別紙４

Ⅲ．研究成果の刊行に関する一覧表

書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書　籍　名	出版社名	出版地	出版年	ページ
尾崎米厚	集団の健康状態の把握、疾病の予防とスクリーニング、がん登録、おもな疾患の疫学保健統計学の基礎、人口統計の基礎、演習問題・国会試験勉強の手引き．疫学・保健統計学	牧本清子	疫学・保健統計学	医学書院	東京	2021	P8-16、60-70、76-95、107-141、144-154、184-210

雑誌

著者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
Kuwabara Y, Kinjo A, Fujii M, Minobe R, Maesato H, Higuchi S, Yoshimoto H, Jike M, Otsuka Y, Itani O, Kaneita Y, Kanda H, Osaki Y.	Effectiveness of Screening and Brief Alcohol Intervention at the Workplace: A Study Protocol for a Randomized Controlled Trial at Five Japan-Based Companies.	Yonago Acta Med.	64(4)	330-338	2021
Fujii M, Kuwabara Y, Kinjo A, Imamoto A, Jike M, Otsuka Y, Itani O, Kaneita Y, Minobe R, Maesato H, Higuchi S, Yoshimoto H, Kanda H, Osaki Y.	Trends in the co-use of alcohol and tobacco among Japanese adolescents: periodical nationwide cross-sectional surveys 1996-2017.	BMJ Open	11(8)	e045063	2021
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桑原 祐樹, 金城 文, 藤井麻耶, 尾崎 米厚, 真栄里仁, 美濃部 るり子, 樋口進, 吉本 尚, 大塚 雄一郎, 井谷 修, 兼板 佳孝, 地家真紀, 神田 秀幸	産業保健の現場における減酒支援ブリーフインターベンションの飲酒量改善への効果	日本アルコール・薬物医学会雑誌	56(6)	288	2021

金城文、藤井麻耶、桑原祐樹、尾崎米厚	日本におけるハームリダクションのアディクション予防・治療への応用　未成年の飲酒実態と課題	日本アルコール・薬物医学会雑誌	56(6)	169	2021
尾崎　米厚，金城　文，桑原　祐樹，藤井　麻耶	公衆衛生の観点からみたアディクション　公衆衛生の観点からみた喫煙問題	日本アルコール・薬物医学会雑誌	56(6)	148	2021

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Effectiveness of Screening and Brief Alcohol Intervention at the Workplace: A Study Protocol for a Randomized Controlled Trial at Five Japan-Based Companies

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ABSTRACT

Background Despite evidence regarding the effectiveness of screening and brief interventions for excessive alcohol use in primary care, these tools are not a part of routine practice. It has been suggested that using these tools at the workplace may be critical to alcohol-associated harm; however, evidence for this claim is unclear. The aim of this article is to develop a study protocol which evaluates the effect of brief alcohol intervention at the workplace to reduce harmful alcohol drinking.

Methods A randomized controlled trial involving employees (aged 20–74 years) of five Japan-based companies who were screened "positive" by Alcohol Use Disorder Identification Test (AUDIT) is ongoing. Participants were randomized into "Patient Information Leaflet" (control group), "Brief Advice and Counselling," and "Five-minute Brief Advice" groups. A self-administered questionnaire was used to assess alcohol consumption, lifestyle behavior, health status, work performance, and consequences of alcohol use. Data of laboratory markers were collected from routine health checkups.

Results A total of 351 participants were randomized into Patient Information Leaflet (n = 111), Brief Advice and Counselling (n = 128), and Five-minute Brief Advice (n = 112) groups. Participants were mostly men with a median age of 49 years. Median AUDIT score and weekly alcohol consumption were 11 points and 238 g/week, respectively. Two-thirds of the participants were manufacturing workers.

Conclusion This study protocol developed the first trial in Japan to investigate the effect of brief alcohol intervention combined with a recommended screening tool at the workplace. Our findings can provide evidence on the effectiveness and relevance of these tools to occupational health.

Key words brief intervention; excessive alcohol drinking; prevention; workplace

Excess alcohol use is a public health threat worldwide.[1] It is a leading cause of global morbidity and premature mortality, associated with violence, risk of injuries, various social harms, and substantial economic losses.[2, 3] In Japan, excess alcohol use (defined as > 40 g/day for men and > 20 g/day for women) is a critical public health issue.[4, 5]

The effectiveness of screening and brief interventions (SBIs) for harmful alcohol use in primary healthcare (PHC) settings has been established.[6–10] However, SBIs are not currently part of routine PHC practice, despite evidence in their favor.[11, 12] Previous reports have indicated that this issue is due to the limited time allocated to prevent harmful alcohol use over other potential targets for prevention such as poor diet, too little exercise, or smoking. Moreover, workload pressure, anxiety due to offending clients, and difficulty in getting past an addictive preoccupation with alcoholism are explained as the reasons for the limited implementation. SBIs should be accessible to the public to reduce alcohol-associated harm. Studies have evaluated the effect of SBI use outside of PHC settings, including at accident and emergency departments,[13–15] and non-healthcare

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Abbreviations: ANOVA, a one-way analysis of variance; AUDIT, alcohol use disorder identification test; IPAQ, International Physical Activity Questionnaire; JPY, Japanese Yen; K6, K6 Distress Scale; MCS, Mental Component Summary; PCS, Physical Component Summary; PHC, primary healthcare; PIL, patient information leaflet; QOL, Quality of Life; SBIs, screening and brief interventions; SF-8, SF-8 health survey; UMIN-CTR, university hospital medical information network clinical trials registry

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settings such as the workplaces.[16, 17]

Insufficient implementation of SBI in PHC settings leads to the necessity to implement alcohol-related interventions within the workplaces.[18] Interventions delivered at the workplaces have potential advantages, including reaching populations that tend to be missed by healthcare systems. Additionally, they might be able to address alcohol-related harm other than that related to health.[11] Excess alcohol use can cause economic loss due to accidents or low performance. A study on SBI efficacy at the workplace reported a positive effect on alcohol consumption reduction,[19] suggesting it could be an important strategy to alleviate alcohol-associated harms. However, other studies on its effectiveness have delivered inconsistent results.[20–22] Previous reports have indicated that the results may be due to bias in the selection of study participants. These studies also targeted relatively heavier drinkers from the onset, which meant the intervention effects were not apparent. It is worth mentioning that effective use of SBI at a the workplace requires screening to identify drinkers who are rarely reached by the PHC system. Moreover, considering the time-constraint in daily clinical practice that we have described above, there may be certain advantages in the implementation of SBI if short intervention shows sufficient effect.

The aim of this article is to develop a study protocol which evaluates the effectiveness of SBIs using the Alcohol Use Disorder Identification Test (AUDIT)[23]-screened participants using two types of interventions aimed at reducing excessive alcohol consumption, delivered in the workplace setting.

MATERIALS AND METHODS

Study setting

Employees from five companies (35–910 employees) in two western Japanese regions were recruited for this study. Four of these companies had well-organized occupational health departments.

Participant recruitment and screening

Specific health checkups and health guidance is a feature of Japan's public health system.[24] National law stipulates that medical insurers and employers are obliged to provide health checkups and guidance regarding visceral fat obesity for every person insured over 40 years of age and their dependents.[25] Health checkup guidelines recommend AUDIT screening.[23] We contacted companies that had incorporated self-reported AUDIT screening into their routine health checkups; thereafter, a site visit was arranged for research staff to explain trial protocols and acquire employer and occupational health care worker consent to participate in this study.

Inclusion criteria

Employees were eligible for inclusion in this study if they were aged 20-years or older, and their AUDIT score was ≥ 8 points. Staff from the occupational health department judged that they were alert and orientated enough to participate in the study. Screening cut-off points were based on the values reported in the literature.[26]

Exclusion criteria

Employees were excluded from participation if they were aged ≥75 years, involved in an alcohol treatment program in the previous year, reported symptoms of alcohol withdrawal in the last 12-months, received advice from their physician in the previous three months to change their pattern of alcohol consumption, were pregnant, or reported suicidal tendencies.

The occupational health department of each company that accepted our invitation to participate recruited participants from among their employees during January–December 2019.

Randomization

An individual participant was the unit of randomization. Unrestricted simple randomization was used. The intervenient was informed of the group allocation of each participant, by letter. Participants who met the inclusion criteria were enrolled and randomized into three groups by researchers using a computer-generated allocation method.

Consent

Consent to participate was obtained in a two-stage process. Staff from the occupational health department at each site screened employees for eligibility. No identifiable information was collected at this stage. Employees who met the inclusion criteria received information about the study from the research team. Written informed consent was obtained at this stage including permission to allow the research staff access to participant personal and contact details and routine health checkup records. Participants agreed to be followed up after six and 12-months. After providing consent, participants filled out the baseline questionnaire; once the external staff confirmed that the questionnaire was completed, participants received their allocated intervention.

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Training and brief intervention manual

External health professionals with nursing qualifications conducted the brief intervention. Before the study, each participating nurse received training on alcohol SBIs. The training program consisted of e-learning and role playing using on an SBI manual developed specifically for this study. The program conveyed basic details about the AUDIT program and relevant techniques and tips for giving advice to individuals with alcohol-related problems.[27] Training material included the stages of change model[28] and techniques of motivational interviewing.[29] After the training, the participating nurses were provided the opportunity to observe an actual brief alcohol intervention which was implemented by well-trained physicians.

Interventions

Our trial aimed to examine whether standard brief alcohol intervention is effective for reducing alcohol consumption. Internationally, a 15-minute brief advice and counselling is within the standard time length.[6] Moreover, we aimed to investigate the effectiveness of short intervention. If short intervention shows sufficient effect, there may be certain advantages in the implementation of SBI under the time-constraint in daily clinical practice. Therefore, we set up three groups: Patient information leaflet group, Brief advice and counseling group, and Five-minute brief advice group.

Participants were randomized into three groups and external health professionals randomly took charge the company's employees, randomly. The interventions were provided at the time of recruitment at their the workplaces. Every participant was requested to use the original smartphone application which contained a drinking diary and self-study tools.[30] The application contained functions that allowed users to create a diary on how much they drink in a day, week, or month. It also had an educational function as it contained materials that provided users with information on the consequences of drinking and how to reduce alcohol consumption. All intervention tools and protocols are available from our university website.[31] At the beginning stage of the study, we prioritized and conducted sessions with the participants who were allocated to the *Brief Advice and Counseling* group. Well-trained physicians demonstrated the intervention and checked whether the trained nurse provided appropriate intervention to the participants. Therefore, the number of participants in the Brief Advice and Counselling group was larger than the other two groups.

Patient information leaflet

Participants in the control group completed baseline questionnaires and were provided their AUDIT score together with a patient information leaflet (PIL). The PIL used in this trial was adapted from the Kurihama National Hospital's leaflet, "Getting on well with alcohol."[32]

Brief advice and counseling[33]

Participants in the brief advice and counseling group completed the baseline questionnaires and received 15-minute SBI sessions, including a one-on-one interview with trained health staff and an original worksheet. The sessions aimed to have the participants complete six tasks from a worksheet. The worksheet was based on the principles of cognitive-behavioral therapy and included an AUDIT evaluation, feedback on results, a balance sheet for considering of pros and cons of drinking, drinking-related goal-setting, and a list of coping methods for dealing with risky situations associated with binge drinking.

Five-minute brief advice[34, 35]

Participants in the five-minute brief advice group completed the baseline questionnaire and received up to five minutes of a simple structured brief intervention from a trained professional. The worksheet used with the brief advice and counseling group was also used with the five-minute group. The SBI session aimed to complete three tasks from the worksheet i.e. AUDIT evaluation, feedback on results, and drinking-related goal-setting.

Follow-up and outcomes

The primary outcome was a change in alcohol consumption amount per week (gram of pure alcohol per week). By using a self-administered questionnaire, we assessed the frequency of drinking alcohol, binge drinking in the previous 30-days, and the amount of alcohol usually consumed at baseline, 6 (±1) months, and 12 (±1) months. These three questions were the same as those asked in the AUDIT-C.[36] The research member calculated the alcohol consumption per week by assessing the frequency of alcohol use and the type of alcohol and the amount of drinking on a daily and monthly basis. "Binge drinking" was defined as drinking > 60 g of pure alcohol per occasion.

In addition, a self-administered questionnaire at baseline, 6-months, and 12-months assessed health service use, laboratory markers, health-related quality of life (SF-8),[37, 38] sleep disorders,[39] mental health status,[40] physical activity,[41, 42] selected eating behavior,[43] smoking, and work performance.[44, 45]

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Each participant received a JPY 1000 (USD 10) voucher from the interviewer after completing the baseline questionnaire. Another JPY 1000 voucher was posted after the completion of the six and 12-month follow-up questionnaires.

Sample size calculation

Sample size was calculated to account for participant-level outcomes. Change in weekly alcohol consumption at 6-months was the primary outcome of interest. Based on a previous study,[6] we expected a 40 g/week consumption reduction in the brief intervention group compared to the control group. The standard deviation in 7-day alcohol use: 100 g/week was estimated based on a previous study[46, 47] Given a 5% significance level, 80% statistical power of a two-sided test, the number of participants per group is 100, yielding a total sample of 300 participants. Our experience with other trials of SBIs at their workplaces suggested a potential 10% loss at follow-up across groups, resulting in a final sample of 110 participants per group (a total of 330).

Blinding

The present study did not involve the blinding of participants due to the nature of the intervention. Nevertheless, blinding was performed for the outcome assessment.

Planned analysis

The planned analysis was by intention-to-treat. The primary outcome (changes in alcohol consumption per week) was continuous and was analyzed using a one-way analysis of variance (ANOVA). Dunnett's tests were used to determine the differences between the intervention groups against the control group in the case of statistical significance being detected using ANOVA. In addition, a logistic regression model was used to examine the independent effect of the interventions on alcohol use after adjusting for covariates. Secondary analyses were undertaken using the method appropriate for each outcome, adjusting where appropriate for intake values and other known prognostic variables in the analysis of covariance. Intervention efficacy was examined with a secondary analysis, following a per-protocol approach; a sub-sample of participants who engaged with their allocated treatment were used in this analysis. Here, the definition of the per-protocol group is the group that contained participants who responded to both six months and 12-months of intervention. Finally, sub-group analysis was conducted to explore intervention effectiveness stratified by age into the under 49-years old and over 50-years old groups and occupational status groups into manufacturing workers and office workers.

Ethical and research governance approval

This trial protocol was reviewed and approved by the Ethics Review Committee of Faculty of Medicine, Tottori University, at the time of the survey (Reference No. 18B002).

The current trial was registered at the University Hospital Medical Information Network (UMIN) Clinical Trials Registry (UMIN-CTR[48]) (unique ID UMIN000036244). In addition, research governance approval was granted by the Ministry of Health and Welfare Health Science Research Fund in Japan (Grant No. 29060801).

Project timescales

The trial commenced in January 2019 and will continue until March 2025.

RESULTS

Participant recruitment process is shown in Fig. 1. A total of 2,276 employees from five companies completed the AUDIT screening. Among them, 505 participants scored > 8 points on AUDIT and were invited to participate. Finally, based on inclusion/exclusion criteria, verbal consent was requested and obtained from 351 participants who were randomized into the PIL (n = 111), Brief Advice and Counselling (n = 128), and Five-minute Brief Advice (n = 112) groups.

Baseline descriptive statistics

Participant characteristics are shown in Table 1. Participants were predominantly men with a median age of 49-years. Median AUDIT score and number of weekly alcohol consumption was 11-points and 238.0 g/week, respectively. The proportion of participants who drank > 3 days/week, who binge drank in the previous 30-days, and who currently smoke was 84.9%, 73.5%, and 39.3%, respectively. Most participants had completed 12-years of education (graduated from high school) and were within the 6–8 million yen household income bracket. Moreover, 71.2% of participants were married, and approximately two-thirds were engaged in a manufacturing occupation. No significant differences were observed between study groups on any of the baseline variables except for marital status.

DISCUSSION

One main strength of this study is that it is the first randomized controlled trial in Japan to investigate the impact of SBIs in the workplace combined with a recommended screening tool at the workplace. Despite

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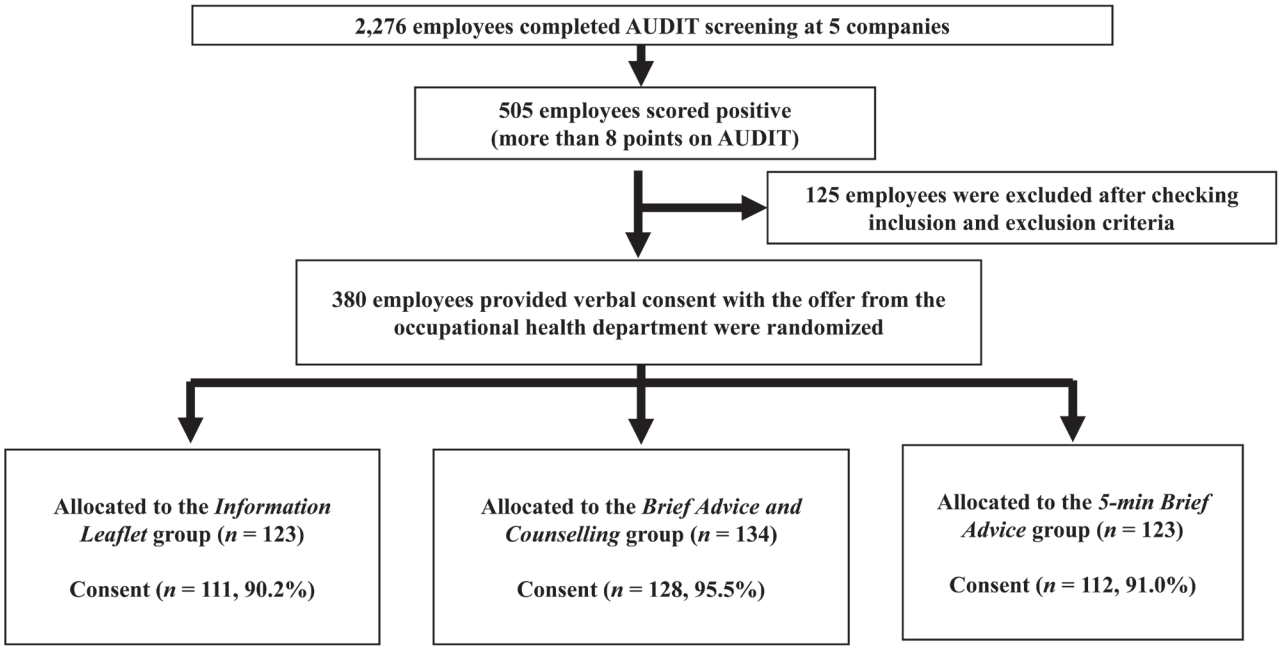

Fig. 1. Participant recruitment and inclusion flow chart.

the evidence in other countries, no trial in Japan showed the effectiveness of brief alcohol intervention at the workplace. Screening by AUDIT enabled us to select the study participants who are more suitable to examine the effectiveness of brief alcohol intervention. The intervention tools in our study were originally developed and simple to use for any health professionals. In the previous studies from other countries, most interventions were provided multiple times by doctors in a healthcare setting.[6] However, in this study, trained nurses provided a single-time intervention at the workplace. If the novel intervention shows sufficient effect, our findings can provide evidence which recommends the occupational health staff to use the implementable SBI in daily practice. Moreover, we aimed to examine the effectiveness of 5-minute brief advice. Conducting a study in the workplace has the advantage of being able to follow-up the participants and would provide the data with a minimum drop-out rate. In addition, the use of routine annual checkup database provided access to data on among others, laboratory markers. Moreover, using laboratory markers and self-reported information allows us to cross-check and validate participant responses. The analyses accounted for a wide-range of patient-level variables such as screening test results, weekly alcohol consumption, alcohol-related problems, public service use, and quality of life. Self-administered questionnaires can be more robust than face-to-face interviews when collecting sensitive information.[22]

Nevertheless, this protocol has some weaknesses, including a measurement of weekly alcohol consumption that was different from that commonly used method.[49] In addition, although blinding was performed for outcome assessment, in line with previous studies, the present study did not involve blinding of participants due to the nature of the intervention. Furthermore, selection bias may have been present in this study, precluding meaningful discussions about generalizability, which require larger studies. Finally, this study presented significant ethical challenges, due to research staff gaining access to sensitive employee information; hence, appropriate data management was required to protect the participants from any occupational disadvantages.

