10.7)	9.2	(9.1, 9.2)	4.0	(4.0, 4.1)	2.5	(2.5, 2.5)	1.4	g ,4, 5)	1.0	(1.0, 1.0)	0.91
~ • • •	Boys	Drinkers	41.2	(41.1, 41.3)	37.6	(37.5, 37.7)	27.1	(27.0, 27.2)	25.8	(25.7, 25.9)	21.3	(a).2, 2.5)	22.1	(21.9, 22.3)	0.46
Smoking in	Cirla	Non-drinkers	3.1	(3.1, 3.1)	3.4	(3.3, 3.4)	1.9	(1.8, 1.9)	1.0	(1.0, 1.0)	0.4	1111111111111	0.4	(0.4, 0.4)	0.87
davs	GIIIS	Drinkers	21.4	(21.3, 21.5)	21.4	(21.3, 21.5)	17.0	(16.9, 17.1)	15.1	(15.0, 15.2)	11.2		14.8	(14.6, 15.0)	0.31
	D-th	Non-drinkers	6.7	(6.7, 6.7)	6.2	(6.2, 6.2)	3.0	(2.9, 3.0)	1.8	(1.8, 1.8)	0.9	Siff).9, 6 9)	0.7	(0.7, 0.7)	0.90
	Both	Drinkers	32.5	(32.4, 32.5)	30.2	(30.1, 30.2)	22.2	(22.2, 22.3)	20.6	(20.5, 20.7)	16.2	(16.1, 16.3)	18.9	(18.8, 19.0)	0.42
CI, confiden	ice inter	val										e 11, chnol			
^a adjusted fo	or grade	and sex										202: logi			
^b reduction r	ate = (P	revalence in 1996	6 - Preval	ence in 2017)	Prevale	ence in 1996						5 at . es.			
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BMJ Open Table 3. Prevalence of alcohol use depending on smoking, and prevalence of smoking depending on alcohol use among BMJ Open

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2		
3 4	228	Table 4 shows the prevalence of alcohol use and smoking among senior high school students (aged 15-18 years)
5	229	by the intention to pursue further education, adjusted for grade and sex. The prevalence of alcohol use decreased
6 7	230	in each survey among the three groups, except for the junior college degree group between 1996 and 2000. The
8	231	prevalence of smoking decreased in each survey among the three groups, except for the high school graduation
9 10	232	group and college or the higher education degree group between 1996 and 2000. Both the prevalence of alcohol
11	233	use and smoking in the college or higher educational degree groups were the lowest in each survey, with the
12 13	234	reduction rate being the highest among the three groups.
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Table 4. Prevalence of alcohol use	and si	noking amo	ng Jap	anese senioi	high s	school stude	nts (ag	ed 15-18 yea	ars) bet	nclen 150996 werdin o	and 2	017 by the i	ntention to
Year		1996	2000		2004			2008	ق n + 4 دوری A		2017		
	a	95%CI	% a	95%CI	⁰⁄0 a	95%CI	0∕0 a	95%CI	⁰∕₀ a		⁰∕o a	95%CI	Reduction
Alcohol use in the past 30 days										seign seign			
High school graduation	52.7	(52.6, 52.9)	53.1	(52.9, 53.2)	43.7	(43.6, 43.9)	29.2	(29.0, 29.3)	19.9	(11. 10) (11. 10)	9.4	(9.4, 9.5)	0.82
Junior college degree	46.7	(46.6, 46.8)	47.1	(47.0, 47.2)	42.8	(42.6, 42.9)	28.8	(28.7, 29.0)	21.6	ont ov (කු.හු.සු.7)	9.8	(9.7, 9.8)	0.79
College or higher educational degree	18.0	(17.9, 18.1)	16.6	(16.5, 16.6)	10.1	(10.1, 10.2)	5.7	(5.7, 5.8)	3.2	uperio	1.8	(1.8, 1.8)	0.90
Smoking in the past 30 days										ieur d da			
High school graduation	36.8	(36.7, 36.9)	37.7	(37.5, 37.8)	23.7	(23.6, 23.8)	15.5	(15.4, 15.7)	7.6	ta AB: 7.6)	4.0	(3.9, 4.0)	0.89
Junior college degree	23.4	(23.3, 23.5)	22.6	(22.5, 22.7)	15.3	(15.2, 15.4)	10.2	(10.1, 10.3)	5.0		3.0	(3.0, 3.1)	0.87
College or higher educational degree	13.1	(13.0, 13.2)	14.6	(14.6, 14.7)	6.7	(6.6, 6.7)	3.1	(3.1, 3.1)	1.4	A .3, 4)	1.0	(1.0, 1.0)	0.92
CI, confidence interval							•			jope train			
^a adjusted for grade and sex										n.bm ving,			
^o reduction rate = (Prevalence in 1996 - F	revalen	ce in 2017)7 P	revalen	ce in 1996.						om/ on June 11, 2025 at Agence E nd similar technologies.			
										ce Bib			