In conclusion, this study protocol developed the first trial in Japan to investigate the effect of brief alcohol intervention combined with a recommended screening tool at the workplace. The findings from this study protocol can provide the first evidence that SBI at the workplace is effective on reducing harmful alcohol use.

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Table 1. Baseline characteristics of participants and variables for randomization

		All participants		Information leaflet		Brief advice/ counselling		5-min brief advice		
		n = 351		*n* = 111		*n* = 128		*n* = 112		*P*-value [a]
Age (years)	Median (IQR)	49	(42, 55)	49	(40, 54)	49	(41, 55)	49	(43, 56)	0.536
Sex										
Male	*n* (%)	345	(98.3)	108	(97.3)	125	(97.7)	112	(100.0)	0.234
Female	*n* (%)	6	(1.7)	3	(2.7)	3	(2.3)	0	(0.0)	
AUDIT score	Median (IQR)	11	(9, 15)	10	(9, 14)	12	(9, 15)	12	(9, 15)	0.098
Weekly alcohol consumption (gram/week)	Median (IQR)	238	(121, 392)	231	(98, 394)	247.1	(126, 420)	248.5	(137, 352)	0.719
Frequency of drinking > 3 days/week	*n* (%)	298	(84.9)	90	(81.1)	108	(84.4)	100	(89.3)	0.226
Binge drinking in previous 30 days	*n* (%)	258	(73.5)	80	(72.1)	99	(77.3)	79	(70.5)	0.451
Current smoker	*n* (%)	138	(39.3)	48	(43.2)	47	(36.7)	43	(38.4)	0.571
Subjective sleep quality										
Very good	*n* (%)	26	(7.4)	10	(9.0)	8	(6.3)	8	(7.1)	0.308
Good	*n* (%)	192	(54.7)	66	(59.5)	69	(53.9)	57	(50.9)	
Bad	*n* (%)	127	(36.2)	33	(29.7)	47	(36.7)	47	(42.0)	
Very bad	*n* (%)	6	(1.7)	2	(1.8)	4	(3.1)	0	(0.0)	
Health-related QOL: SF-8 score										
PCS	Median (IQR)	50.6	(46.5, 53.6)	50.9	(48.0, 54.3)	49.8	(45.3, 53.0)	50.8	(45.9, 53.6)	0.119
MCS	Median (IQR)	52.3	(47.5, 54.9)	51.3	(47.1, 55.0)	52.7	(47.5, 54.9)	52.6	(47.8, 54.8)	0.522
Mental health status: K6 score										
Well: K6 ≤ 4	*n* (%)	135	(38.5)	35	(31.5)	49	(38.3)	51	(45.5)	0.241
Moderate depression: K6 = 5–12	*n* (%)	184	(52.4)	67	(60.4)	66	(51.6)	51	(45.5)	
Serious depression: K6 ≥ 13	*n* (%)	32	(9.1)	9	(8.1)	13	(10.2)	10	(8.9)	
Physical activity: IPAQ score										
Low	*n* (%)	186	(53.0)	61	(55.0)	69	(53.9)	56	(50.0)	0.39
Moderate	*n* (%)	108	(30.8)	31	(27.9)	44	(34.4)	33	(29.5)	
High	*n* (%)	57	(16.2)	19	(17.1)	15	(11.7)	23	(20.5)	
Educated years	Median (IQR)	12	(12, 14)	12	(12, 14)	12	(12, 14)	12	(12, 14)	0.256
Marital status										
Married and living with spouse	*n* (%)	238	(67.8)	68	(61.3)	86	(67.2)	84	(75.0)	0.027
Married and separated from spouse	*n* (%)	12	(3.4)	2	(1.8)	7	(5.5)	3	(2.7)	
Never married	*n* (%)	74	(21.1)	35	(31.5)	23	(18.0)	16	(14.3)	
Divorced/widowed	*n* (%)	27	(7.7)	6	(5.4)	12	(9.4)	9	(8.0)	
Equivalent household income										
< 6 million JPY	*n* (%)	103	(29.3)	33	(29.7)	41	(32.0)	29	(25.9)	0.704
6–8 million JPY	*n* (%)	83	(23.6)	26	(23.4)	27	(21.1)	30	(26.8)	
> 8 million JPY	*n* (%)	86	(24.5)	23	(20.7)	32	(25.0)	31	(27.7)	
I cannot answer	*n* (%)	79	(22.5)	29	(26.1)	28	(21.9)	22	(19.6)	

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Table 1. Baseline characteristics of participants and variables for randomization (*Continued*)

		All participants		Information leaflet		Brief advice/ counselling		5-min brief advice		
		n = 351		*n* = 111		*n* = 128		*n* = 112		*P*-value [a]
Occupational status										
Professional/technical occupation	*n* (%)	51	(14.5)	17	(15.3)	23	(18.0)	11	(9.8)	0.488
Managers	*n* (%)	34	(9.7)	13	(11.7)	11	(8.6)	10	(8.9)	
Office work	*n* (%)	38	(10.8)	15	(13.5)	10	(7.8)	13	(11.6)	
Production site/manufacturing occupation	*n* (%)	225	(64.1)	65	(58.6)	84	(65.6)	76	(67.9)	
Transport service	*n* (%)	2	(0.6)	1	(0.9)	0	(0.0)	1	(0.9)	
I cannot answer	*n* (%)	1	(0.3)	0	(0.0)	0	(0.0)	1	(0.9)	

[a] Kruskal-Wallis analysis or chi-square test was used for between-group comparisons. AUDIT, Alcohol Use Disorders Identification Test; IPAQ, International Physical Activity Questionnaire; IQR, Interquartile Range; JPY, Japanese Yen; K6, K6 Distress Scale; MCS, Mental Component Summary; PCS, Physical Component Summary; QOL, Quality of Life; SF-8, SF-8 health survey.

The authors declare no conflict of interest.

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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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ABSTRACT

Objectives This study aimed to assess trends in the prevalence of alcohol use depending on smoking behaviours and that of smoking depending on drinking behaviours among Japanese adolescents.

Design This was a retrospective study using Japanese school-based nationwide surveys conducted between 1996 and 2017.

Setting Surveyed schools, both junior and senior high schools, considered representative of the entire Japanese population, were sampled randomly.

Participants We enrolled 11 584–64 152 students from 179 to 103 schools yearly. They completed a self-reported and anonymous questionnaire on smoking and drinking behaviour.

Results Since 1996, the prevalence of alcohol use and smoking among adolescents decreased in each survey (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 the smokers group, it 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 was 32.5% in 1996 and 18.9% in 2017. The reduction rate was 0.90 in the non-drinkers group and 0.42 in the drinkers group. Therefore, downward trends differed among the groups. In a subanalysis of senior high school students, we divided students into three groups according to their intention to pursue further education. Between 1996 and 2017, there was a consistent difference in the prevalence of alcohol use and smoking among these groups.

Conclusions Alcohol use and smoking among Japanese adolescents seem to have reduced. However, certain groups showed poor improvements, and health risk behaviour disparity exists, which may widen further. We need to focus on high-risk groups and implement appropriate measures or interventions accordingly.

Strengths and limitations of this study

- The data were collected from periodical, nationwide large-sample surveys on Japanese adolescents between 1996 and 2017, and the study contained a large sample size (n=11 584–64 152 per year).
- This study focused on the co-use of alcohol and tobacco and analysed respective trends in the subgroups.
- Due to ethical concerns and inconvenience, school response rates were not as high as expected; however, the student response rate was consistent.
- Due to the ethical concerns, we did not ask students about their social and economic status and instead, analysed the trends by the students' intention to pursue further education.
- The study used a self-reporting questionnaire; hence, further studies to examine the accuracy of these findings are required.

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

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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 USA.[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 socioeconomic 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, this 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 extracted, and all students enrolled in the sampled schools were participants of the study. The number, selection rate and response rate of the schools in each survey are shown in online supplemental table 1. The response rates of schools ranged between 49.0% and 79.8%.

To test our hypothesis, the research population was divided into the following subgroups: smokers group/non-smokers group, drinkers group/non-drinkers group and their intention to pursue further education fell under four categories: (1) senior high school graduation, (2) junior college (2-year college/vocational school), (3) college or higher educational degree (4-year or 6-year college/graduate school) and (4) unknown. Next, trends in the prevalence of alcohol use and smoking in each group were examined.

Data collection

Online supplemental figure 1 shows the flow chart of data collection in 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 and sealed by the students themselves, and these envelopes were collected by the teachers and returned to our institute.

Patient and public involvement

No patients were involved in this study.

Measures

Alcohol use and smoking

Drinkers and smokers were defined as those who had consumed alcohol or smoked at least once during the past 30 days. The questionnaire focused on the students' experiences, frequency of alcohol use ('How many days in the past 30 days have you had alcohol?') and smoking ('How many days in the past 30 days have you smoked cigarettes?'), amount of alcohol use ('How much alcohol have you had on a drinking day?') and smoking ('How many cigarettes on average per day have you smoked in the past 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 I got drunk'.

In the 1996 and 2000 surveys, to assess smoking, seven options were provided: 'have not smoked in past 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'; in the 2004 to 2017 surveys, eight options were provided: 'have not smoked in past 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' (online supplemental file 1). It was only in the 2017 survey when the questions on 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.

Intention to pursue further education

We assessed the intention to pursue further education after graduating from school ('What is your intention

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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% CIs 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 V.13 for Windows (SAS). 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.

Online supplemental figures 2 and 3 show 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 4-year survey and between the 7th grade in 2012 and the 12th grade in 2017. Online supplemental figures 4 and 5 show the change in smoking prevalence in the same groups described in online supplemental figures 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% to 93.0%; girls 95.0%, 95% CI: 95.2% to 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<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.

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

Year	1996	2000	2004	2008	2012	2017
	(n=115 814)	(n=106 297)	(n=102 451)	(n=95 680)	(n=100 050)	(n=64 152)
No of participants	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Sex						
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)
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)
School grade						
Junior high school (12–15 years old)						
Grade 7	14 369 (12.4)	15 372 (14.5)	13 146 (12.8)	13 302 (13.9)	13 405 (13.4)	7384 (11.5)
Grade 8	14 118 (12.2)	15 916 (15.0)	13 079 (12.8)	13 649 (14.3)	12 884 (12.9)	7329 (11.4)
Grade 9	14 311 (12.4)	15 958 (15.0)	13 160 (12.8)	12 925 (13.5)	12 205 (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 years old)						
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)
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)
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)
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	259 (0.3)	0 (0.0)	120 (0.2)
Alcohol use/smoking in the past 30 days						
Alcohol use	44 545 (38.7)	39 497 (37.4)	30 233 (29.7)	16 110 (16.9)	12 034 (12.1)	3584 (5.6)
Smoking	20 070 (17.9)	16 237 (15.7)	9614 (9.5)	4966 (5.2)	2851 (2.9)	1183 (1.8)

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

Year		1996 % 95% CI	2000 % 95% CI	2004 % 95% CI	2008 % 95% CI	2012 % 95% CI	2017 % 95% CI	P value*
Boys	No use†	50.3 (50.9 to 49.7)	54.7 (55.3 to 54.1)	66.4 (66.9 to 65.9)	80.4 (80.8 to 80.0)	86.9 (87.2 to 86.6)	93.3 (93.5 to 93.0)	<0.01
	Alcohol use only†	23.9 (24.2 to 23.6)	24.2 (24.6 to 23.9)	21.5 (21.8 to 21.3)	12.7 (12.8 to 12.5)	9.2 (9.3 to 9.0)	5.1 (5.3 to 5.0)	<0.01
	Smoking only†	6.9 (7.1 to 6.8)	5.8 (6.0 to 5.7)	3.2 (3.3 to 3.1)	2.3 (2.4 to 2.2)	1.3 (1.4 to 1.3)	0.5 (0.5 to 0.5)	<0.01
	Co-use†	18.9 (19.5 to 18.3)	15.3 (15.7 to 14.8)	8.9 (9.1 to 8.6)	4.7 (4.9 to 4.5)	2.6 (2.7 to 2.5)	1.1 (1.2 to 1.0)	<0.01
Girls	No use†	63.2 (63.6 to 62.8)	62.8 (63.3 to 62.4)	70.3 (70.7 to 69.8)	82.8 (83.1 to 82.4)	87.3 (87.5 to 87.0)	95.0 (95.2 to 94.8)	<0.01
	Alcohol use only†	26.7 (25.2 to 25.3)	27.2 (27.5 to 26.8)	23.3 (23.7 to 23.0)	13.8 (14.1 to 13.6)	11.0 (11.2 to 10.8)	4.3 (4.4 to 4.1)	<0.01
	Smoking only†	2.3 (2.3 to 2.2)	2.3 (2.4 to 2.2)	1.5 (1.5 to 1.4)	0.9 (0.9 to 0.8)	0.4 (0.4 to 0.3)	0.2 (0.2 to 0.1)	<0.01
	Co-use	7.8 (8.0 to 7.6)	7.7 (7.9 to 7.5)	5.1 (5.1 to 4.8)	2.5 (2.6 to 2.4)	1.4 (1.4 to 1.3)	0.6 (0.6 to 0.5)	<0.01
Both	No use†	56.8 (57.3 to 56.3)	58.6 (59.1 to 58.2)	68.1 (68.6 to 67.7)	81.6 (81.9 to 81.2)	87.1 (87.3 to 86.8)	94.1 (94.3 to 93.9)	<0.01
	Alcohol use only†	25.3 (25.5 to 25.1)	25.6 (25.9 to 25.4)	22.4 (22.6 to 22.1)	13.2 (13.4 to 13.0)	10.1 (10.2 to 9.9)	4.7 (4.9 to 4.6)	<0.01
	Smoking only†	4.6 (4.7 to 4.4)	4.1 (4.2 to 4.0)	2.4 (2.5 to 2.3)	1.6 (1.6 to 1.5)	0.9 (0.9 to 0.8)	0.3 (0.4 to 0.3)	<0.01
	Co-use†	13.3 (13.7 to 12.9)	11.6 (11.9 to 11.3)	7.1 (7.3 to 6.9)	3.6 (3.8 to 3.5)	2.0 (2.1 to 1.9)	0.9 (0.9 to 0.8)	<0.01

*Based on the Cochran-Armitage trend test.
†In the past 30 days.

Online supplemental 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. Online supplemental 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.

Figure 1 and table 3 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.

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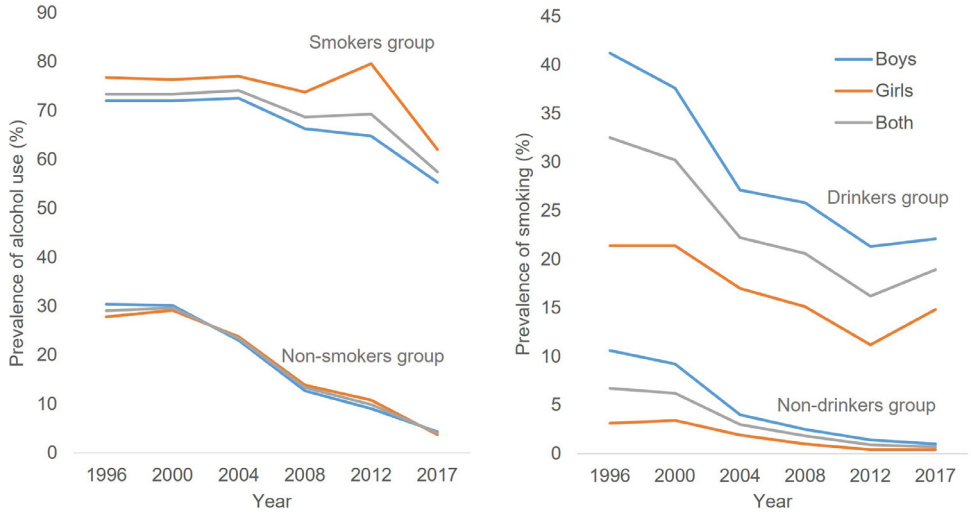

Figure 1 Prevalence of alcohol use depending on smoking and prevalence of smoking depending on alcohol use among Japanese adolescents (aged 12–18 years) between 1996 and 2017 by sex.

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 high school graduation group and college or the higher education 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.

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 USA.[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 socioeconomic 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.

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

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Table 3 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

Year			1996 %* 95% CI	2000 %* 95% CI	2004 %* 95% CI	2008 %* 95% CI	2012 %* 95% CI	2017 %* 95% CI	Reduction rate†
Alcohol use in the past 30 days	Boys	Non-smokers	30.4 (30.3 to 30.5)	30.1 (30.1 to 30.2)	23.0 (22.9 to 23.0)	12.7 (12.7 to 12.8)	9.0 (9.0 to 9.1)	4.3 (4.3 to 4.3)	0.86
		Smokers	72.0 (71.9 to 72.1)	72.0 (71.9 to 72.1)	72.5 (72.4 to 72.7)	66.3 (66.1 to 66.5)	64.8 (64.5 to 65.0)	55.3 (54.9 to 55.7)	0.23
	Girls	Non-smokers	27.8 (27.7 to 27.8)	29.1 (29.1 to 29.2)	23.7 (23.7 to 23.8)	13.8 (13.8 to 13.8)	10.7 (10.7 to 10.8)	3.7 (3.7 to 3.8)	0.87
		Smokers	76.7 (76.5 to 76.9)	76.3 (76.2 to 76.5)	77.0 (76.8 to 77.2)	73.7 (73.5 to 74.0)	79.5 (79.2 to 79.9)	62.0 (61.5 to 62.5)	0.19
	Both	Non-smokers	29.0 (29.0 to 29.0)	29.6 (29.6 to 29.6)	23.4 (23.3 to 23.4)	13.3 (13.2 to 13.3)	9.9 (9.8 to 9.9)	4.0 (4.0 to 4.0)	0.86
		Smokers	73.3 (73.2 to 73.4)	73.3 (73.2 to 73.4)	74.1 (74.0 to 74.2)	68.7 (68.6 to 68.9)	69.2 (69.0 to 69.4)	57.4 (57.1 to 57.7)	0.22
Smoking in the past 30 days	Boys	Non-drinkers	10.6 (10.6 to 10.7)	9.2 (9.1 to 9.2)	4.0 (4.0 to 4.1)	2.5 (2.5 to 2.5)	1.4 (1.4 to 1.5)	1.0 (1.0 to 1.0)	0.91
		Drinkers	41.2 (41.1 to 41.3)	37.6 (37.5 to 37.7)	27.1 (27.0 to 27.2)	25.8 (25.7 to 25.9)	21.3 (21.2 to 21.5)	22.1 (21.9 to 22.3)	0.46
	Girls	Non-drinkers	3.1 (3.1 to 3.1)	3.4 (3.3 to 3.4)	1.9 (1.8 to 1.9)	1.0 (1.0 to 1.0)	0.4 (0.4 to 0.4)	0.4 (0.4 to 0.4)	0.87
		Drinkers	21.4 (21.3 to 21.5)	21.4 (21.3 to 21.5)	17.0 (16.9 to 17.1)	15.1 (15.0 to 15.2)	11.2 (11.1 to 11.3)	14.8 (14.6 to 15.0)	0.31
	Both	Non-drinkers	6.7 (6.7 to 6.7)	6.2 (6.2 to 6.2)	3.0 (2.9 to 3.0)	1.8 (1.8 to 1.8)	0.9 (0.9 to 0.9)	0.7 (0.7 to 0.7)	0.90
		Drinkers	32.5 (32.4 to 32.5)	30.2 (30.1 to 30.2)	22.2 (22.2 to 22.3)	20.6 (20.5 to 20.7)	16.2 (16.1 to 16.3)	18.9 (18.8 to 19.0)	0.42

*Adjusted for grade and sex.
†Reduction rate = (prevalence in 1996 − prevalence in 2017)/prevalence in 1996.