DISCUSSION

In this study, we found a decrease in the prevalence of alcohol use and smoking among the representative sample groups of Japanese adolescents between 1996 and 2017. Moreover, this prevalence decreased to levels lower than those in the European countries [23] and the United States [24] Japan and other countries have shown a declining trend in alcohol and tobacco use [23-26] which may have been due to the influence of the devaluation of alcohol and tobacco, as well as socio-economic changes. In terms of alcohol, reports have indicated that the global reduction in drinking habits in youth may have been due to a change in the societal and economic devaluation of alcohol.[27-29] Tobacco control activity may have influenced those smokers who found it easier to quit, while the remaining smokers were those who were less likely to stop smoking.[30,31] However, according to the results of this study, the prevalence of frequent users of alcohol and tobacco did not show an increase. The prevalence of alcohol use and smoking among Japanese adolescents seems to have improved, even if the goal of zero prevalence established by the Japanese government has not been reached. In this study, we hypothesised that some groups may have certain characteristics that demonstrate a slow rate of improvement in reducing alcohol use and smoking. To this end, we compared the trend of alcohol use by dividing the students into two groups: smokers and non-smokers, and similarly, the trend of smoking by creating two groups: drinkers and non-drinkers. Between 1996 and 2017, the prevalence of alcohol use in the smokers group was consistently higher than that in the non-smokers group, and the reduction rate in the smokers group was lower than that in the non-smokers group. In other words, the prevalence of alcohol use among smokers decreased at a rate slower than that among non-smokers. Further, we compared the trend of smoking between the non-drinkers and drinkers groups and examined the overall trend in the prevalence of smoking. Between 1996 and 2017, the prevalence of smoking in the drinkers group was consistently higher than that in the non-drinkers group, and the reduction rate in the drinkers group was lower than that in the non-drinkers group. In other words, the prevalence of smoking in the drinkers group decreased at a rate slower than that in the non-drinkers group. These findings suggest that not only does an HRB disparity exist among Japanese adolescents, but also that it may be widening.

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The trends in alcohol and tobacco use among the adults around adolescents may explain our results. Adolescent smoking behaviour is influenced by their parents, older brothers, older sisters, and friends.[32] In terms of their friends, the school environment influenced their alcohol use and smoking behaviour.[33,34] Of the 153 schools that participated in the 1996 survey, the prevalence of alcohol use in every participating school ranged from 12.1% to 76.0%, and that of smoking from 0.7% to 50.5%. All the participating schools had at least one student who drank alcohol and smoked tobacco. Of the 103 schools that participated in the 2017 survey, the prevalence of alcohol use in every participating school ranged from 0% to 13.8% and that of smoking from 0% to 8.8%. There were two schools (1.9%) where no student used alcohol in the past 30 days and 17 schools (16.5%) where no student smoked tobacco in the past 30 days. Although the differences in prevalence between schools were reducing, they still existed. Adolescent drinking and smoking prevention efforts should include enhancing the collective efficacy of schools. In terms of their families, boys are influenced by their fathers and girls by their mothers.[11] In Japan, the prevalence of smoking among adults was shown to have decreased annually among both men and women,[35] which may have affected the change in smoking behaviour among adolescents.

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Adolescents' drinking behaviours are also related to their family and friends. In particular, an adolescent's drinking behaviour is more influenced by their mother's alcohol consumption pattern than those of other family members.[12] In Japan, the prevalence of alcohol consumption among men has not increased significantly, whereas it has grown among women.[35] This behaviour among women may affect their children's adolescent drinking behaviour. The prevalence of alcohol use among girls in the smokers group was consistently higher than that among boys in the same group, and the reduction rate was the lowest. A probable reason for these trends is that the prevalence of alcohol use in the parents' generation, especially in women, did not decrease, unlike that of smoking. Further, girls were influenced considerably by their mothers. Additionally, the reduction rate in the prevalence of smoking in the drinkers and non-drinkers groups was higher than that of alcohol use in the smokers and non-smokers groups. This may have been the result of the different political measures instituted against tobacco and alcohol use in Japan. Since the implementation of the tobacco tax in the country, tobacco and consumer taxes have increased several times. For example, the price of a pack of 20 of the most popular cigarette brands was 240 yen (equivalent to 2 USD) in 1996. This increased to 250 yen (4% increase), 270 yen (8% increase), 300 yen (11% increase), 410 yen (37% increase), and 420 yen (2% increase) in 1998, 2003, 2006, 2010, and 2014, respectively. Moreover, self-regulation of the tobacco industry from 1998 resulted in the regulation of tobacco commercials. An increase in the price of cigarettes and the regulation of tobacco commercials may, thus, have contributed to the decrease in the rate of smoking among adolescents. However, the prevalence of smoking among drinkers increased between 2012 and 2017. Further, the alcohol tax varied according to the type of alcohol; the tax on beer was stable between 1996 and 2017. Thus, the price of alcohol increased by only 2-3% because of the consumer tax; the cheapest beer or alcopop was sold for less than 1 USD. Before 2000, students could buy alcohol from supermarkets, convenience stores, and vending machines. In 2000, Japan enacted a revision of the Act to Prohibit Minors from using alcohol with a reinforcement of penalty for selling alcoholic beverages to minors. The law was revised again in 2001 to reinforce age confirmation by liquor distributors. After 2000, the number of alcohol vending machines also decreased due to the self-regulation of the alcohol industry.[36] Therefore, the decrease in the prevalence of alcohol use among adolescents since 2000 may be attributed to the aforementioned policy. However, from 2004, a bigger decrease was shown among both the smokers and non-smokers groups, suggesting that although alcohol policies were changed in 2000, their effect was delayed as the policies were spread widely and slowly. Moreover, alcohol commercials remained unbanned. These policies had different effects on each subgroup. Increasing tobacco prices and deferring alcohol prices may have contributed to the differences in the reduction

rates of the prevalence of alcohol use and smoking, respectively. Our findings revealed that the trends in alcohol use and smoking differed between the non-smokers and smokers groups and between the non-drinkers and drinkers groups. These results can be partly explained by the social context of those substance users. Some Japanese researchers have reported an association between the social context and HRBs. For example, the prevalence of lifetime alcohol use and smoking was found to be much higher in adolescent youth detention centres in Japan than that outside such centres,[21] schools and neighbourhood contexts were also found to be associated with adolescent drinking [33] and childhood poverty had a negative effect on adult HRBs.[37] The present study showed different trends in the prevalence of alcohol