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Table 4 Prevalence of alcohol use and smoking among Japanese senior high school students (aged 15–18 years) between 1996 and 2017 by the intention to pursue further education

Year	1996 %* 95% CI	2000 %* 95% CI	2004 %* 95% CI	2008 %* 95% CI	2012 %* 95% CI	2017 %* 95% CI	Reduction rate†
Alcohol use in the past 30 days							
High school graduation	52.7 (52.6 to 52.9)	53.1 (52.9 to 53.2)	43.7 (43.6 to 43.9)	29.2 (29.0 to 29.3)	19.9 (19.8 to 20.0)	9.4 (9.4 to 9.5)	0.82
Junior college degree	46.7 (46.6 to 46.8)	47.1 (47.0 to 47.2)	42.8 (42.6 to 42.9)	28.8 (28.7 to 29.0)	21.6 (21.5 to 21.7)	9.8 (9.7 to 9.8)	0.79
College or higher educational degree	18.0 (17.9 to 18.1)	16.6 (16.5 to 16.6)	10.1 (10.1 to 10.2)	5.7 (5.7 to 5.8)	3.2 (3.1 to 3.2)	1.8 (1.8 to 1.8)	0.90
Smoking in the past 30 days							
High school graduation	36.8 (36.7 to 36.9)	37.7 (37.5 to 37.8)	23.7 (23.6 to 23.8)	15.5 (15.4 to 15.7)	7.6 (7.5 to 7.6)	4.0 (3.9 to 4.0)	0.89
Junior college degree	23.4 (23.3 to 23.5)	22.6 (22.5 to 22.7)	15.3 (15.2 to 15.4)	10.2 (10.1 to 10.3)	5.0 (4.9 to 5.0)	3.0 (3.0 to 3.1)	0.87
College or higher educational degree	13.1 (13.0 to 13.2)	14.6 (14.6 to 14.7)	6.7 (6.6 to 6.7)	3.1 (3.1 to 3.1)	1.4 (1.3 to 1.4)	1.0 (1.0 to 1.0)	0.92

*Adjusted for grade and sex.
†Reduction rate = (prevalence in 1996 – prevalence in 2017)/prevalence in 1996.

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. 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 (equivalent to US$2) in 1996. This increased to ¥250 (4% increase), ¥270 (8% increase), ¥300 (11% increase), ¥410 (37% increase) and ¥420 (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 US$1. 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

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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] This study showed different trends in the prevalence of alcohol 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 minimise 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.

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 subanalysis 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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Contributors YOs, SH and YKa designed the study and devised its protocols. OI, YOt, MJ and HY reviewed the literature and helped summarising previous research studies. HK, AK, YKu, RM, HM and AI carried out statistical analyses. MF wrote the first draft of the manuscript. All authors read and approved the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval 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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Research paper

Trends in sleep problems and patterns among Japanese adolescents: 2004 to 2017

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ABSTRACT

Background: Sleep problems in adolescence, such as insomnia and short sleep duration, are associated with physical and mental health problems. However, little is known about the recent trends in sleep problems among adolescents. Therefore, this study examined trends in sleep problems among Japanese adolescents.

Methods: Using data from the Lifestyle Survey of Adolescents collected in 2004 (n = 102,451), 2008 (n = 95,680), 2010 (n = 98,867), 2012 (n = 101,134), 2014 (n = 85,931), and 2017 (n = 64,417), we calculated the trends of insomnia, shorter sleep duration, late bedtimes, and poor sleep quality. Multivariable logistic regression analysis models were used to examine the association of each sleep problem and survey years.

Findings: We analyzed data from 545,285 Japanese adolescents. Results indicated that, since 2004, the odds ratio for insomnia have decreased (Adjusted odds ratio [AOR] 0•85, 95% CI 0•82–0•87), as have the odds ratio for poor sleep quality (AOR 0•92, 95% CI 0•88–0•95). However, the odds ratio for shorter sleep duration (AOR 1•13, 95% CI 1•10–1•17) and late bedtimes tended to increase (AOR 1•06, 95% CI 1•03–1•08) during this period.

Interpretation: The prevalence of insomnia symptoms and poor sleep quality among adolescents decreased from 2004 to 2017. However, there were increasing trends toward shorter sleep duration and late bedtimes. These changes are both relieving and concerning. Teachers, parents, and health professionals should consider educating adolescents regarding sleep hygiene, adjusting schedules of extracurricular activities, and enhancing time management to improve their sleep quantity.

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Research in context

Evidence before this study

Adolescent sleep problems are becoming increasingly recognized as a significant public health concern. We searched PubMed with the following search terms: "Sleep Disorders," "Adolescent" (Adolescents, Adolescence, Teens, Teen, Teenagers, Teenager, Youth, Youths), and "trend or change." We reviewed titles and abstracts and excluded articles not published in English, that did not target humans, or were not relevant to adolescent sleep problems. Given the extensive literature on adolescent sleep, we included studies that were specific to changes in adolescent insomnia symptoms and sleep duration. Most previous work and a meta-analysis of international studies reported that adolescent bedtimes tended to become increasingly delayed and sleep duration tended to decrease with increasing age, leading to shorter sleep on school nights. However, sleep deterioration among adolescents has been prominent mainly in Western countries and was limited until the early 2000s. We found very few studies that examined the trends of sleep problems in Asian countries.

Added value of this study

The trends of sleep problems have not been previously investigated among Asian countries, creating a significant knowledge gap. This is the first nationally representative repeated cross-sectional study that examines trends in sleep problems among Japanese adolescents. The trends identified here demonstrate that the prevalence of insomnia symptoms and poor sleep quality decreased among Japanese adolescents from 2004 to 2017. However, there were increasing trends toward shorter sleep duration and late bedtimes. This study provides important evidence for policy makers and school officials to educate adolescents regarding improved time management and to address adolescents' sleep needs.

Implications of all the available evidence

The prevalence of later bedtime among adolescents is increasing in line with technological developments such as the Internet and cellular phones. In many countries, the prevalence of adolescent insomnia-related symptoms has tended to increase while, in a few countries, a downward trend has been observed. These differences could be useful in developing more effective prevention strategies in the future. Interventions tailored to prevent late bedtime may aid in maximizing the effects of health education during adolescence. Finally, the results provide a benchmark for monitoring trends in adolescent sleep in Japan and other East Asian countries in the future.

1. Introduction

Adolescent sleep problems are becoming increasingly recognized as a significant public health issue, with many countries reporting a high prevalence of sleep disturbance in adolescence [1]. Previous studies reported that the prevalence of insomnia among adolescents worldwide ranged from 16•9% to 34•0% [2–4]. Most epidemiological studies define insomnia symptoms as having one or more of the following: difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), early morning awakening (EMA), or nonrestorative sleep (NRS) [2,3,5]. A meta-analysis of international studies reported that, from 1999 to 2010, adolescent bedtimes tended to become increasingly delayed and sleep duration tended to decrease with increasing age, leading to shorter sleep on school nights [1].

In Japan, a representative epidemiological study of sleep disturbances in adolescence was first conducted in 2000 [6] and reported that 28•7% of boys and 32•6% of girls slept on average for less than six hours per night [6]. In 2004, the prevalence of insomnia, which was defined as DIS, DMS, or EMA, among Japanese adolescents was 23•5% [7].

An important question concerning adolescents' sleep is whether sleep problems are increasing in line with other social changes. There are concerns that emergent technological developments, such as the Internet and cellular phones, and the rise of the "24-hour society," have affected adolescents' sleep in recent years [8]. Few studies, however, have investigated population trends in adolescent sleep issues. In the U.S., a study with a representative sample of 272,077 adolescents aged 12 to 19 years showed a 30% lower prevalence of sleep duration of more than seven hours in 2012 compared to 1991 [9]. A systematic cross-country review of data from 690,747 children from 20 countries identified a decline of 0•75 min per year in children's sleep duration over the last 100 years [10]. Another study demonstrated increases in the prevalence of sleep-onset difficulties in Norwegian adolescents from 1983 to 2005 [11] and among European adolescents from 2002 to 2014 [12]. American adolescents' self-reported sleep time also decreased from 2009 to 2015 [13]. These changes have been attributed to increases in electronic device use, including social media engagement and reading news online [13], as well as limited physical activity [12]. Thus, it is recognized that sleep is deteriorating among adolescents in Western societies. Very few studies have examined the trends of sleep problems in Asian countries. For example, sleep duration increased for children from Shanghai aged 6 to 11 years (2005 to 2014) but decreased for children from Hong Kong (2003 to 2012) [14]. The opposite results in sleep duration between the two regions have been attributed to changes in school start times [14]. This is particularly problematic, given that East Asian people are known to sleep less and have later bedtimes than people from Western countries [1,15]. Thus, studies on the sleep trends of Asian adolescents are urgently needed. Furthermore, previous studies of trends in adolescent sleep patterns have focused mainly on sleep disorders and sleep duration, and no studies have evaluated multiple dimensions of sleep, such as insomnia symptoms, sleep quality, and sleep duration.

In 2014, the Japanese Ministry of Health, Labour and Welfare published the "Sleep Guidelines 2014 for Health Promotion." The document is aimed at the general public and includes 12 basic sleep guidelines designed for use in lifestyle coaching to promote health in the population. Since then, schools and corporations in Japan have begun to provide sleep hygiene education [16,17].

According to media campaigns, many Japanese citizens are motivated to get sufficient sleep [18]. However, there is little information about recent trends in sleep problems, such as insomnia symptoms, short sleep duration, and poor sleep quality among Japanese adolescents.

This study aimed to investigate the trends in self-reported sleep problems among Japanese adolescents using nationally representative cross-sectional surveys of adolescents' lifestyle behavior from 2004 to 2017. Given the findings of previous research, we hypothesized that trends in the prevalence of sleep problems, such as insomnia, short sleep duration, and poor sleep quality, among Japanese adolescents would have increased until 2014, when the campaign was implemented, and then declined by 2017.

2. Method

2.1. Data sources

We used data from the Lifestyle Survey of Adolescents collected in 2004, 2008, 2010, 2012, 2014, and 2017. Since 1996, the working group of the Lifestyle Survey of Adolescents, conducted by the Japanese Ministry of Health, Labour and Welfare, has surveyed a representative sample of Japanese adolescents using a single stratified single-stage standard cluster sampling procedure. The cluster

unit was schools. The method involved dividing Japan into regional blocks and randomly selecting schools from each block.

2.2. Participants

The study population was restricted to students between grades 7 and 12 of junior and senior high schools selected throughout Japan using the National School Directory. The proportion of private schools was approximately 7% for junior high schools and 30% for senior high schools in each survey. These proportions are highly similar to the statistics reported by the Ministry of Education, Culture, Sports, Science and Technology, Japan. All students enrolled in the sampled schools were included as the target population of the study. Due to survey budget limitations, the number of schools and students completing the survey varied in each survey year, resulting in changes in sample size across the years. The distribution of the characteristics of schools (e.g., private vs. public) was selected to be representative of the study population [6,7].

2.3. Survey procedure

A letter was sent to the principal of each selected school requesting their cooperation along with a questionnaire form and an envelope for each enrolled student. In participating schools, class teachers informed the students about the study in detail and reassured them about privacy protection and that the completed questionnaires would not be seen by the teachers. Informed written consent was obtained from all study participants. Due to the new epidemiological research guidelines, informed consent was obtained from each junior high school student's parent or guardian for the 2017 survey. Parents' and guardians' informed consent was not required by the guidelines governing anonymous and non-invasive research entailing students who had finished junior high school in the earlier years. The teachers explained the nature of confidentiality and voluntary participation to all the students, and completed questionnaires were returned to the working group in sealed envelopes. This protocol is in accordance with the Japanese Ethical Guidelines for Epidemiological Research announced by the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology of Japan. The working group used anonymized questionnaires to prevent the identification of individual participants and to safeguard their privacy. This study was approved by the ethical review board of the Nihon University School of Medicine.

2.4. Outcome measures

The sleep-related items in the survey included questions about insomnia symptoms, sleep duration, and subjective sleep quality. The following three questions were asked to assess insomnia symptoms experienced during the previous month: (1) Did you have difficulty falling asleep at night?; (2) Did you wake up during the night after you had gone to sleep?; and (3) Did you wake up too early in the morning and have difficulty getting back to sleep? Each question had five possible responses: never, seldom, sometimes, often, and always. We defined those reporting "often" and "always" as displaying "severe" symptoms and those reporting "sometimes" as displaying "moderate" symptoms. The severity of insomnia symptoms was defined based on responses to one or more of the three questions. Sleep duration was assessed by asking, "How many hours on average have you slept at night during the previous month?" with response options of less than five hours, five hours or more but less than six hours, six hours or more but less than seven hours, seven hours or more but less than eight hours, eight hours or more but less than nine hours, and nine hours or more. Subjective sleep quality was assessed by asking, "How was the quality of your sleep during the previous month?" with the following response options: very good, good, bad, very bad. If the response to this question was bad or very bad, the adolescent was rated as having poor sleep quality [19]. Concerning the question, "What time do you go to bed?" those who answered 1 am or later were considered as having a "late bedtime (LBT)" [20].

2.5. Covariates

Participants also provided data on demographic and school characteristics, including gender, grade, and type of school (junior high or senior high school). They responded to lifestyle behavior questions including the frequency of eating breakfast ("every day," "sometimes," or "seldom"); participation in club activities ("participation," or "no participation"); smoking status; and alcohol drinking status. Respondents were rated as having regular breakfast if they responded "every day" to the relevant question. For the smoking question ("How many days did you smoke during the previous month?"), participants were considered to be current smokers if they answered that they smoked one or more days. Similarly, those who responded "one day or more" to the alcohol question ("How many days did you consume alcoholic beverages during the previous month?") were considered to be current drinkers.

To evaluate student life plans, students were asked, "What is your plan for your future life course?" Those who selected "university" or "postgraduate school" were grouped as students who intended to go to university, and those who selected "high school," "vocational school," "junior college," "taking a job after leaving the current school," or "not decided yet" were grouped as students who did not intend to go to university. The participants were also asked if they felt happy at school, with the choice of the following responses: "Yes, I do," "Yes and no," and "No, I don't."

Mental health status was assessed using the 2-item General Health Questionnaire (GHQ-2) instead of the 12-item version (GHQ-12), given the limited space available in the survey questionnaire. Previous research indicates a cut-off score of 1 on GHQ-2 has a sensitivity and specificity of 87•0% and 85•1%, respectively, using GHQ-12 as the gold standard [21]. The GHQ-2 included the following questions: "Have you felt more unhappy and depressed than usual in the past 30 days?" and "Have you been able to enjoy your normal daily activities more than usual?" Each item was rated from 0 to 1, with a total score ranging from 0 to 2. A score of 0 was regarded as indicative of good mental health, whereas scores of 1 or 2 were regarded as indicative of poor mental health.

2.6. Statistical analysis

First, we compared the number of participants in each survey year using chi-squared tests and examined the participants' demographic characteristics by survey year. Second, we calculated the prevalence of insomnia symptoms, shorter sleep duration, late bedtimes, and poor sleep quality by survey year. Third, we examined time trends of sleep problems using bivariate and multivariate binary logistic models. To better describe sleep trends across the entire study period, the survey year was transformed by subtracting 2004 from the year and dividing the results by 13. Thus, the transformed value ranged from 0 for 2004 to 1 for 2017. The odds ratios associated with this transformed variable of survey year represent changes in odds of sleep problems during the study period. This method enabled us to interpret the corresponding regression coefficients as changes in the odds of each sleep problem from 2004 to 2017 [22]. The outcome for these analyses was the dichotomous variable for the presence of sleep problems, and the predictor was each survey year. To evaluate insomnia and sleep duration, we performed ordinal logistic regression. The final covariates

in the ordinal and binary logistic regression analysis included demographic characteristics (gender, birth cohort, and school grade), lifestyle behaviors (having breakfast, participating in clubs, drinking alcohol, smoking status), student life (intention to study at university and having fun at school), and mental health status. These covariates were selected because they have been associated with sleep problems in previous studies [6,7,19,23]. The birth cohort was divided into three categories (1984–1989, 1990–1997, and 1998–2005) based on the revision of the Learning Guidance Guidelines in 1989 and 1998. Sampling weights were constructed based on the participation rate of junior/senior high school students in each survey year. The grade-adjusted estimates were calculated using the direct method with projected students in the year 2004 as the standard. We set the significance level at $p<0•01$ because of the large sample size. We adopted pairwise deletion to handle missing data. All analyses were performed using Stata 15 (Statacorp, College Station, Texas).

2.7. Sensitivity analyses

To assess reproducibility and validity in defining the prevalence of sleep problems across the years, we redefined each sleep problem. Insomnia was redefined as one or more symptoms of DIS, DMS, or EMA experienced "often" and "always" [7]. Short sleep duration was defined as less than seven hours [9]. Subjective poor sleep quality was redefined as a response of "very bad." LBT was redefined as a bedtime of 12 am or later. To examine gender effects, we analyzed trends in sleep problems according to gender.

2.8. Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the paper. The corresponding author had full access to all the data in the study and all authors shared final responsibility for the decision to submit for publication.

3. Results

The number of participants in each survey year was determined by budgetary constraints, and it varied from 102,451 in 2004 to 64,417 in 2017 (Table 1). The respective student response rates declined from 64•7% in 2004 to 54•5% in 2017.

Regarding demographic characteristics over the survey years, approximately twice as many participants were high school students (Grades 10–12) as junior high school students (Grades 7–9; Table 2). The prevalence of smoking and drinking consistently declined over the survey years, whereas the prevalence of mental health problems increased in 2014 and 2017. The prevalence of poor mental health was lowest in 2012.

Table 3 and Fig. 1 present the trends in sleep problems from 2004 to 2017. Significant linear trends were observed for all sleep problems except for LBT. The unadjusted prevalence of severe insomnia decreased from 23•3% in 2004 to 18•3% in 2017. The unadjusted prevalence of sleep duration below seven hours was the lowest in 2004. The unadjusted and adjusted prevalence of LBT was least prevalent in 2008 and highest in 2010. The prevalence of poor sleep quality displayed a declining trend overall but was the highest in 2008. In the final model (adjusted for participants' weight, gender, birth cohort, junior/senior high school, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol, smoking, and future plans), the adjusted prevalence of severe and moderate insomnia decreased from 22•0% and 40•1% in 2004 to 19•2% and 38•9% in 2017 (adjusted odds ratio [AOR] 0•85, 95% confidence interval [CI] 0•82–0•87). Similarly, the adjusted prevalence of poor sleep quality decreased

Table 1
Response rate statistics from 2004 to 2017.

Year	Junior high school			Senior high school			p-value	Total eligible participants	Total enrolled participants	Total response rate (%)
	Eligible participants	Enrolled participants	Response rate (%)	Eligible participants	Enrolled participants	Response rate (%)				
2004	64,885	39,385	60•7	93,155	63,066	67•7		158,040	102,451	64•8
2008	62,638	40,151	64•1	89,419	55,529	62•1		152,057	95,680	62•9
2010	62,081	38,552	62•1	92,366	60,315	65•3		154,447	98,867	64•0
2012	65,002	38,871	59•8	101,571	62,263	61•3	0.007	166,573	101,134	60•7
2014	65,638	31,769	48•4	99,563	54,162	54•4		165,201	85,931	52•0
2017	48,641	22,275	45•8	69,662	42,142	60•5		118,303	64,417	54•5

p-value was calculated for the chi-squared test (junior versus senior response rate).

Table 2
Demographic characteristics of the participants.

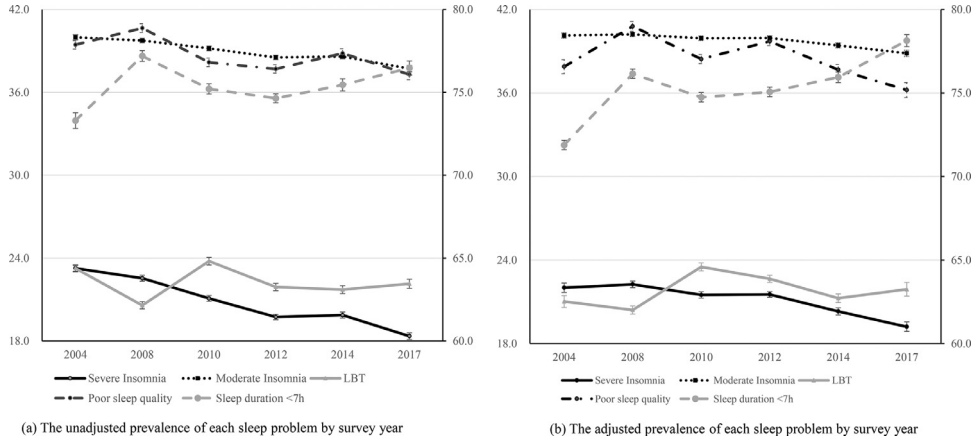
		2004		2008		2010		2012		2014		2017		p-value	Total
		N	%	N	%	N	%	N	%	N	%	N	%		
Grade															
	7	13,146	12•8	13,266	14•0	13,041	13•3	13,405	13•4	10,528	12•4	7384	11•6	<0.001	70,770
	8	13,079	12•8	13,606	14•4	12,816	13•0	12,884	12•9	10,481	12•3	7329	11•5		70,195
	9	13,160	12•9	12,871	13•6	12,476	12•7	12,205	12•2	10,465	12•3	7415	11•6		68,592
	10	21,815	21•3	20,118	21•2	21,444	21•8	21,480	21•5	19,048	22•4	14,201	22•2		118,106
	11	21,530	21•0	18,261	19•3	20,168	20•5	20,026	20•0	17,738	20•9	14,212	22•2		111,935
	12	19,721	19•3	16,655	17•6	18,466	18•8	20,050	20•0	16,728	19•7	13,404	21•0		105,024
	Number missing	0		0		456		0		0		384			840
Gender															
	Boy	55,998	54•7	48,077	50•7	48,794	49•4	51,587	51•6	41,225	48•5	34,582	53•9	<0.001	280,263
	Girl	46,453	45•3	46,700	49•3	50,073	50•7	48,463	48•4	43,763	51•5	29,570	46•1		265,022
	Number missing	0		0		0		0		0		177			177
Mental health															
	Good	56,112	55•2	50,737	54•1	52,384	53•8	59,093	60•3	35,615	42•8	28,045	45•0	<0.001	281,986
	Poor	45,528	44•8	43,038	45•9	44,968	46•2	38,860	39•7	47,649	57•2	34,232	55•0		254,275
	Number missing	811		1002		1515		2097		1724		2052			9201
Eating breakfast															
	Sometimes/seldom	17,561	18•2	14,091	15•4	14,281	14•6	12,618	12•9	11,255	13•7	9169	14•7	<0.001	78,975
	Daily	78,733	81•8	77,461	84•6	83,273	85•4	85,330	87•1	70,688	86•3	53,262	85•3		448,747
	Number missing	6157		3225		1313		2102		3045		1898			17,740
Participating in extracurricular activities															
	No	33,017	33•0	27,812	30•5	28,529	29•4	27,710	28•4	25,470	31•0	17,123	27•5	<0.001	159,661
	Yes	67,157	67•0	63,271	69•5	68,396	70•6	69,894	71•6	56,689	69•0	45,141	72•5		370,548
	Number missing	2277		3694		1942		2446		2829		2065			15,253
Having fun at school															
	Yes	58,752	58•4	58,058	63•5	62,523	64•2	65,208	66•7	54,395	66•2	41,697	67•0	<0.001	340,633
	Neither	32,739	32•5	25,836	28•3	27,121	27•9	25,661	26•3	21,548	26•2	16,249	26•1		149,154
	No	9137	9•1	7568	8•3	7688	7•9	6891	7•1	6172	7•5	4311	6•9		41,767
	Number missing	1823		3315		1535		2290		2873		2072			13,908
Present drinking alcohol															
	No	71,684	70•3	78,312	83•1	84,038	85•6	87,569	87•9	76,605	91•8	60,282	94•4	<0.001	458,490
	Yes	30,233	29•7	15,956	16•9	14,127	14•4	12,034	12•1	6812	8•2	3584	5•6		82,746
	Number missing	534		509		702		447		1571		463			4226
Present smoking															
	No	91,603	90•5	89,640	94•8	94,723	96•0	97,075	97•2	82,568	98•1	63,299	98•8	<0.001	518,908
	Yes	9614	9•5	4903	5•2	3934	4•0	2851	2•9	1570	1•9	769	1•2		23,641
	Number missing	1234		234		210		124		850		261			2913
Intention to study at university															
	No	62,996	62•7	53,441	58•5	57,990	59•6	58,919	60•2	48,708	59•1	34,854	55•9	<0.001	316,908
	Yes	37,467	37•3	37,936	41•5	39,291	40•4	38,893	39•8	33,655	40•9	27,515	44•1		214,757
	Number missing	1988		3400		1586		2238		2625		1960			13,797

p-values were calculated for chi-square-test (survey year) × (each variables).
Participants for whom data were missing were excluded from the analyses.

Table 3
Trends of sleep problems from 2004 to 2017 in Japanese adolescents.

	Insomnia (n = 328,379)				Sleep duration (n = 533,580)				LBT (n = 118,933)				Poor sleep quality (n = 206,446)			
	OR	95% CI		p-value	OR	95% CI		p-value	OR	95% CI		p-value	OR	95% CI		p-value
Trend (2004–2017)																
Adjusted	0.85	0.82	0.87	<0.001	1.13	1.10	1.17	<0.001	1.17	1.12	1.23	<0.001	0.92	0.88	0.95	<0.001
Crude	0.74	0.73	0.75	<0.001	0.93	0.92	0.95	<0.001	0.88	0.86	0.91	<0.001	0.86	0.85	0.88	<0.001

Abbreviations: OR = odds ratio, CI = confidence interval.
Participants for whom data were missing were excluded from the analyses.
Insomnia in those who answered that they experienced one or more symptoms of DIS, DMS, or EMA "often" or "always" was classified as "severe" and in those who answered "sometimes" was classified as "moderate.".
Sleep duration were classified as less than five hours, five hours or more but less than six hours, six hours or more but less than seven hours, seven hours or more but less than eight hours, eight hours or more but less than nine hours, and nine hours or more.
LBT: late bedtime (after 1:00 a.m.).
Poor sleep quality: those who answered that their sleep quality was bad or very bad.
Odds ratios were derived from ordinal and binary logistic regression models and adjusted for participants' weight, birth cohort, gender, junior/senior high school, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol status, smoking status, and intention to study at university.



(a) The unadjusted prevalence of each sleep problem by survey year

(b) The adjusted prevalence of each sleep problem by survey year

Fig. 1. Trends of the prevalence of each sleep problem by survey year.

Table 4
Sensitivity analyses for trend of sleep problems among Japanese adolescents from 2004 to 2017.

	Insomnia (n = 114,421)				Sleep duration <7 h (n = 404,392)			
	AOR	95% CI		p-value	AOR	95% CI		p-value
Trend (2004–2017)	0.87	0.83	0.91	<0.001	1.37	1.31	1.43	<0.001
	LBT (n = 242,815)				Poor sleep quality (n = 28,379)			
	AOR	95% CI		p-value	AOR	95% CI		p-value
	1.15	1.11	1.20	<0.001	0.84	0.77	0.91	<0.001

Abbreviations: AOR = adjusted odds ratio, CI = confidence interval.
Participants for whom data were missing were excluded from the analyses.
This logistic model was adjusted for participants' weight, birth cohort, gender, junior/senior high school, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol status, smoking status, and intention to study at university.
Insomnia: Those who experienced one or more of DIS, DMS, or EMA "often" or "always" were considered to have insomnia.
SSD: short sleep duration (< 7 h).
LBT: late bedtime (after 12:00 a.m.).
Poor sleep quality: those who answered that their sleep quality was very bad.

from 37•9% in 2004 to 36•2% in 2017 (AOR 0•92, 95% CI 0•88–0•95). Conversely, the adjusted odds ratio of shorter sleep duration significantly increased (AOR 1•13, 95% CI 1•10–1•17) and the adjusted prevalence of LBT increased from 21•0% in 2004 to 21•9% in 2017 (AOR 1•17, 95% CI 1•12–1•23).

3.1. Sensitivity analyses

The odds ratios of all sleep problems were in the same direction as the original results (Table 4). The statistical tests for all analyses remained highly significant (p<0•001), suggesting that the results are robust to these alternative definitions of sleep problems. The adjusted prevalence of sleep duration below seven hours increased from 71•9% in 2004 to 78•1% in 2017 (AOR 1•37, 95% CI 1•31–1•43) (Table 4 and Fig. 1). There were no gender differences in the trends of sleep problems (Supplemental Table 1).

4. Discussion

This study is the first nationwide, representative study to examine trends of sleep problems among Japanese adolescents and indicates decreased trends of insomnia symptoms and poor sleep quality in this population from 2004 to 2017. However, there were increasing trends toward shorter sleep duration and late bedtimes.

Thus, both welcome and unwelcome developments were observed in adolescent sleep patterns, with important implications for public health.

Surprisingly, the decreasing trend of insomnia observed among Japanese adolescents contrasts with trends in other countries. A large international study including 33 European countries/regions reported that the average prevalence of sleep-onset difficulties in adolescents aged 11, 13, and 15 years increased from 17•5% in 2002 to 20 0•8% in 2014 [12]. Twenty-eight out of the 33 countries showed an increasing trend in the prevalence of difficulty falling asleep during the 12-year period, except for Greece (−4•3%), Spain (−4•1%), Norway (−2•0%), England (−1•7%), and Portugal (−1•3%) [12]. Difficulty in sleep-onset and DIS represent the same symptom, which is the highest among all the insomnia symptoms [7]. In Finland, the prevalence of insomnia symptoms (DIS and DMS) increased approximately two-fold from the mid-1990s to the end of the 2000s, while the increasing trend for insomnia abated after 2008 [24]. Thus, in many countries, the prevalence of insomnia-related symptoms has tended to increase while, in a few countries, a downward trend has been observed.

The trend of shorter sleep duration worsened between 2004 and 2017. Several studies have reported on trends of sleep duration in adolescence. In the U.S., compared to 1995, the probability of regularly getting more than seven hours of sleep significantly decreased from 1996 to 2012 [9]. Additionally, U.S. adolescents in 2015 were 16–17% more likely to report insufficient sleep compared to 2009 [13]. Matricciani et al. noted that 34 of the 51 reports on long-term trends in sleep time among school-aged children cited evidence of declines in sleep duration [25]. Shortened sleep duration in adolescence occurs as a result of progressive delays in bedtimes, not as a result of a change in wake-up time [26]. Notably, later night electronic media use is associated with delayed bedtimes and shortened sleep duration [13,26]. These results of increasing trends of shorter sleep duration and delayed bedtimes are consistent with those of the present study.

The National Sleep Foundation recommends that adolescents should sleep nine hours per night [27], but our results demonstrated that almost all Japanese adolescents get significantly less than nine hours of sleep [6]. The consistent declines observed in adolescents' sleep are concerning given that shorter sleep durations have been associated with negative health outcomes such as cardiovascular disease, diabetes mellitus, and depression [28]. One of the key questions for future research is whether sleep deprivation experienced during adolescence has an adverse effect on adult health, independent of sleep duration in adulthood.

Our results revealed that the prevalence of insomnia and poor sleep quality among Japanese adolescents decreased between 2004 and 2017. There are at least two possible explanations for these results. The first explanation is related to sleep education policy in school. The Ministry of Health, Labour and Welfare of Japan introduced the "Sleep Guidelines for Health Promotion" in 2003 and dissemination of information on sleep has been promoted in cooperation with the local governments and mass media. In 2014, the sleep guidelines were changed to 12 messages on how to improve sleep for health and how adequate sleep can reduce the risk of non-communicable diseases as well as accidents. The 12 messages were included in the Japanese school text. These policies may have raised the general population's awareness of sleep by promoting sleep hygiene education activities and campaigns through the mass media [17]. Our data showed lower smoking and drinking alcohol prevalence and higher breakfast intake rates during this period, which suggests that adolescents tend to exhibit healthy lifestyle behaviors. Lifestyle education was also taught in japan schools. In fact, smoking education in Japanese schools contributed to the reduction of smoking rates [29]. For cultural reasons, the magnitude of the effectiveness of lifestyle education in schools may be greater in Japan than in Western countries. Thus, these activities can, directly and indirectly, produce positive changes or prevent negative changes in sleep problems. In reference to these life style behaviors and the prevalence insomnia parallel, consider clearly stating that this relationship is correlational and not causal. Future studies will require a longitudinal approach to examine the relationship between lifestyles and sleep problems.

The second potential explanation is a change in the value placed on sleep among the Japanese with the greater public recognizing that sleep deprivation is associated with reduced academic performance and both physical and mental illness. These changes in understanding the effect of poor sleep may have led to improved sleep hygiene.

Interestingly, the present survey showed a discrepancy between insomnia improvement and the worsening of mental health problems between 2004 and 2017. There are at least two possible explanations for the discrepancy. First, insomnia and short sleep duration are known to be related to mental health problems [7,30]. Our data suggested that short sleep duration may have a greater association with mental health than insomnia. Our hypothesis was supported that short sleep duration was significantly associated with most mental health problems in adolescents without insomnia but not in those with insomnia [31]. Second, this study used GHQ-2 to evaluate mental health. However, this scale is too short and may not represent the actual prevalence of poor mental health. Future research should use more appropriate scales such as GHQ-12 or Depression Self-Rating Scale for Children [32].

Some limitations of this study bear mention. First, the data are subject to a variety of biases. For example, a non-response bias existed, as over 40% of adolescents did not participate in the 2017 survey. This could be due to some schools refusing to participate in the survey at the discretion of the school principals. However, the survey accounts for nonresponse by weighting participants relative to their likelihood of responding. These weights increase the likelihood that the data obtained are adequately representative of the target population. Second, although we adjusted for several potential confounding variables, no data on factors related to participants' socioeconomic status (SES) such as family income or parental educational levels, school start time, pubertal development, or media screen-time were available. Previous research indicates an association between sleep problems and these factors [13,14,27,33–35]. Thus, future research should include SES, school start time, pubertal development, and media screen-time factors. Third, due to limited space on the questionnaire, our insomnia assessment did not include the entire clinical diagnostic criteria listed in the International Classification of Sleep Disorders [36]. Therefore, insomnia as measured in this study may not reflect clinical insomnia. Future studies should use validated questionnaires such as the Insomnia Severity Index (ISI) and Pittsburgh Sleep Quality Index (PSQI) [37,38]. Fourth, the surveys did not distinguish between sleep duration on weekends and weekdays. Objective data indicate that a misalignment in bedtimes and wake-up times on both weekdays and weekends have been observed among East Asian adolescents [15]. Previous research indicated that irregular sleep-wake patterns characterized by variations between school day and non-school day sleep-wake timing may be a factor contributing to sleep problems [39]. Some researchers have recommended a school start time later than 8:30 am in junior and senior high schools to ensure adolescent health and improve academic performance [40]. Future studies should examine not only the total sleep duration but also the regularity of adolescent sleep-onset and wake-up time on weekends and weekdays and school start time. Fifth, this study was based on self-reports, which are prone to bias. Objective measurements such as an actigraph could be employed to evaluate sleep duration. Although desirable, such measurements are not normally included in epidemiological stud-

ies because of the number of participants involved. However, several studies have indicated that self-reported sleep data have moderate agreement with laboratory studies [41].

In conclusion, findings from this study of large-scale repeated cross-sectional surveys of adolescents in Japan over 13 years suggest that insomnia and poor sleep quality are declining; however, many adolescents continue to have late bedtimes and a lack of sufficient sleep duration. Despite the improvement of insomnia and sleep quality, the survey's results suggested that adolescents should show greater interest in their sleep duration; inadequate sleep may cause, and aggravate, physical and mental health problems. These results could be useful in developing more effective prevention strategies in the future. Interventions tailored to prevent late bedtimes may aid in maximizing the effects of health education in adolescence. Finally, the results provide a benchmark for future monitoring of trends in adolescent sleep in Japan and other East Asian countries.

5. Contributors

Dr. Otsuka and Dr. Kaneita conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Spira and Dr. Mojtabai critically reviewed the manuscript for important intellectual content and edited the manuscript.

Drs. Iatni, Jike, Kuwabara, and Kinjyo designed the data collection instruments and collected data.

Drs. Kanda and Higuchi conceptualized and designed the study.