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use and smoking in each subgroup, that is, the lifestyle of non-drinkers and non-smokers has become healthier, whereas that of drinkers and smokers has not changed, despite the decrease in the number of adolescent drinkers and smokers. Additionally, we observed that there were differences in the trends of the prevalence of alcohol use and that of smoking depending on the intentions of pursuing further education: the group that had the highest intention to pursue further academic studies had the greatest reduction rate; that is, students who had higher academic intentions showed a greater decrease in prevalence than those who had lower academic intentions. Student choices after graduating from senior high school influenced their future socioeconomic status and lifestyle. Some researchers have reported that HRBs, such as alcohol use and smoking, were associated with lower academic performance.[38, 39] This observation was consistent with our findings, where there were differences in the trends of prevalence of alcohol use, that of smoking and reduction rate depending on the intention to pursue further education. This implied that adolescent HRBs could be a driving factor in their life in the future. In the context of not widening the inequality gap, these results highlighted the importance of focusing on the high-risk groups that delay the reduction in the prevalence and develop appropriate strategies to intervene in such groups; for example, school-based interventions.

The strength of our study is that the data were collected from periodical, nationwide large-sample surveys. This methodology enabled us to minimize any sampling bias.[22] Hence, the results of this study can potentially be generalised nationwide for Japanese adolescents. However, our study also had several limitations. First, the sample of the participants was possibly biased, since 30-50% of the sampled schools did not respond to the surveys. Despite the efforts made by the research team, ethical concerns, and inconvenience due to the need for elaborate explanations may have resulted in the lower rate of cooperation among schools. Specifically, the most pertinent ethical issue was the requirement to meet the criteria required for ethical approval. However, the characteristics of the schools that responded did not differ significantly from those of the non-responding schools. Since this tendency was consistent across the surveys, the trends in this study were interpreted easily. Second, although student questionnaires were anonymous and the students put them into private envelopes themselves, the distribution of the forms by class teachers may have influenced the results. Additionally, the explanatory document given to the class teachers explained that they had to ensure the students' privacy. Notwithstanding these limitations, it is important to continue conducting periodic nationwide surveys, even if some methodological problems persist.

347 CONCLUSION

 Since 1996, the prevalence rates of drinking and smoking among Japanese adolescents have decreased. However, the trends were different between the non-drinkers and drinkers groups, and the non-smokers and smokers groups. In other words, not only does an HRB disparity exist among Japanese adolescents, but it may be widening. The results from the sub-analysis indicated that students who had higher academic intentions presented a greater reduction in the prevalence of alcohol use and smoking, a trend associated with their future socioeconomic status. To further decrease the prevalence of alcohol use and smoking among adolescents, it is imperative to comprehensively adapt interventions, enlighten adults and parents, raise the prices of tobacco and alcohol, and regulate sale promotions. Furthermore, to not widen the inequality gap further, the results suggest
that it is important to focus on the high-risk group that delays improvement, consider social contexts, and
develop an appropriate strategy to approach or intervene in this group.

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363 Authors' contributions

YoO, SH, and YoK designed the study and devised its protocols. OI, YuO, MJ, and HY reviewed the literature and helped summarising previous research studies. HK, AK, YuK, RM, HM and AI carried out statistical analyses. MF wrote the first draft of the manuscript. All authors have read and approved the manuscript.

368 Competing interest statement

The authors declare that they have no competing interests.

371 Data availability

The data are owned by the research group and cannot be shared by the authors.

374 Ethics approval and consent to participate

The participants were older than 12 years of age. Before the survey, the school principals provided participant parents with the survey details. The parents were advised that they could 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 their participation. The students whose parents refused permission for their participation in 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).

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4 484 FIGURE LEGENDS 5 485

Figure 1. Prevalence of alcohol use depending on smoking and prevalence of smoking depending on alcohol use among Japanese adolescents (aged 12-18 years) between 1996 and 2017 by sex
** [colour image] Figure 1

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Supplementary Figure 2.

¹ Prevalence of alcohol use between the 7th grade and 211th grade in every four-year survey



3 Supplementary Figure 4.

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Prevalence of alcohol use between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



Supplementary Figure 5.

Prevalence of smoking between the 8th grade and 12th grade in every four-year survey; and between the 7th grade in 2012 and the 12th grade in 2017



3Prevalence of smoking between the 7th grade and 11th 33grade in every four-year survey

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Supplementary File 1. The list of questions from the survey questionnaire

Students were asked to select one option in each question.