Dr. Osaki conceptualized and designed the study, and coordinated and supervised data collection.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declaration of Competing Interest

Yoshitak Kaneita reports grants from Eisai, outside the submitted work; Adam P. Spira received an honorarium from Springer Nature Switzerland AG for Guest Editing a Special Issue of Current Sleep Medicine Reports. The other authors declare no conflicts of interest associated with this manuscript.

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Data Sharing

The datasets generated and/or analyzed during the current study are not publicly available because it is necessary to obtain permission from the Ministry of Health, Labour and Welfare in Japan. Related documents will be available from https://mhlw-grants.niph.go.jp/niph/search/NIST00.do.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lanwpc.2021.100107.

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ORIGINAL ARTICLE

A nationwide cross-sectional study of difficulty waking up for school among adolescents

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Abstract

Study Objectives: To determine the prevalence of and risk-factors for difficulty waking up for school among adolescents.

Methods: We used a self-administered questionnaire (140 junior high schools [JHSs]; 124 senior high schools [SHSs]) selected randomly in 2012 from throughout Japan.

Results: Total response rate: 60.7%. Data from 38 494 JHS and 61 556 SHS students were analyzed. The prevalence of at least one instance of school tardiness/absence due to difficulty waking up over a 30-day period was 10.9 (95% confidence-interval:10.5–11.3)%/2.9(2.7–3.1)% for JHS-boys and 7.7(7.3–8.1)%/2.0(1.8–2.2)% for JHS-girls. The prevalence was 15.5(15.1–15.9)%/5.6(5.3–5.9)% for SHS-boys and 14.4(14.0–14.8)%/5.9(5.6–6.2)% for SHS-girls. We used ordinal regression to identify the risk factors associated with the experience of school tardiness/absence. Factors significantly associated with school tardiness in all four groups (JHS boys/girls, SHS boys/girls) were "no-participation-in-club-activities," "early-morning-awakening," "feeling bad throughout a morning," "drinking," and "smoking." Among associated factors, the highest odds ratio was found for monthly smoking-days (none vs. at least one-day or more) for JHS-girls at 5.30(3.57–7.85). Factors significantly associated with school absence in all four groups were "no wishing to go to university," "no participation in club activities," "disorders of initiating and maintaining sleep," "long internet use," "drinking," "smoking," "poor-mental-health" and "feeling bad throughout a morning." Among associated factors, the highest odds ratio was found for monthly smoking-days (none vs. at least one-day or more) for JHS-girls at 4.60(3.45–6.15).

Conclusions: These results suggest that the risk factors for difficulty waking up among adolescents are sleep status, lifestyle, and mental health, which can indicate the presence of an underlying disease.

Statement of Significance

Throughout adolescence, the most prevalent sleep complaints are related to difficulty waking up for school in the morning. We conducted a novel nationwide epidemiological study of difficulty waking up for school among adolescents in Japan. Previous sleep epidemiological studies of adolescents have mainly surveyed sleep duration and insomnia; this is the first study from the perspective of difficulty waking up. The associated risk factors (sleep status, lifestyle, mental health status) identified here form a basic knowledge source that can be utilized in research on the diagnosis and treatment of difficulty waking up among adolescents and in the examination of social policies. Future research should examine unmeasured potential confounders, such as socioeconomic status and medical history, using more objective measurement methods.

Key words: sleep wake disorders; circadian rhythm; autonomic nervous system diseases; prevalence; students; risk factors; epidemiology; Japan

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Introduction

Sleep is an important daily habit that helps maintain adolescents' physical and mental health [1]. Multiple previous studies have reported that sleep disorder during adolescence is a risk factor for future onset of physical diseases such as obesity, hypertension, and diabetes mellitus [2]. Sleep disorders have also been linked to decreased cognitive/academic performance through cognitive impairment, difficulties with focus, memory, and attention, impaired decision-making, decreased reaction time, impaired academic performance, and decreased creativity [3, 4]. Moreover, sleep disorders have been associated with increased risk of psychiatric/psychological problems such as alcohol and drug use, aggression, irritability, risky behaviors, anxiety, depression, suicidal thoughts and behaviors, poor impulse control and social skills, and low motivation [3–7].

Thus, sleep is a daily life habit that is important to adolescents' health; accordingly, epidemiological studies of sleep disorders have been vigorously conducted. Nevertheless, many previous epidemiological studies of sleep disorders among adolescents have only focused on sleep duration and insomnia [8].

In the present study, we focused on difficulty waking up for school as a sleep-related problem among adolescents in Japan. Various physical changes occur during adolescence. There are changes in hormonal balance, which lead to physical changes in both boys and girls that mark their transition from childhood to adulthood. Moreover, adolescence is characterized by profound changes in sleep timing and composition [9–14]. In addition to these biological and physiological factors, there are also associated social factors such as changes in their living environment. Thus, difficulty waking up for school is a popular issue in the study of adolescents. Once difficulty waking up becomes increasingly severe and chronic, adolescents become maladapted to school life, possibly leading to more serious problems such as poor grades, poor behavior, and school absenteeism. Even though it has long been known that "after the onset of puberty and throughout the adolescent period, the most prevalent sleep complaints tend to center on difficulty waking up for school in the morning" [15], epidemiological studies with difficulty waking up for school as the primary outcome measure have almost never been conducted previously.

Therefore, we decided to conduct a nationwide epidemiological study with difficulty waking up for school among adolescents as the primary outcome measure. We aimed to determine the prevalence of difficulty waking up for school among adolescents. As a secondary issue, we intended to identify the risk factors associated with the experience of difficulty waking up for school. In planning and carrying out this study, after formulating the hypothesis that the adolescent attributes (sex, age, intelligence, and mental health status) and various lifestyle factors (school life, sleep pattern, sleep disorders, smoking, drinking, and media use) are driving or moderating factors for their difficulty waking up, we carried out an epidemiological analysis of the relationship between these factors and adolescent difficulty waking up. In this study, tardiness and absence due to difficulty waking up were used as outcome measures to evaluate the experience of difficulty waking up for school.

The epidemiological findings related to difficulty waking up obtained through this study can provide valuable insight and suggestions for future efforts to create public health policies for high school students' lifestyle and health guidance. They may also provide a scientific basis for the future consideration of effective public health interventions.

Methods

Study design and participants

We conducted a cross-sectional study of students enrolled in junior/senior high schools selected through random sampling from among schools throughout Japan. In the Japanese education system, students enter JHS, which is the last stage of compulsory education, at the age of 12 years. After 3 years of study (grades 7–9), they graduate from JHS. Those who wish to continue their studies then complete a selection process for entering SHS that consists of taking an entrance exam, after which they are enrolled in SHS. Once again, they study for 3 years (grades 10–12), following which they graduate from SHS. In May 2012, our study group used the single-stage cluster sampling method to randomly sample 140 JHSs (65 053 students) and 124 SHSs (101 591 students) from among 10 018 JHSs and 4603 SHSs located throughout Japan. Students from these schools participated in our survey.

Questionnaire

Our survey involved distributing self-administered questionnaires to participating students, after which the students themselves completed the questionnaire. The questionnaires were distributed mainly in October 2012 to all participating schools. Subsequently, each school distributed the questionnaires to individual students enrolled in their school. The students completed the questionnaires on their own, and each school collected the questionnaires completed by their students. The questionnaires were returned to us in March 2013.

The questionnaire began with two questions and their response options regarding "difficulty waking up for school": (1) "During the past 30 days, have you been late to school because you were unable to wake up in the morning?" Responses: none, 1–3 times, 4–7 times, 8 times, or more. (2) "During the past 30 days, have you been absent from school because you were unable to wake up in the morning?" Responses: none, 1–3 times, 4–7 times, 8 times, or more. The students chose one response from the four options provided. The basic attributes portion of the questionnaire asked the students to identify their sex, age, type of school they attended (junior/senior high school), and grade.

The lifestyle factors portion of the questionnaire asked the students to respond to questions regarding the following: (1) sleep status: sleep duration, presence or absence of insomnia symptoms (disorders of initiating and maintaining sleep (DIMS), and early morning awakening (EMA)), bedtime, and wake-up time; (2) media use: hours spent watching television/using the internet; (3) school life and study: whether they participated in extracurricular activities, whether they wished to continue their education; and (4) monthly drinking and smoking frequency (days).

In our questionnaire, we used the simplified version of the Japanese version of the 12-item General Health Questionnaire (GHQ-12) [16, 17], known as the GHQ-2 [18], which contains only the question that evaluates depression/anxiety factors (asking

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whether respondents felt an anxiety and depression in the previous 30 days; response options were "not at all," "no more than usual," "more than usual," and "much more than usual") and the question that evaluates factors reflecting a possible decrease in positive feelings (asking whether respondents could enjoy normal activities in the previous 30 days; response options were "more so than usual," "same as usual," "less than usual," and "much less than usual") to survey participants' mental health status. Previous research has shown that the ability of the GHQ-2 to evaluate mental health status is comparable to that of the GHQ-12 [18]. The GHQ-2 has been indicated to show good sensitivity and specificity (87.0% and 85.1%, respectively) and to provide a cut-off score of ≥1 [18].

Finally, a question regarding subjective symptoms was also included: "During the past 30 days, have you felt bad during the morning?" Responses: never, seldom, sometimes, often, and always. The students chose one response from the five options provided.

Ethical considerations

In conducting this study, the following ethical considerations were made. (1) Prior to implementing the survey, all school principals and associated boards of education were provided with a detailed description of the survey, and their consent to participate in the survey was obtained. (2) Each participating student was provided with a full description of the specifics and objectives of the survey and informed that participation was voluntary, after which written informed consent to participate in this survey was obtained from each individual. (3) After each individual student completed the questionnaire, the anonymous questionnaires were placed into an envelope, which was then sealed and sent back to the researchers. All efforts were made to protect the privacy of all students. (4) Approval for this study was obtained from the Ethics Committee of Nihon University School of Medicine prior to the implementation of the study. (5) This study was conducted in strict accordance with the Ethical Guidelines for Epidemiological Research determined by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare of Japan [19].

Statistical analysis

First, we collected data related to the prevalence of difficulty waking up for school. Specifically, responses to question (1) school tardiness due to difficulty waking up and question (2) school absence due to difficulty waking up, both of which are related to "difficulty waking up for school," were stratified by sex (boys/girls) and type of school (JHS/SHS). Subsequently, we performed a chi-square test to determine the relationship of the prevalence of school tardiness/absence due to difficulty waking up with sex (m/f) and type of school (JHS/SHS).

Next, we performed an ordinal logistic regression analysis with "school tardiness due to difficulty waking up" (none, 1–3 times, 4–7 times, 8 times, or more) as the dependent variable. The following explanatory variables were entered into the model: bedtime, symptoms of insomnia, lifestyle factors (2)–(4), mental health status, and subjective symptoms (feeling bad in the morning). Logit was used as the model formula of ordinal regression analysis. Participants with missing data were excluded from the analysis. Using the same method, we also analyzed "school absence due to difficulty waking up." For the above analyses, participants were divided into four groups (JHS boys, JHS girls, SHS boys, SHS girls), and analysis was performed for each respective group.

For all statistical analyses, the significance level was set at $P < 0.05$. The analyses were performed using IBM SPSS Statistics version 22.0 for Windows (IBM Corp., Armonk, NY, USA).

Results

Participants number and characteristics

Figure 1 shows how participating schools and students were selected. Participation was requested from 140 JHS and 124 SHS. Of these, 94 JHS and 85 SHS agreed to participate in the survey. Thus, the JHS school participation rate was 67.1%, and the SHS school participation rate was 68.5%. Of the 41 965 students enrolled at the 94 JHS, 38 871 students responded to the questionnaire. Of the 67 882 students enrolled at the 85 SHS, 62 263 students responded to the questionnaire. Thus, the JHS student response rate was 92.6%, and the SHS student response rate was 91.7%. Then, the percentage of students who ultimately responded compared to the number of students who were originally selected was used as the "total student response rate" to yield a JHS of 59.8%, a SHS total student response rate of

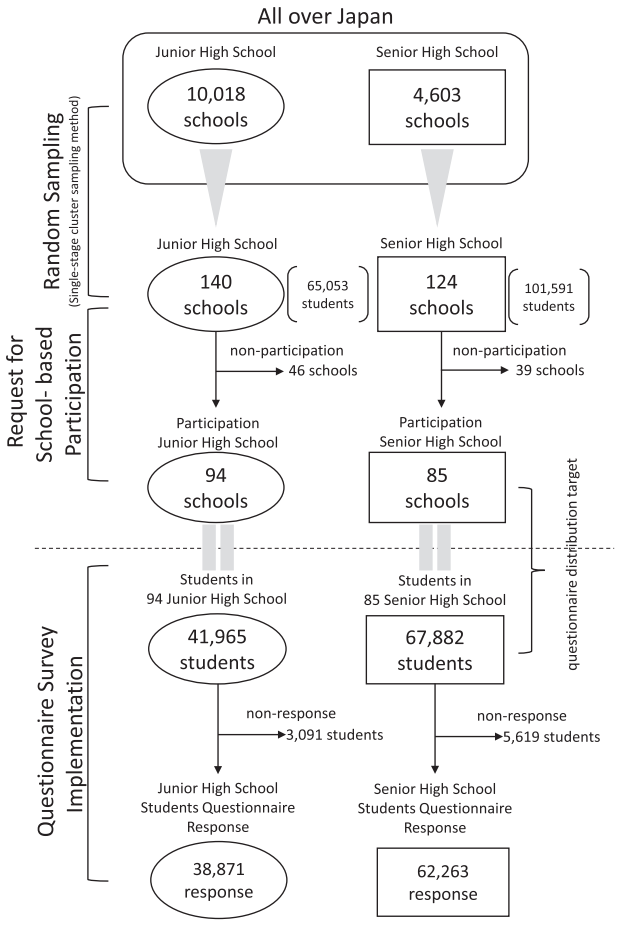

Figure 1. Flowchart of the selection of schools, request for participation, and students' response.

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Table 1. Characteristics of the analyzed subjects

	Junior high school		Senior high school	
	Boys n = 19 662	Girls n = 18 832	Boys n = 31 925	Girls n = 29 631
Grade				
Junior high school				
7th	35.2%	34.4%		
8th	33.3%	33.6%		
9th	31.5%	32.0%		
Senior high school				
10th			35.2%	34.6%
11th			32.8%	32.2%
12th			32.0%	33.2%
Wishing to go to university				
Yes	12.4%	9.3%	38.6%	54.0%
No	84.8%	89.4%	38.6%	44.1%
Unknown	2.7%	1.3%	2.9%	1.8%
Participation in club activities				
Yes	80.0%	78.0%	65.9%	62.2%
No	17.0%	20.2%	31.1%	35.8%
Unknown	2.9%	1.8%	3.0%	2.0%
Bedtime				
Before 10 pm	12.6%	7.0%	5.4%	3.2%
Before 0 am	59.5%	59.4%	40.0%	39.5%
Before 2 am	22.0%	29.0%	44.2%	48.7%
After 2 am	3.7%	3.7%	7.9%	6.9%
Unknown	2.2%	1.0%	2.5%	1.7%
Wake up time				
Before 5 am	3.3%	1.7%	5.7%	4.3%
Before 7 am	65.6%	73.0%	66.0%	74.6%
Before 9 am	28.3%	23.8%	25.2%	18.9%
After 9 am	0.4%	0.3%	0.5%	0.3%
Unknown	2.3%	1.1%	2.7%	1.8%
Disorders of initiating and maintaining sleep				
Never/seldom	43.7%	41.4%	41.3%	38.8%
Sometimes	36.5%	39.7%	38.8%	40.8%
Often/always	16.7%	17.3%	16.8%	18.2%
Unknown	3.1%	1.6%	3.1%	2.2%
Early morning awakening				
Never/seldom	81.9%	83.8%	80.4%	80.8%
Sometimes	10.6%	10.4%	12.0%	12.6%
Often/always	5.1%	4.7%	4.8%	4.7%
Unknown	2.3%	1.1%	2.7%	1.8%
Feeling bad throughout a morning				
Never/seldom	63.3%	55.6%	56.0%	49.2%
Sometimes	25.8%	32.6%	30.6%	36.8%
Often/always	8.6%	10.7%	10.7%	12.3%
Unknown	2.3%	1.1%	2.7%	1.8%
Hours spent watching television				
<2 h/d	40.6%	37.6%	59.9%	53.3%
>2 ~ <5 h/d	44.3%	48.6%	30.6%	37.3%
>5 h/d	12.5%	12.6%	6.8%	7.5%
Unknown	2.5%	1.3%	2.7%	1.9%
Hours spent using internet				
<2 h/d	64.8%	63.9%	51.8%	46.8%
>2 ~ <5 h/d	23.9%	25.8%	31.7%	36.2%
>5 h/d	8.9%	9.2%	13.8%	15.2%
Unknown	2.4%	1.1%	2.7%	1.8%
Monthly drinking days				
None	91.9%	91.8%	85.3%	84.3%
1–5 d	6.3%	6.8%	11.8%	13.4%
6–19 d	0.9%	0.7%	2.1%	1.6%
20-d	0.3%	0.2%	0.5%	0.3%
Unknown	0.7%	0.5%	0.4%	0.4%

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Table 1. Continued

	Junior high school		Senior high school	
	Boys n = 19 662	Girls n = 18 832	Boys n = 31 925	Girls n = 29 631
Monthly smoking days				
None	97.7%	98.8%	94.9%	97.8%
1–5 d	0.9%	0.6%	1.3%	0.8%
6–19 d	0.5%	0.2%	0.7%	0.3%
20-d	0.8%	0.3%	3.0%	1.0%
Unknown	0.1%	0.1%	0.1%	0.1%
Mental health status				
Good (GHQ-2 score < 1 point)	72.2%	59.6%	61.2%	47.8%
Poor (GHQ-2 score > 1 point)	25.4%	39.3%	36.0%	50.3%
Unknown	2.4%	1.2%	2.8%	1.9%
School tardiness due to difficulty waking up over a 30-day period				
None	86.7%	91.2%	81.7%	83.8%
At least one instance	10.9%	7.7%	15.5%	14.4%
Unknown	2.4%	1.1%	2.7%	1.8%
School absence due to difficulty waking up over a 30-day period				
None	94.7%	96.9%	91.5%	92.2%
At least one instance	2.9%	2.0%	5.6%	5.9%
Unknown	2.4%	1.1%	2.8%	1.9%

GHQ, general health questionnaire.

61.3%, and an overall total student response rate of 60.7%. Of the data obtained from the returned questionnaires, those of 1084 students were invalid due to missing data relating to basic attributes, such as sex and grade, and due to contradictory responses. Data from the remaining 100 050 students were used for the final analysis.

The characteristics of the participants (JHS boys/girls, SHS boys/girls) included in the final analysis are shown in Table 1; 51.6% were boys and 48.4% were girls, and their age ranged from 12 to 19 years.

Prevalence of difficulty waking up for school

Figure 2 shows the prevalence of school tardiness due to difficulty waking up by sex and grade. The percentage of boys who responded that they had at least one experience during the past 30 days of school tardiness due to difficulty waking up was 10.9% (95% confidence interval: 10.5–11.3%) for JHS students, and the percentage of SHS students in this category was 15.5% (15.1–15.9%). The percentage of girls who responded that they had at least one experience during the past 30 days of school tardiness due to difficulty waking up was 7.7% (7.3–8.1%) for JHS students and 14.4% (14.0–14.8%) for SHS students. Thus, a significant relationship was found between sex and prevalence of school tardiness due to difficulty waking up ($P < 0.001$). A significant relationship was also found between grade and prevalence of school tardiness due to difficulty waking up for both boys ($P < 0.001$) and girls ($P < 0.001$).