English version

1. Demographic data

- (1) Are you male or female?
 - 'Male' or 'Female'
- (2) What is your grade in school?
 - 'Grade 1', 'Grade 2', or 'Grade 3'

2. Use of Alcohol

- (1) How many days in the past 30 days have you had alcohol?
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'Every day'
- (2) How much alcohol have you had on a drinking day?
 - 'No glass' 'Less than 1 glass (a little bit)', '1 glass', '2 glasses', '3--5 glasses', 'More than 6 glasses', 'Until get drunk'

3. Use of cigarettes

- (1) How many days in the past 30 days have you smoked cigarettes?(In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')
 - '0 day', '1–2 days', '3–5 days', '6–9 days', '10–19 days', '20–29 days' or 'Every day'

(2) How many cigarettes on average per day have you smoked in the past 30 days?

(In the 2017 survey 'cigarettes' was changed to 'combustible cigarette')

- (1996 and 2000 survey)
 - 'Have not smoked in the past 30 days', 'Less than 1 cigarette per day', '1–4 cigarettes', '5–9 cigarettes', '10–14 cigarettes', '15–19 cigarettes', 'More than 20 cigarettes'
- (From the 2004 to 2017 survey)
 - 'Have not smoked in the past 30 days', 'Less than 1 cigarette per day', '1 cigarette', '2–5 cigarettes', '6–10 cigarettes', '11–15 cigarettes', '16–20 cigarettes', 'More than 21 cigarettes'

4. Intention to pursue future education

- (1) What is your intention after graduating from school? Choose the option closest to your current feelings.
 - 'senior high school', 'vocational school', '2-year-college', 'college', 'graduate school', 'start working', 'unknown'

Japane	se version					
1. あ	なた自身のこ	とについて質問し	<i>、</i> ます。			
(1)	あなたは男性	ですか、女性です	-か?あてはま	る数字に〇〇	をつけてくださ	۲ V V °
	1. 男性	2. 女性				
(2)	あなたの学年	は何年生ですか	?あてはまる	数字に○をつ	っけてください。	0
	1. 1年生	2.2年生	3.	3年生		
2. ۲	こからはお酒	についての質問て	ごす。			
(1)	この 30 日間	に、少しでもお濯	暫を飲んだ日 に	合計何日に	なりますか?	
	1.0日	3. 3~5日	5.10	~19 日	7.毎日	(30日)
2	2. 1か2日	4. 6~9日	6.20	~29 日		
(2)	お酒を飲むと	きにはどのくら	いの量を飲み	ますか?		
-	1. 飲まない			5. コップに	3~5杯	
2	2. コップ1杯	未満(ほんの少し	.の量)	6. コップに	6杯以上	
	3. コップに1	杯		7. 酔いつぶ	れるまで	
2	1. コップに2	杯				
3. C	こからはタバ	コについての質問	です。			
(1)	この 30 日間	に、何日、タバコ	を吸いました	:か?		
	(2017 年調査	奎のみ「タバコ」	を「紙巻きタ	バコ」に変更	更)	
	1.0日	3. 3~5日	5.10	~19日	7.毎日	(30日)
2	2. 1か2日	4. 6~9日	6.20	~29日		
(2)	この 30 日間	に、1日平均どの)くらいの本数	(のタバコを)	吸いましたか?	2
	(2017 年調金	至のみ「タバコ」	を「紙巻きタ	バコ」に変見	更)	
(1996年と2000	年の調査)	_			
	1.この間、吸	っていない 4	. 5~9本	7.20)本以上	
2	2.1日1本に	満たない 5	. 10~14本			
	3. 1~4本	6	. 15~19本			
(2004年から201	17年の調査)				
	1.この間、吸	っていない 4	. 2~5本	7.16	5~20本	
2	2.1日1本に	満たない 5	. 6~10本	8.2	1本以上	
	3.1本	6	. 11~15本			
4. あ	なたの将来の	進学希望について	お聞きします	•		
(1)	将来の進路を	どのように考え、	ていますか?	今の気持ちに	近いもの1つ	に○をつけてください
-	1. 高等学校	3. 短大	5.	大学院		7. わからない
2	2. 専門学校	4. 大学	6.	今の学校卒業	業後の就職	