Figure 3 shows the prevalence of school absence due to difficulty waking up by sex and grade. The percentage of boys who responded that they had at least one experience during the past 30 days of school absence due to difficulty waking up was 2.9% (2.7–3.1%) for JHS students, and the percentage of SHS students in this category was 5.6% (5.3–5.9%). For girls, the percentage for JHS students was 2.0% (1.8–2.2%) and that for SHS students was 5.9% (5.6–6.2%). Thus, a significant relationship was found between sex and prevalence of school absence due to difficulty waking up ($P < 0.001$). Moreover, a significant relationship was also found between grade and prevalence of school absence due to difficulty waking up for both boys ($P < 0.001$) and girls ($P < 0.001$).

Associated risk factors of difficulty waking up for school

Figure 4 shows the results of the ordinal logistic regression analysis (*n*, odds ratio, 95% confidence interval, and *P*-values) with school tardiness due to difficulty waking up (none, 1–3 times, 4–7 times, 8 times, or more) used as the dependent variable.

Factors significantly associated with school tardiness due to difficulty waking up in all four groups (JHS boys/girls, SHS boys/girls) were "not participation in club activities," "EMA," "feeling bad throughout a morning," and "Not wishing to go to university" was not significantly associated with school tardiness in the JHS groups, but the association was significant for the SHS groups. Among the associated factors, the highest odds ratio was found for monthly smoking days (none vs. one day or more) for JHS-girls at 4.60 (3.45–6.15).

Figure 5 shows the results of the ordinal logistic regression analysis (*n*, odds ratio, 95% confidence interval, and *P*-values) with school absence due to difficulty waking up (none, 1–3 times, 4–7 times, 8 times, or more) used as the dependent variable.

Factors significantly associated with school absence due to difficulty waking up in all four groups (JHS boys/girls, SHS boys/girls) were "not wishing to go to university," "not participation in club activities," "DIMS," "feeling bad throughout a morning," "long internet use," "drinking," "smoking," and "poor mental health status." "EMA" was significantly associated with absence in boys, but the association was not significant for girls. Among the associated factors, the highest odds ratio was found for monthly smoking days (none vs. one day or more) for JHS-girls at 4.60 (3.45–6.15).

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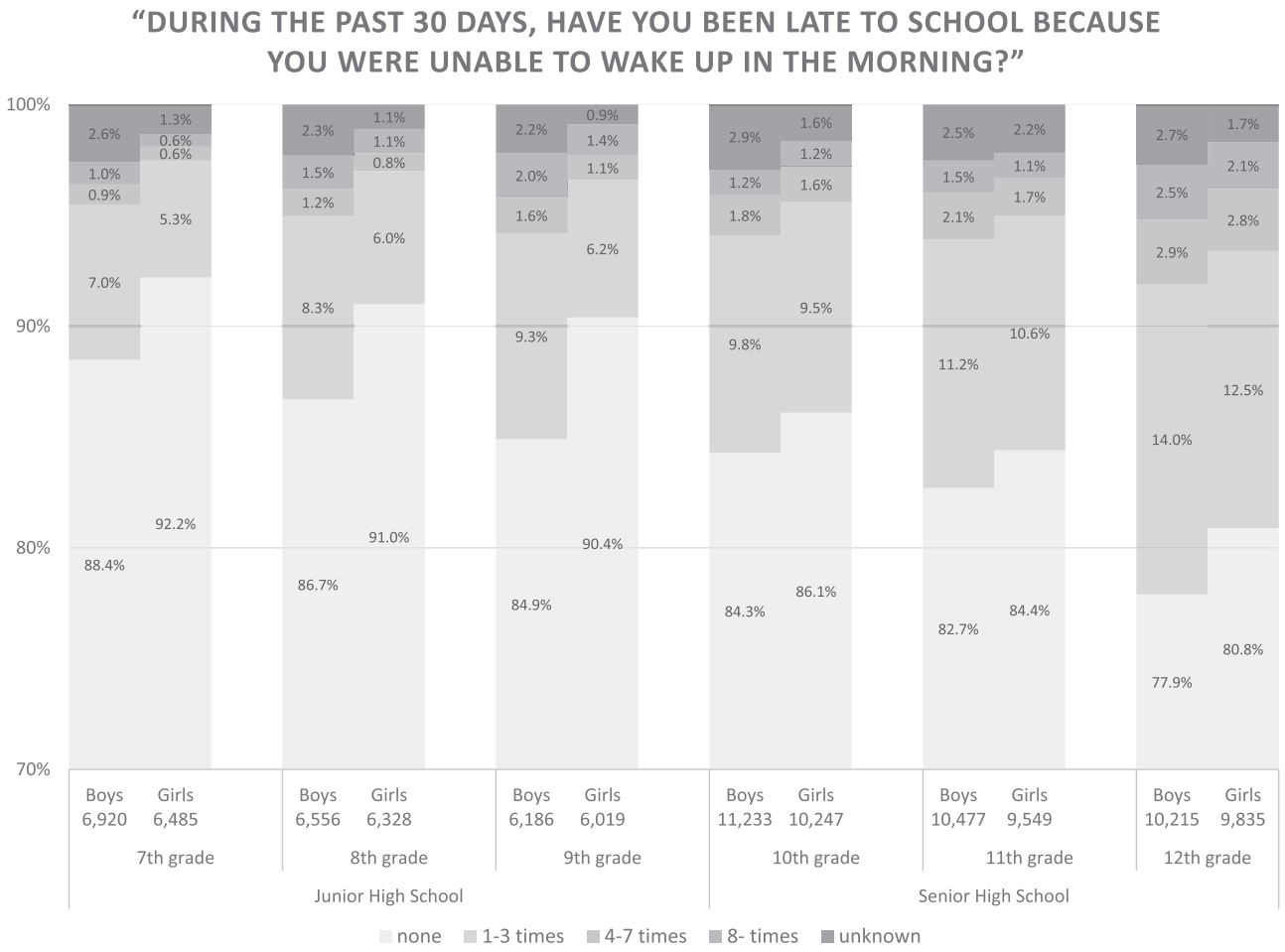

Figure 2. Prevalence of school tardiness due to difficulty waking up in the morning.

Discussion

This epidemiological study successfully determined the prevalence of difficulty waking up for school among adolescents. The prevalence of at least one instance of school tardiness/absence due to difficulty waking up over a 30-day period was 10.9%/2.9% for JHS boys, 7.7%/2.0% for JHS girls, 15.5%/5.6% for SHS boys, and 14.4%/5.9% for SHS girls. Furthermore, sleep status, lifestyles, and mental health were identified as risk factors associated with the experience of difficulty waking up for school. To the best of our knowledge, this study is the world's first epidemiological study with a high degree of national representation that investigated difficulty waking up for school among adolescents. By using big data consisting of over 100 000 cases obtained from participants selected through a strict random sampling method from among students throughout Japan, we were able to conduct a survey with an extremely high degree of statistical reliability.

In this study, we calculated the prevalence of difficulty waking up among high school students. The prevalence of school tardiness/absence due to difficulty waking up in the morning was significantly higher in males than in females and was significantly higher in higher grades. In 2005, the US National Sleep Foundation reported the results of a telephone interview survey of 1602 randomly sampled participants aged 11 to 17 across the entire US [20]. Arriving late or missing school at least once a week within the last 2 weeks was reported by 11% (JHS students 8% and SHS students 12%) [15]. Meanwhile, a study using a web-based questionnaire administered to 8347 participants between the ages of 16 and 19 in the county of Hordaland, Norway found that "5.5% of the adolescents reported oversleeping often (many times a week) or always (every day)" [21]. While the exact questions used differ, the prevalence of difficulty waking up was higher in Japan than in the US or Norway for young people in the same age range. There are likely to be cultural and social factors that also mediate the primary outcome.

In addition, we identified several factors that were significantly related to the experience of difficulty waking up. First, we found that a late bedtime was a significant risk factor for difficulty waking up for school. The onset of puberty triggers "evening preference" in approximately 40% of teenagers [10, 12]. Progression to extreme evening preference leads to the onset of delayed sleep-wake phase disorder (DSWPD) [15]. Second, we found a significant relationship between the frequency of experiencing the subjective symptom "feeling bad in the morning" and the experience of difficulty waking up for school. Difficulty waking up and feeling bad in the morning are the main symptoms of a disorder called orthostatic dysregulation (OD) [22]. Difficulty waking up in the morning is also a main symptom of OD [22]. Third, we found that media use (e.g. television, internet) was significantly related to difficulty waking up. Recent studies have reported that there is a link between excessive internet usage and sleep disorders [23–26]. A study

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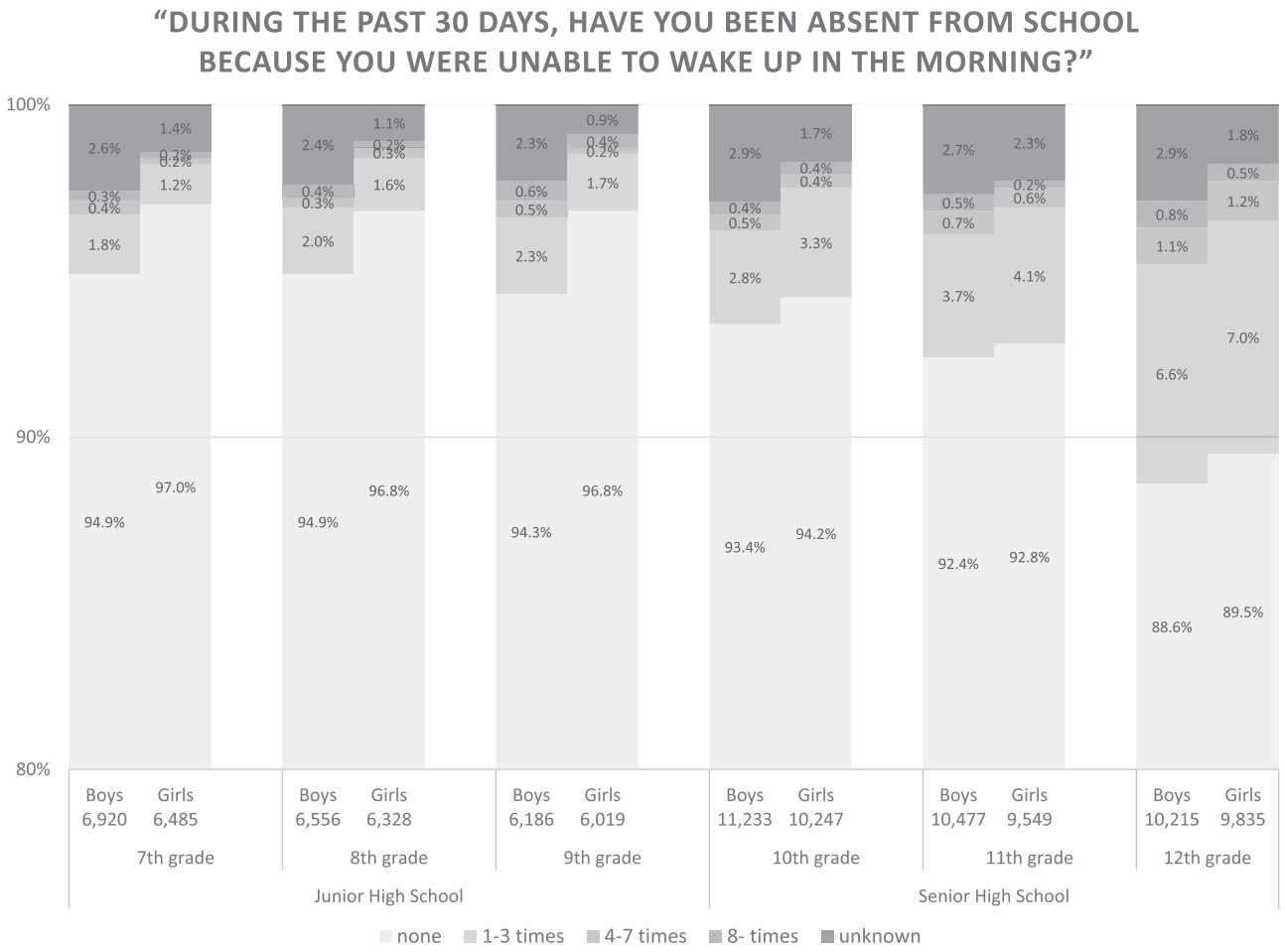

Figure 3. Prevalence of school absence due to difficulty waking up in the morning.

of adolescents reported a significant link between the Internet Addiction Scale [27] and difficulty waking up in the morning [28]. Fourth, smoking and drinking habits were found to be significantly related to difficulty waking up. Finally, we also found a significant link between mental health and difficulty waking up. In psychiatric disorders, hypersomnia is a frequently observed symptom [29].

Study strength and limitations

One of the great strengths of our study is high response rate and national representativeness of the sample. In our study, response rate was calculated in two steps. The first stage is what proportion of schools said yes (school response rate). And then second state is each school what proportion of students said yes (student response rate). Dividing response rate into two steps is advantageous in that it makes the breakdown of nonresponses evident. The survey's total response rate was 60.7%, but this breaks down into a school response rate of approximately 70% in the first step and a student response rate of over 90% in the second step. In other words, the cause of non-response was more so nonparticipation at the school level than non-participation in the survey by students themselves. As this survey addresses students, not schools, the extremely high response rate for students is a strength and signifies high reliability.

This study has several limitations. First, we used a subjective assessment method in the form of a self-administered questionnaire rather than objective measurement methods such as a polygraph or actigraph test. Second, although we asked multiple questions to identify the associated risk factors for difficulty waking up, we were unable to include more questions due to ethical considerations and space restrictions. For example, we could have asked about students' socioeconomic status (household finances, academic records), their sleeping environment (e.g. the temperature and humidity of their bedrooms, the number of people with whom they sleep), and their medical history. We cannot rule out the possibility that these factors may be unmeasured confounders related to the experience of difficulty waking up, and therefore, they should be considered in future research on this issue. Finally, due to the cross-sectional design of the study, we were unable to address the issue of causality in the relationship between the experience of difficulty waking up and the associated risk factors [30]. Despite these limitations, this study provides novel epidemiological data on the experience of difficulty waking up among high school students.

Clinical utility and future research

In our study, we performed sex-specific analyses in JHS and SHS. This analysis identified some important differences in correlates

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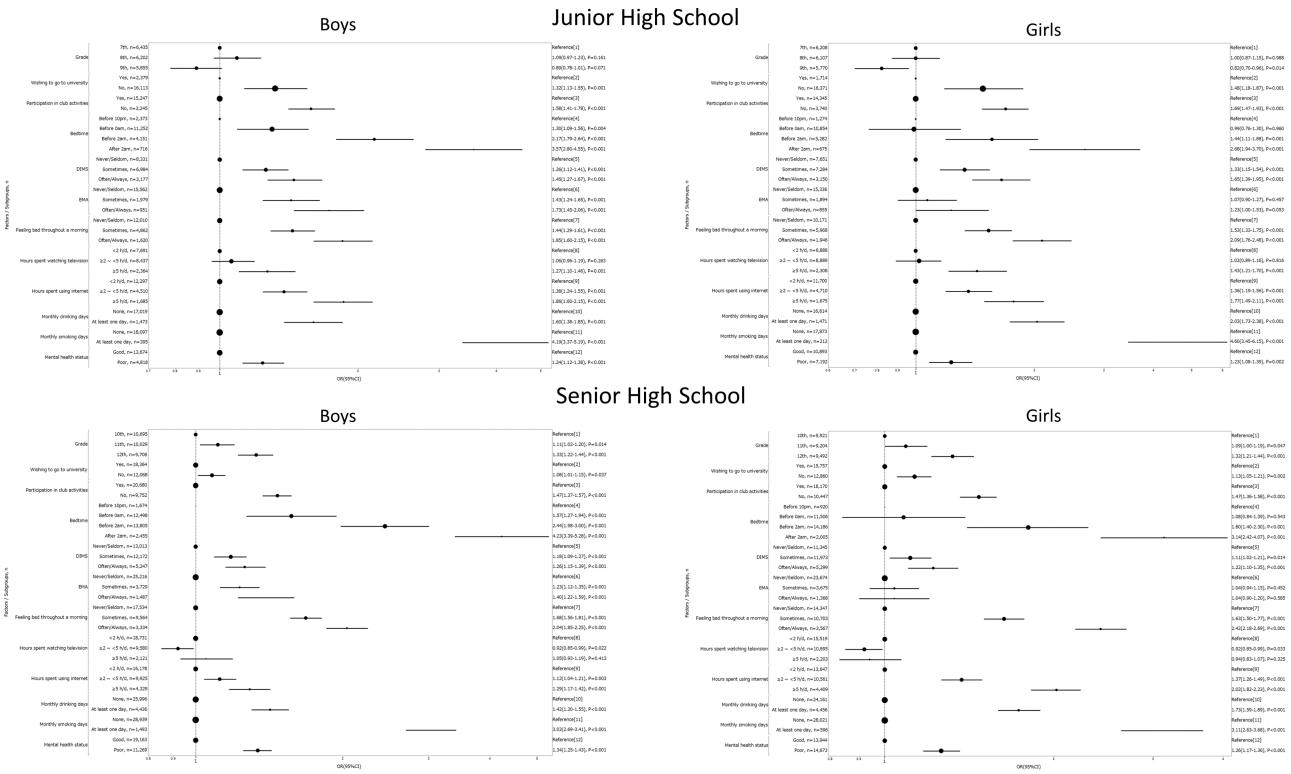

Figure 4. Associated factors of school tardiness due to difficulty waking up in the morning. Subjects with missing data were excluded from the analysis. The dependent variable was the experience of school tardiness due to difficulty waking up (none, 1–3 times, 4–7 times, 8 times, or more) over the past 30 days. OR(95%CI) was calculated by ordinal logistic regressions. The circle size represents sample size.