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Supplementary Table 1. Sampling of the study-participating schools in 1996, 2000, 2004, 2008, 2012, and 2017

	199	96	200)0	200)4	200)8	201	12	203	17
	n	(%)										
lunior high school												
(A) Number of schools in Japan	11,194		11,153		11,060		10,882		10,018		10,325	
(B) Number of schools sampled	122	(1.1)	132	(1.2)	131	(1.2)	130	(1.2)	140	(1.4)	98	(0.9)
(C) Number of schools which took part	80		99		92		92		94		48	
Response rate	65.6		75.0		70.2		70.8		67.1		49.0	
Senior high school												
(D) Number of schools in Japan	5,330		5,315		5,193		5,115		4,603		4,907	
(E) Number of schools sampled	109	(2.0)	102	(1.9)	109	(2.1)	110	(2.2)	124	(2.7)	86	(1.8)
(F) Number of schools which took part	73		77		87		80		85		55	
Response rate	67.0		75.5		79.8		72.7		68.5		64.0	

Supplementary Table 2. Prevalence of the amount of alcohol use per day among drinkers on a drinkin
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Year		1996		2000		2004		2008		2012		2017
Number of drinkers	n	= 44,545	n	= 39,497	n	= 30,233	n	= 16,110	n	= 12,034	n	= 3,584
	%	95%CI										
Less than 2 glasses	42.1	(41.7, 42.6)	60.3	(59.9, 60.8)	60.9	(60.4, 61.5)	61.6	(60.9, 62.4)	63.8	(62.9, 64.6)	65.2	(63.6, 66.7)
More than 3 glasses	39.4	(39.0, 39.9)	31.3	(30.9, 31.8)	32.2	(31.7, 32.7)	31.3	(30.6, 32.0)	30.2	(29.3, 31.0)	27.2	(25.7, 28.7)
Until I got drunk	10.6	(10.3, 10.9)	6.8	(6.6, 7.1)	5.9	(5.7, 6.2)	5.8	(5.4, 6.2)	4.4	(4.1, 4.8)	5.6	(4.8, 6.3)

Cl, confidence interval

Supplementary Table 3. Prevalence of the average number of cigarettes smoked among smokers per day

				-		-		-				
Year		1996		2000		2004		2008		2012		2017
Number of smokers	n	= 20,070	n	= 16,237	n	= 9,614	n	= 4,966	n	= 2,851	I	n = 769
	%	95%CI										
Less than 9 cigarettes	60.2	(59.5, 60.9)	74.0	(73.2, 74.5)								
More than 10 cigarettes	35.9	(35.2, 36.5)	23.0	(21.9, 23.2)								
Less than 10 cigarettes		_			67.4	(66.4, 68.3)	67.3	(66.0, 68.6)	73.2	(71.5, 74.8)	69.1	(65.8, 72.3)
More than 11 cigarettes					29.3	(28.4, 30.2)	28.4	(27.2, 29.7)	23.1	(21.6, 24.7)	25.0	(21.9, 28.0)

Cl, confidence interval

Supplementary Table 4. Prevalence of the number of days alcohol was used in the past 30 days among drinkers

Year		1996		2000		2004		2008		2012		2017
Number of drinkers	n	= 44,545	n	= 39,497	n	= 30,233	n	= 16,110	n	= 12,034	n	= 3,584
	%	95%CI										
1-9 days	91.5	(91.3, 91.8)	91.1	(90.9, 91.4)	90.1	(89.8, 90.5)	89.6	(89.2, 90.1)	90.6	(90.1, 91.1)	89.3	(88.3, 90.3)
10-29 days	7.1	(6.8, 7.3)	8.0	(7.7, 8.3)	8.7	(8.4, 9.0)	8.9	(8.5, 9.4)	8.3	(7.8, 8.8)	9.1	(8.1, 10.0)
Every day	1.4	(1.3, 1.5)	0.9	(0.8, 1.0)	1.2	(1.1, 1.3)	1.4	(1.2, 1.6)	1.1	(1.0, 1.3)	1.6	(1.2, 2.0)

CI, confidence interval

Supplementary Table 5. Prevalence of the number	r of days when cigarettes were	e smoked in the past 30 days among smokers
---	--------------------------------	--

 Year		1996		2000		2004		2008		2012		2017
Number of smokers	n	= 20,070	n	= 16,237	n	= 9,614	n	= 4,966	n	n = 2,851		n = 769
	%	95%CI										
 1-9 days	33.0	(32.4, 33.7)	32.3	(31.6, 33.0)	35.0	(34.0, 35.9)	38.4	(37.1, 39.8)	38.0	(36.2, 39.7)	47.2	(43.7, 50.7)
10-29 days	19.2	(18.6, 19.7)	19.0	(18.4, 19.6)	21.0	(20.2, 21.9)	20.7	(19.6, 21.8)	23.7	(22.2, 25.3)	21.2	(18.3, 24.1)
Every day	47.8	(47.1, 48.5)	48.7	(47.9, 49.5)	44.0	(43.0, 45.0)	40.9	(39.5, 42.2)	38.3	(36.5, 40.1)	31.6	(28.3, 34.9)

CI, confidence interval

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

			Page
		Reporting Item	Number
Title and abstract			
Title	<u>#1a</u>	Indicate the study's design with a commonly used term in the title or the abstract	
Abstract	<u>#1b</u>	Provide in the abstract an informative and balanced summary of what was done and what was found	
Introduction			ar tech
Background / rationale	<u>#2</u>	Explain the scientific background and rationale for the investigation being reported	3 3 9 10 10 10 10 10 10 10 10 10 10 10 10 10
Objectives	<u>#3</u>	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	<u>#4</u>	Present key elements of study design early in the paper	3-4
Setting	<u>#5</u> For	Describe the setting, locations, and relevant dates, including periods of peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	3-4

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1			recruitment, exposure, follow-up, and data collection	
2 3 4 5	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of selection of participants.	
6 7 8 9		<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	
10 11 12 13 14 15	Data sources / measurement	<u>#8</u>	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	2
16 17 18	Bias	<u>#9</u>	Describe any efforts to address potential sources of bias	
19 20	Study size	<u>#10</u>	Explain how the study size was arrived at	-
21 22 23 24	Quantitative variables	<u>#11</u>	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	2
25 26 27 28	Statistical methods	<u>#12a</u>	Describe all statistical methods, including those used to control for confounding	
29 30 31	Statistical methods	<u>#12b</u>	Describe any methods used to examine subgroups and interactions	2
32 33 34 35	Statistical methods	<u>#12c</u>	Explain how missing data were addressed	
36 37 38 39	Statistical methods	<u>#12d</u>	If applicable, describe analytical methods taking account of sampling strategy	2
40 41 42 43	Statistical methods	<u>#12e</u>	Describe any sensitivity analyses	1
44 45	Results			
46 47 48 49 50 51 52 53 54	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
55 56	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	1
57 58 50	Participants	<u>#13c</u>	Consider use of a flow diagram	
60		For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

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Descriptive data	#149	Give characteristics of study participants (eq. demographic, clinical	6
	<u>#14a</u>	social) and information on exposures and potential confounders. Give	0
		information separately for exposed and unexposed groups if applicable.	
Descriptive data	<u>#14b</u>	Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	6-11
Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-9
Main results	<u>#16b</u>	Report category boundaries when continuous variables were categorized	7-9
Main results	<u>#16c</u>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	<u>#18</u>	Summarise key results with reference to study objectives	12
Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-14
Generalisability	<u>#21</u>	Discuss the generalisability (external validity) of the study results	n/a
Other			
Information			
Funding	<u>#22</u>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15
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