OR, odds ratio; CI, confidence interval; DIMS, disorders of initiating and maintaining sleep; EMA, early morning awakening

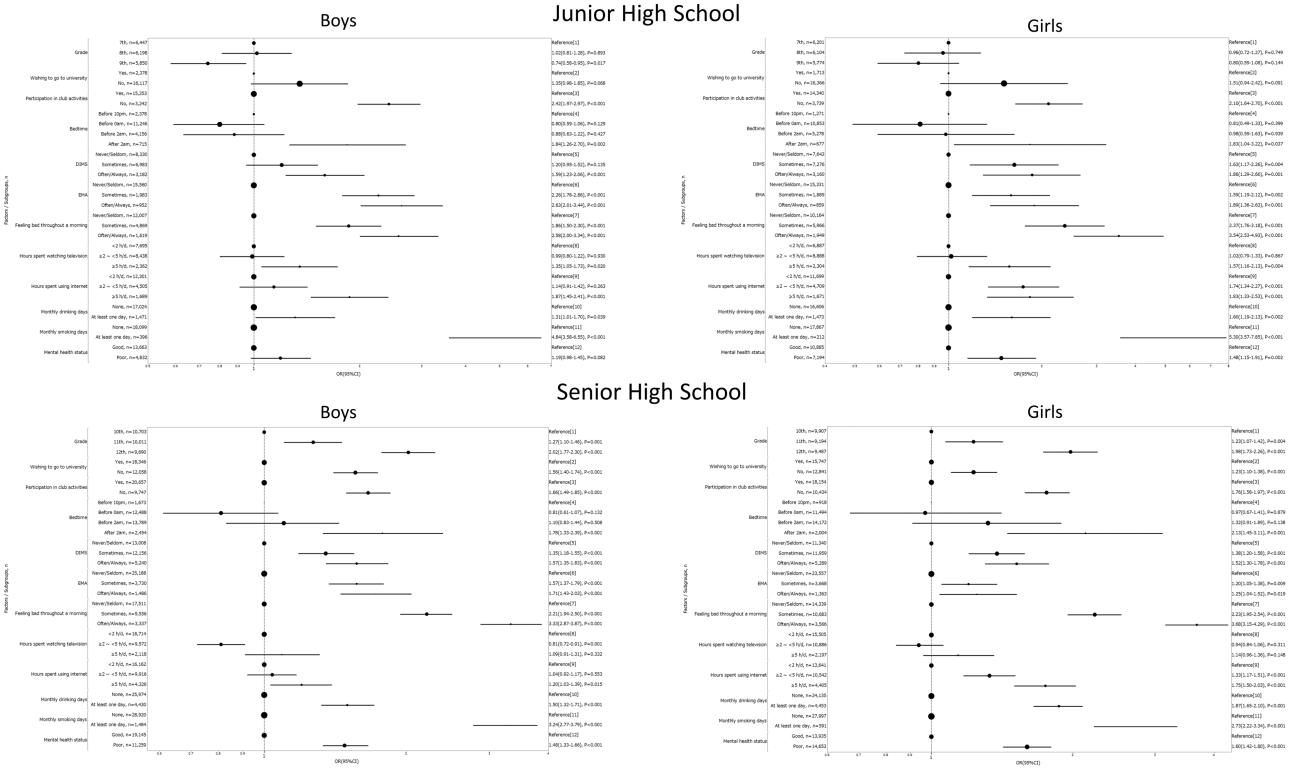

Figure 5. Associated factors of school absence due to difficulty waking up in the morning. Subjects with missing data were excluded from the analysis. The dependent variable was the experience of school absence due to difficulty waking up (none, 1–3 times, 4–7 times, 8 times, or more) over the past 30 days. OR(95%CI) was calculated by ordinal logistic regressions. The circle size represents sample size.

OR, odds ratio; CI, confidence interval; DIMS, disorders of initiating and maintaining sleep; EMA, early morning awakening

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of difficulty waking. For example, in the analysis of factors associated with school tardiness due to difficulty waking up in JHS, EMA was found to have a significant relationship with absence in boys, but a significant relationship was not observed for girls. In the analysis of factors associated with school tardiness due to difficulty waking up in JHS, mental health status was not found to have a significant relationship for boys but was found to have a significant relationship for girls. Identification of modifiable risks/correlates in JHS will be important to optimize sleep health and school attendance in SHS. This analytical approach would allow the development of possible interventions for testing in trials of sleep hygiene to reduce difficulties awakening and develop policies on providing appropriate lifestyle and health guidance to high school students. For example, in this study, the lifestyle factors that correlated with difficulty waking up in all analysis categories were "drinking" and "smoking." If students to whom these factors applied were able to improve their situation, either through personal interventions involving smoking/drinking cessation guidance or population interventions consisting of general hygiene education, it is likely that this type of public health approach would be able to contribute substantially to solving problems related to difficulty waking up. Finally, our results can be used to inform the development of future epidemiological studies. First, the present findings may be useful when planning more advanced cohort and interventional epidemiological studies in the future. Second, the novel and important evidence reported here can be used when conducting research to provide high-level evidence through the systematic review and meta-analysis of multiple epidemiological studies on the issue of difficulty waking up.

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Conflict of interest statement. None declared.

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ORIGINAL ARTICLE

The association between Internet usage and sleep problems among Japanese adolescents: three repeated cross-sectional studies

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Abstract

Study Objectives: Sleep problems and problematic Internet use have important implications for adolescent health; however, there have been no large-scale surveys using comprehensive measures. We examined the association between Internet use duration and sleep problems among Japanese adolescents.

Methods: We used data from the Lifestyle Survey of Adolescents collected in 2012, 2014, and 2017. We calculated the change in sleep status (insomnia, sleep duration, bedtime, and sleep quality) and Internet usage (screen time and services such as Internet surfing, social media use, streaming such as YouTube, and online gaming). A binary logistic model was estimated for insomnia. Generalized ordered logit models were employed for the ordinal outcomes (sleep duration, bedtime, sleep quality, and multidimensional sleep health). Sampling weights were constructed based on participation rate on survey years and selection rates from population statistics.

Results: We analyzed data from 248 983 adolescents. Sleep status was unchanged; however, many adolescents used more Internet services and for longer durations. The odds ratio of Internet screen time for all sleep problems (insomnia, shorter sleep duration, later bedtime, and worse sleep quality) gradually declined. Longer Internet screen time (>5 hours) was strongly associated with all sleep problems. Internet services were also associated with sleep problems; particularly, social media use and online gaming were linked to later bedtimes.

Conclusions: Despite the decreased strength in the association between Internet usage and sleep problems, longer Internet time was strongly associated with sleep problems. Public health interventions should consider Internet use as an intervention target to improve adolescents' health.

Statement of Significance

This was the first large-scale study to examine the association between Internet usage and sleep problems among Japanese adolescents. Longer Internet usage may have addictive associations, which leads to poor sleep health, particularly a later bedtime and worse sleep quality. Social networking and online gaming were both strongly related to a later bedtime and poorer sleep quality. The findings provide evidence for policymakers and teachers to educate adolescents on healthy Internet use to maintain their health.

Key words: adolescence; sleep; Internet; health surveys; insomnia

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Introduction

Adolescent sleep problems are a critical public health concern. A meta-analysis indicated that inadequate sleep is associated with obesity, negative somatic and psychosocial health, poor school performance, and risk-taking behavior [1]. Previous studies reported many factors that affect adolescent sleep such as unhealthy dietary behaviors [2], smoking [3], drinking alcohol [4], consuming caffeine [5], time spent with peers [6], involvement in extracurricular activities [7], poor mental health [8], having no intent to study at university [4], and the use of electronic media [9, 10].

Many studies have reported that technological developments, such as the Internet and cellular phones, and the rise of the "24-hour society" affect adolescents' sleep [9–13]. Increased new media screen time in 2009–2015 may be involved in the increasing trends of short sleep duration among US adolescents [14]. A systematic review involving data from 690 747 children from 20 countries identified a decline of 0.75 min/year in children's sleep duration over the last 100 years [15]. There was also an increased prevalence in the sleep-onset difficulties among European adolescents from 2002 to 2014 [16]. These changes were attributed to increases in electronic device use, including social media engagement and reading news online [17]. A meta-analysis showed a significant odds ratio (OR) for sleep problems and significant reduced sleep duration among individuals with Internet addiction [18]. Another meta-analysis showed that Internet, computer and phone use, and video games were all associated with late bedtime [11]. The use of electronic devices may have led to arousal, activation, and exposure to light before bedtime, affecting sleep duration and quality [10]. Thus, media use is associated with delayed bedtime and reduced total sleep duration.

Despite the association between the Internet and sleep problems, most previous studies did not investigate a dose–response relationship between Internet screen time and sleep problems. In Japan, the Cabinet Office reported that adolescent Internet users increased from 76.0% in 2012 to 93.2% in 2017, and the smartphone ownership rate among adolescents increased from 45.7% in 2012 to 72.8% [19]. In 2012, the estimated prevalence of problematic Internet use was 6.2% in boys, 9.8% in girls, and 7.9% in total among Japanese adolescents [20]. With the explosive spread of the Internet and smartphone ownership, the prevalence of problematic Internet users is likely to increase further. Previously, we reported that there were increasing trends toward shorter sleep duration and late bedtimes from 2004 to 2017 [21]. However, we also showed that the prevalence of insomnia and poor sleep quality among Japanese adolescents had decreased during that period [21]. There is no doubt that excessive Internet use has a negative impact on sleep; however, to our knowledge, no study has investigated why the prevalence of insomnia and sleep quality has decreased despite the increasing influence of the Internet in adolescence. In addition, few studies have evaluated which sleep problems are the most associated with Internet screen time.

We sought to explore the cross-sectional relationship between Internet screen time and sleep problems in three repeated large national studies of Japanese adolescents from 2012 to 2017. We also examined the association between Internet service and sleep problems. Previous findings showed that the prevalence of insomnia among Japanese adolescents decreased despite increased trends of adolescent Internet users [19, 21]. Thus, we hypothesized that the associations of Internet use with sleep problems would be modified by survey year. The results may provide new evidence to promote sleep-related education for adolescents.

Materials and Methods

Study sample

We used data from the Lifestyle Survey of Adolescents (aged 12–18 years) collected in 2012, 2014, and 2017. We obtained a representative sample of Japanese adolescents using a stratified single-stage standard cluster sampling procedure supported by the Japanese Ministry of Health, Labour and Welfare. The method involved dividing Japan into regional blocks and randomly selecting schools from each block. All students in selected schools were asked to respond to the survey. The respondents completed a self-administered anonymous questionnaire at their school. The study population was restricted to junior and senior high school students between grades 7 and 12. The distribution of the characteristics of schools (e.g. private vs. public) was selected to be representative of the study population. Detailed information about the design and content of these surveys can be found elsewhere [10, 21]. This study was exempted from full review by the Nihon University School of Medicine review board. It was conducted in accordance with the Declaration of Helsinki.

Variables

Four outcome variables on sleep problems were constructed from relevant survey questions. The sleep problems included questions about insomnia symptoms, sleep duration, and self-reported sleep quality. Insomnia symptoms were defined as answering "yes" to any of the following three questions during the previous month. (1) Did you have difficulty falling asleep at night? (2) Did you wake up during the night after you had gone to sleep? (3) Did you wake up too early in the morning and had difficulty getting back to sleep? Each question had five possible responses: *never*, *seldom*, *sometimes*, *often*, and *always*. "Often" and "always" were considered affirmative answers to the question [4]. For self-reported sleep duration, the survey asked, "How many hours did you sleep on average each day during the last month?" Each question had six possible responses: less than 5 hours, 5 hours or more but less than 6 hours, 6 hours or more but less than 7 hours, 7 hours or more but less than 8 hours, 8 hours or more but less than 9 hours, and 9 hours or more. As for self-reported sleep quality, the survey asked, "How do you assess the quality of your sleep during the previous month (*very good*, *good*, *poor*, or *very poor*)?" Regarding bedtime, the survey asked, "What time do you go to bed?" Bedtime was categorized into three levels: before 11 pm, from 11 pm to 1 am, and after 1 am.

Variables on Internet screen time were derived from the survey question, "How many hours on average did you spend using the Internet on a school day for the previous month?" Internet screen time was categorized into four levels: less than 1 hour, 1 or more but less than 3 hours, 3 or more but less than 5 hours, and 5 hours or more. Regarding Internet services, the survey asked, "What kind of Internet services have you used

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in the previous month? Choose all services that apply (*Internet surfing to search for information and news*; *social media use*; *streaming services such as YouTube, Niconico, etc.*; or *online gaming*)?" Other explanatory variables included survey year, sex, school grade, type of school (junior high or senior high school), lifestyle behavior (eating breakfast, participation in extracurricular activities, smoking, drinking alcohol), having fun at school, future plans to study at a university, and mental health status.

Statistical analysis

First, we calculated participants' selection rate from statistics by survey year. Second, we calculated the status of sleep problems such as insomnia symptoms, sleep duration, bedtime, and sleep quality by survey year. In this study, sleep duration was categorized into three levels: less than 6 hours, 6 or more but less than 8 hours, and 8 hours or more to fit a uniform log cumulative odds of association across these three categories. Third, the status of Internet use was calculated by survey year. Fourth, we analyzed the association between Internet use duration and sleep problems. Fifth, a binary logistic model was estimated for insomnia. A generalized ordered logit model was employed for the three ordinal outcomes (sleep duration, bedtime, and sleep quality). This method relaxes the parallel lines assumption and thus allows the impact of each independent variable to differ across the ordinal outcome categories [22]. Both variable-specific and Wald tests indicated that there was no evidence of parallel lines assumptions violations [23]. Therefore, ordered logit models were deemed acceptable. Ordered logit models are more parsimonious and easier to interpret [24]. As the associations of survey year may vary with different levels of Internet usage, we combined the survey year and the Internet screen time as the explanatory variables. The final covariates in the logistic regression analysis included sampling weights, demographic characteristics (sex and school grade), lifestyle behaviors (having breakfast, participating in extracurricular activities, drinking alcohol, smoking status), student life such as having fun at school and future plans to study at a university, and mental health status. These covariates were selected because they have been associated with sleep problems in previous studies [2, 4, 10, 21]. We also analyzed these associations by gender to identify gender differences. Finally, we examined the associations between multiple sleep dimensions, Internet screen time, and Internet service using a generalized ordered logit model. A multidimensional index of poor sleep health scores was calculated as the sum of the number of the following four dimensions self-reported as "poor." Adolescents who reported insomnia symptoms and/or reported that their sleep hours were less than 6 hours were scored as "poor" in the sleep duration dimension; those who went to bed after 1 am were scored as "poor" on bedtime; those who reported poor or very poor sleep quality were scored as "poor" on sleep quality. Male participants who responded that it took 30 minutes or more to fall asleep were classified as "poor" on the sleep-onset latency dimension. In this study population, the distribution of total risks ranged from 0 to 4 with a median of 1. Weights were constructed based on participation rate by junior/senior high school and selection rate from matched national population statistics in each survey year. We set the significance level at $p < .01$ (two-tailed test) because of the large sample size. All analyses were performed using Stata 15 (Statacorp, College Station, TX).

Results

In 2012, 2014, and 2017, the response rates were 60.7%, 52.0%, and 54,4%, respectively. After excluding 2499 observations (0.99% of the original sample) with missing information regarding sex, inconsistent responses, or missing variables, the final sample included 248 983 complete cases.

The number of participants in each survey year varied from 100 050 in 2012 to 63 945 in 2017 (Table 1). The overall selection rates from population statistics were 1.45% in survey year 2012, 1.25% in survey year 2014, and 0.97% in survey year 2017. Almost twice as many participants were in grades 10–12 as compared to grades 7–9.

Table 2 shows the lifestyle behaviors of analyzed participants. Most adolescents ate breakfast daily and participated in extracurricular activities. The prevalence of smoking and drinking consistently declined over the survey years, whereas

Table 1. Participants' demographic characteristics

		2012		2014		2017	
		Participants	Selection rate (%)	Participants	Selection rate (%)	Participants	Selection rate (%)
Total Grade		100 050	1.45	84 988	1.25	63 945	0.97
7	Boy	6920	1.15	5467	0.92	3740	0.67
	Girl	6485	1.13	5061	0.89	3644	0.68
8	Boy	6556	1.08	5426	0.91	3687	0.65
	Girl	6328	1.08	5055	0.89	3642	0.67
9	Boy	6186	1.02	5320	0.89	3702	0.64
	Girl	6019	1.04	5145	0.90	3713	0.67
10	Boy	11 233	1.94	9058	1.57	7963	1.42
	Girl	10 247	1.82	9990	1.78	6238	1.14
11	Boy	10 477	1.92	8348	1.52	7903	1.44
	Girl	9549	1.77	9390	1.72	6309	1.17
12	Boy	10 215	1.84	7606	1.41	7470	1.39
	Girl	9835	1.80	9122	1.71	5934	1.12

The selection rate was calculated from the national population statistics of all junior and senior high school students in each survey year throughout Japan.

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Table 2. Lifestyle behaviors of analyzed participants

	2012 (*N* = 100 050)		2014 (*N* = 84 988)		2017 (*N* = 64 329)	
	%	95% CI	%	95% CI	%	95% CI
Daily eating breakfast	87.7	87.5–87.9	87.0	86.8–87.3	86.5	86.2–86.7
Participating in extracurricular activities	86.3	86.1–86.5	86.2	85.9–86.4	85.7	85.4–86.0
Present smoking	2.3	2.2–2.4	1.6	1.6–1.7	1.0	0.9–1.0
Present drinking alcohol	9.4	9.2–9.5	7.3	7.1–7.5	4.6	4.4–4.8
Having fun at school	67.1	66.8–67.4	66.6	66.3–67.0	68.3	67.9–68.7
Future plans to study university	33.3	33.0–33.6	33.7	33.3–34.0	35.7	35.3–36.1
Poor mental health	38.3	38.0–38.6	55.6	55.2–56.0	53.8	53.4–54.3

CI, confidence interval. Participants for whom data were missing were excluded from the analyses. Weights were adjusted to ensure that the weighted proportions of students in each grade matched national population statistics.

Table 3. Estimated change status of sleep problems among Japanese adolescent from 2012 to 2017

			Sleep duration				Bedtime				Sleep quality				
Year	Insomnia		≥8 h	6–7.99 h	<6 h		Before 11 pm	11 pm–1 am	After 1 am		Very good	Good	Poor	Very poor	
2012	19.7	(*n* = 97 475)	12.5	61.4	26.2	(*n* = 98 120)	21.1	58.8	20.1	(*n* = 97 890)	15.0	48.3	32.1	4.7	(*n* = 97 615)
2014	21.0	(*n* = 82 129)	10.3	61.8	27.9	(*n* = 82 301)	21.7	59.0	19.4	(*n* = 82 333)	14.8	47.9	32.5	4.7	(*n* = 82 143)
2017	19.2	(*n* = 62 092)	10.2	63.1	26.7	(*n* = 62 280)	21.7	59.2	19.1	(*n* = 62 299)	14.6	50.4	30.5	4.4	(*n* = 62 192)

Status was expressed in percentages (%). Participants for whom data were missing were excluded from analyses. Insomnia: those who answered one or more of difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA) as experienced "often" or "always." Weights were adjusted to ensure that the weighted proportions of students in each grade matched national population statistics.

Table 4. Demographics of Internet use among Japanese adolescent from 2012 to 2017

	Internet screen time					Internet service				
		<1 h	1–2.99 h	3–4.99 h	≥5 h		Internet surfing	Social media use	Streaming	Online games
2012	(*n* = 97 984)	30.4	43.1	14.6	11.9	(*n* = 100 050)	68.1	36.0	63.5	19.8
2014	(*n* = 83 701)	22.8	48.2	17.3	11.7	(*n* = 84 988)	71.2	53.4	69.5	32.6
2017	(*n* = 62 311)	17.3	49.4	20.7	12.6	(*n* = 63 119)	74.4	79.9	78.4	45.1

All values were expressed in percentages (%). Participants for whom data were missing were excluded from analyses. Questions about Internet service used were multiple-choice style. Weights were adjusted to ensure that the weighted proportions of students in each grade matched national population statistics.

the prevalence of mental health problems increased from 2012 to 2014.

Table 3 shows the percentage of sleep status in each survey year. The percentages for each survey year were similar. However, the percentage of insomnia was highest in 2014 (21.0% [*n* = 17 247]). The proportion of participants who got 8 or more hours of sleep decreased from 12.5% (*n* = 12 265) to 10.2% (*n* = 6353). The proportion that went to bed after 1 am decreased from 20.1% (*n* = 12 265) to 10.2% (*n* = 6353). The percentage of poor and very poor sleep quality was lowest in 2017, 30.5% (*n* = 18 969) and 4.4% (*n* = 2736), respectively. Female adolescents tended to have shorter sleep duration, later bedtime, and poor sleep quality across three surveys (Supplementary Table 1).

Table 4 shows the Internet usage status in each survey year. Regarding Internet screen time, the proportion that used the Internet for less than 1 hour decreased from 30.4% (*n* = 29 787) to 17.3% (*n* = 10 780), while the proportion that used the Internet for 1–2.99 hours and 3–4.99 hours increased from 43.1% (*n* = 42 231) to 49.4% (*n* = 30 782) and from 14.6% (*n* = 14 306) to 20.7% (*n* = 12 898), respectively. All Internet services increased during this period, especially social network services, from 36.0% (*n* = 36 018) to 79.9% (*n* = 50 432), and online gaming, from 19.8% (*n* = 19 810) to 45.1% (*n* = 28 467), indicating that the figure more than doubled in 2017 compared to 2012. Female adolescents tended to use social network services more and male adolescents tended to play online games more (Supplementary Table 2).

Figure 1 shows the relationship between Internet screen time and each sleep problem. Linear relationships were observed between Internet time and each sleep status across all survey years. In the group with the highest Internet time (5 hours or more), the prevalence of insomnia, short sleep duration (less than 6 hours), later bedtime (after 1 am), and very poor sleep quality were around 31%–33%, 39%–42%, 37%, and 11%–12%, respectively.

Figure 2 shows the association between Internet screen time and sleep problems. Longer Internet screen time (vs. the reference of less than 1 hour) was generally associated with a higher likelihood of all sleep problems in all survey years. Respondents who used the Internet for 5 or more hours had a higher OR for sleep problems than did their counterparts. Especially compared with those who has less than 1 hour of Internet screen time in 2012, those who used the Internet for 5 or more hours in 2012 had the highest odds of insomnia (adjusted OR [aOR] = 1.71; 95% confidence interval [CI] = 1.61% to 1.81%), a later bedtime (aOR = 2.44; 95% CI = 2.32% to 2.56%), and worsened sleep quality (aOR range = 1.62; 95% CI = 1.54% to 1.71%). The survey year (vs.

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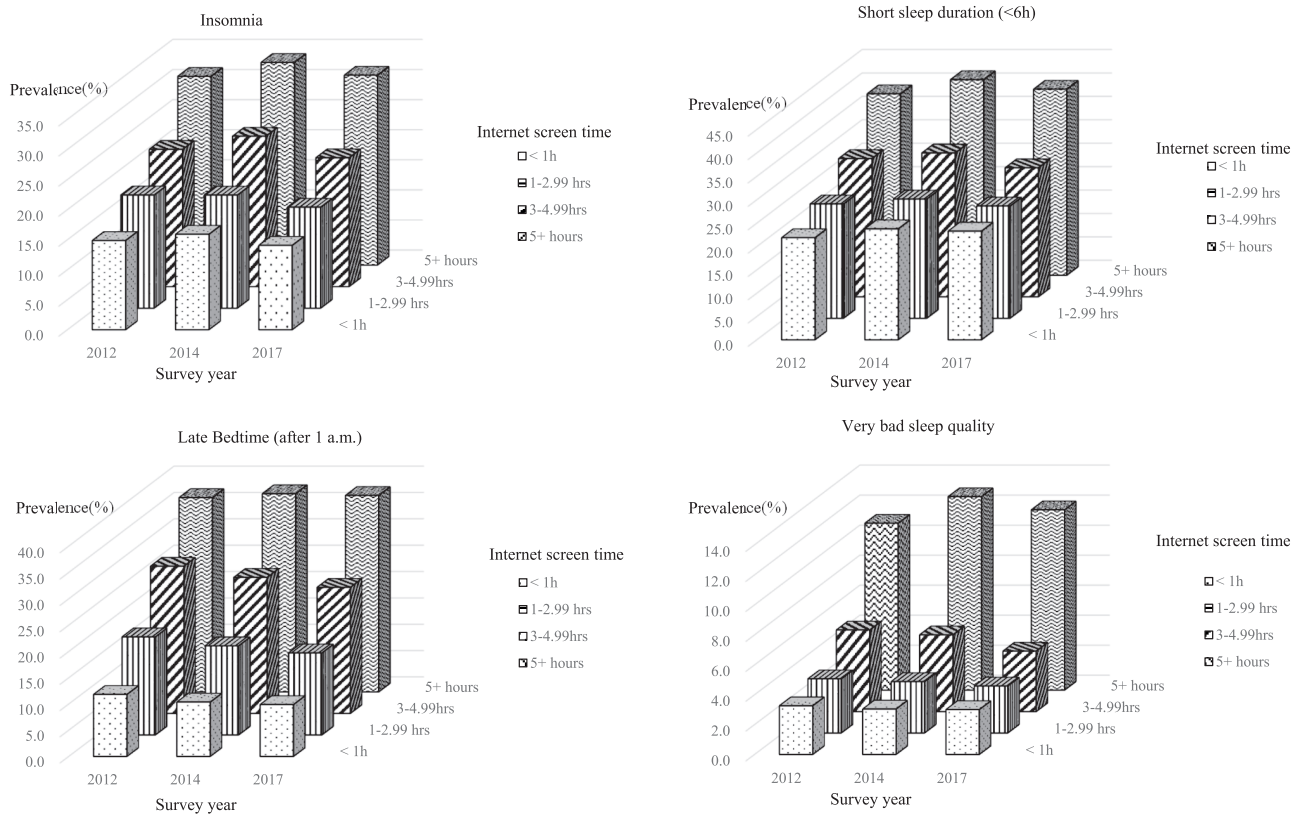

Figure 1. Prevalence of each sleep problem by Internet screen time.

the reference of 2012) was generally associated with a lower likelihood of insomnia, a later bedtime, and worse sleep quality except for shorter sleep duration. There were no gender differences in the association between Internet screen time and sleep problems.

Table 5 shows the association between Internet services and sleep problems. Those who used the Internet for surfing had lower ORs for all sleep problems except shorter sleep duration compared to those who used the Internet for other reasons. Those who used the Internet for online gaming (aOR = 1.26; 95% CI = 1.23% to 1.28%) and social media use (aOR = 1.27; 95% CI = 1.24% to 1.30%) had higher ORs for a later bedtime and worse sleep quality than did their counterparts. There were no gender differences in the association between Internet services and sleep problems.

Table 6 shows the association between Internet screen time, Internet services, and poor sleep health scores. Linear relationships can be observed between Internet screen time, Internet services, and sleep health. Thus, as poor sleep health score increases, the percentage of Internet screen time of 5 hours or more and all Internet services increases. Those who used the Internet for 5 or more hours had a higher OR for poor sleep health than did their counterparts.

Discussion

This study was the first nationwide representative study to examine the association between Internet usage and a variety of sleep problems among Japanese adolescents across recent three surveys. We revealed three main findings: (1) Internet screen time and Internet services were independently associated with sleep problems; (2) linear relationships existed between Internet screen time, multidimensional sleep health, and each sleep problem; and (3) the link between the Internet and sleep problems seemed to weaken over time. These findings have key implications for public health.

As expected, our study was similar to others in that longer Internet time was significantly associated with insomnia, shorter sleep duration, later bedtime, and worse sleep quality. A systematic review reported that 29 out of 31 studies found an association between computer use and sleep outcomes, particularly delayed bedtime and reduced sleep duration [25]. Our results showed further evidence that a linear relationship like dose–response Internet spent time was associated with all sleep problems. One study showed that computer/Internet use of at least 3 h/day (AOR = 2.56) was significantly associated with insomnia complaints among German adolescents boys [26], and a dose–response relationship emerged between sleep duration and use of electronic devices, especially computer use [27]. Another study addressed the association between Internet addiction and sleep problems worldwide [18]. A meta-analysis showed that the pooled OR of sleep problems for the Internet addiction group was 2.20 (95% CI = 1.77% to 2.74%), and the pooled standardized mean difference for sleep duration for the Internet addiction group compared to nonaddicted users was –0.24 (95% CI = –0.38% to –0.10%) hours [18]. Time spent on the Internet was also positively associated with Internet addiction [28].

To our knowledge, there have not been any previous surveys on the association between type of Internet use (e.g. streaming

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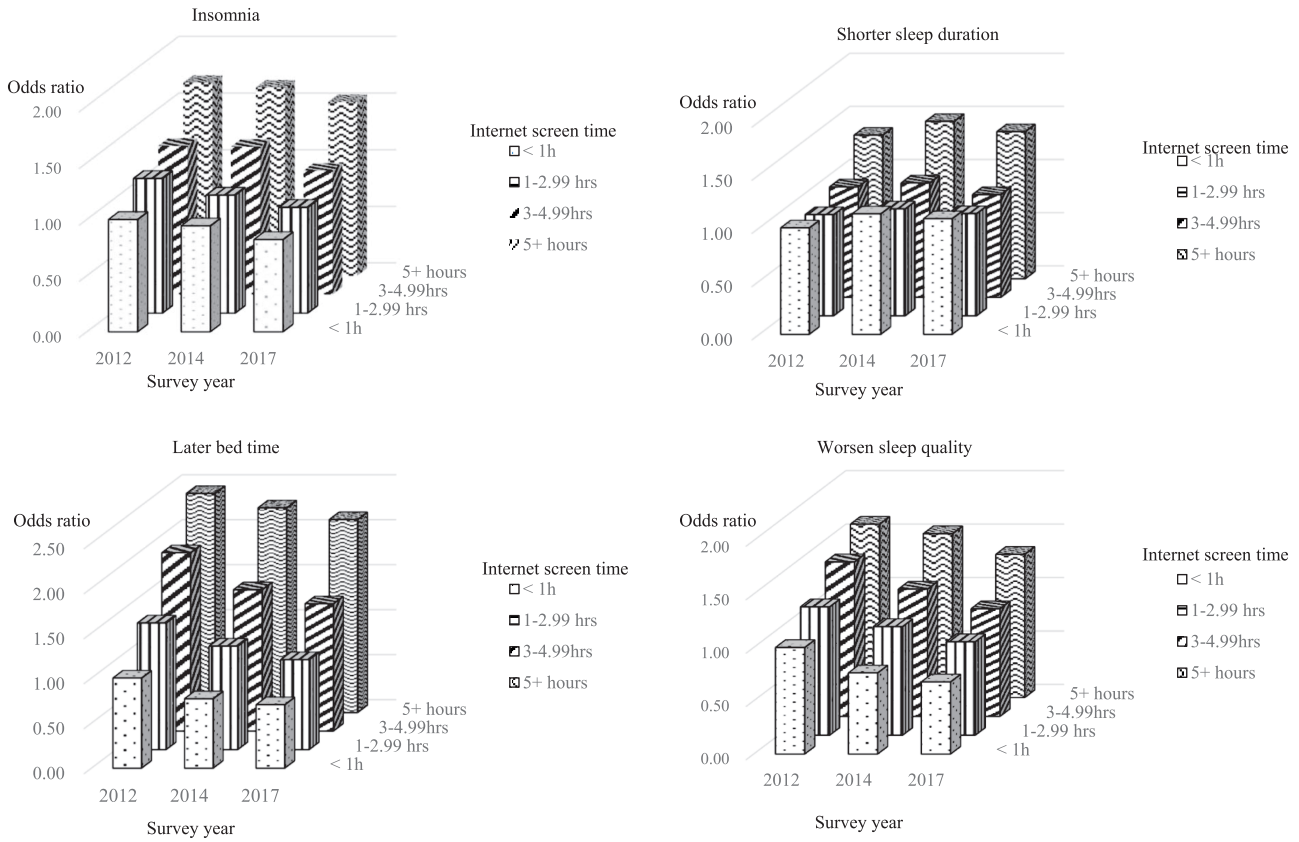

Figure 2. Association between Internet screen time and each sleep problem. Odds ratios came from binary for insomnia and ordinal logistic regression models in shorter sleep duration, longer bedtime, and worsen sleep quality. Adjusted for participants' and statistics population weight, survey year, Internet usage duration, sex, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol status, smoking status, and future plans.

Table 5. Association between Internet service and sleep problems from merged data 2012, 2014, and 2017 among Japanese adolescents

	Sleep problems															
	Insomnia				Shorter sleep duration				Later bedtime				Worse sleep quality			
	aOR	95% CI		*p*	aOR	95% CI		*p*	aOR	95% CI		*p*	aOR	95% CI		*p*
Internet service																
Internet surfing (yes)	0.96	0.93	0.98	.001	1.16	1.14	1.19	<.001	1.10	1.08	1.13	<.001	1.09	1.06	1.11	<.001
Social media use (yes)	1.09	1.05	1.12	<.001	1.15	1.12	1.17	<.001	1.27	1.24	1.30	<.001	1.17	1.15	1.20	<.001
Streaming (yes)	1.07	1.04	1.10	<.001	1.06	1.03	1.08	<.001	1.12	1.09	1.14	<.001	1.15	1.13	1.17	<.001
Online gaming (yes)	1.06	1.03	1.09	<.001	1.06	1.04	1.08	<.001	1.26	1.23	1.28	<.001	1.26	1.23	1.29	<.001

aOR, adjusted odds ratio; CI, confidence interval. Participants for whom data were missing were excluded from analyses. Insomnia: those who answered one or more of difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA) as experienced "often" or "always." Sleep duration was classified as <6 h, 6–7.99 h, and ≥8 h. Bedtimes were classified as before 11 pm, 11 pm–1 am, and after 1 am. Sleep quality was classified as "very good," "good," "poor," and "very poor." Odds ratios came from binary for insomnia and ordinal logistic regression models in shorter sleep duration, later bedtimes, and worsened sleep quality. Weights adjusted to match national population statistics and for survey year, Internet usage duration, sex, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol status, smoking status, and future plans.

and online gaming) and sleep problems. We revealed a negative association between Internet surfing and insomnia, while other Internet services had a positive association with insomnia. In addition, social networking was strongly related to later bedtime, and online gaming was strongly related to later bedtime and worse sleep quality. Gender-specific differences were observed in habitual patterns of Internet services. Adolescent males tended to focus more on the entertainment aspects of the Internet, while females seem to be more interested in the relational aspects of social media and in communicating with friends on the Internet [20, 29, 30]. Thus, it is desirable to focus on social networking for females and online games for males to provide sleep hygiene education.

Some previous studies indicated the association between social media use and sleep problems [31, 32]. For example, a large-scale cross-sectional study among Canadian students aged 11–20 years reported that social media use was associated with higher odds of shorter sleep duration, and a dose–response association was observed between social media use and shorter sleep duration [31]. A systematic review showed a

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Table 6. Association between Internet screen time, Internet service, and sleep health scores from merged data of 2012, 2014, and 2017 in Japanese adolescents

	Sleep health score							
	0 (*N* = 98 232)	1 (*N* = 64 297)	2 (*N* = 40 871)	3 (*N* = 27 040)	4 (*N* = 9052)	aOR	95% CI	*p*
Internet screen time								
<1 h	26.4	23.1	16.5	13.2	10.0	1.00		
1–3 h	50.1	46.9	46.0	42.1	34.0	1.04	1.01–1.06	0.002
3–5 h	15.7	18.3	21.1	22.6	22.3	1.32	1.28–1.36	<0.001
≥5 h	7.9	11.7	16.4	22.1	33.8	2.03	1.96–2.10	<0.001
Internet services							-	
Internet surfing	69.0	72.7	74.1	75.8	75.6	1.11	1.09–1.14	<0.001
Social media use	51.9	56.8	64.9	69.9	73.6	1.14	1.12–1.16	<0.001
Streaming	28.6	30.9	34.0	36.7	41.4	1.13	1.11–1.16	<0.001
Online games	66.5	68.7	74.1	76.7	78.6	1.11	1.09–1.14	<0.001

CI, confidence interval. Participants for whom data were missing were excluded from the analyses. Weights adjusted to match national population statistics. Sleep health scores were expressed in percentage (%). Odds ratios come from ordinal logistic regression models in sleep health scores. Weights adjusted to match national population statistics and for survey year, Internet usage duration, gender, grade, mental health status, breakfast consumption, club activity, having fun at school, drinking alcohol status, smoking status, and future plan to study at a university.

notably strong association between multiplayer online gaming and poor sleep quality [33]. However, our study showed that all reasons for using Internet services had a weak association with adolescents' sleep. In the future, it will be necessary to investigate further the association between sleep problems and service usage time.

The causal pathways linking sleep problems with Internet usage are still not clear. There are several explanations for these associations. First, longer Internet usage time could reduce sleep duration and delay bedtime directly [34] or indirectly by displacing time spent on other behaviors such as physical activity that promote good sleep [35, 36]. Second, exposure to artificial light from viewing the Internet can affect circadian rhythms, which can contribute to shorter sleep duration, poor sleep quality, and insomnia symptoms [10, 37]. Third, Internet use in the evenings may increase mental, emotional, or physiological arousal [38].

In contrast, several studies have suggested that sleep problems could influence electronic media use [38]. Sleep disturbance partially mediated the relationship between electronic media use and depressive symptoms among adolescents in Switzerland [39]. In fact, lack of sleep could lead to tiredness and fatigue the next day, increasing the likelihood of performing sedentary behaviors, such as Internet use [40, 41]. Adolescents with underlying sleep problems may use the Internet as a stress-coping method or to improve sleep. Given the potential tradeoff between sleep duration and Internet time spent among adolescents, bidirectional relationships may exist between sleep and Internet use [12].

Our results showed that the association between Internet use and sleep problems seems to have weakened in more recent surveys, except for shorter sleep duration. Similarly, concerning our findings about sleep duration, a survey of US adolescents from 2009 to 2015 reported that the use of electronic devices, social media, and reading news online significantly increased the odds of short sleep duration, and time spent on these screen activities increased over the survey period [14]. There are two possible reasons for the weakened association between Internet use, insomnia, and sleep quality. The first is that most Japanese adolescents consider the Internet as a part of their daily lives; thus, the association with their sleep habits was reduced. In fact, Japanese adolescents' use of televisions, radios, and magazines has decreased while their Internet usage time has increased [19]. Thus, their overall screen time was unchanged. The second reason may be that adolescents' sleep hygiene activities, such as avoiding using the Internet before bed, prevented insomnia and promoted sleep quality. Our previous study showed that Japanese adolescents' sleep problems such as insomnia and poor sleep quality decreased between 2004 and 2017 [21]. Although the reason was unclear, we suggested the effect of Japanese sleep countermeasures. The Japanese Ministry of Health, Labour and Welfare introduced the "Sleep Guidelines for Health Promotion" in 2014, which included 12 messages about sleep hygiene. These policies may have raised adolescents' awareness of sleep by educating them at school. In fact, lifestyle education was taught in schools in Japan. Specifically, the smoking education provided in Japanese schools contributed to the reduction of smoking rates [42]. Thus, Japanese adolescents tend to adopt healthy lifestyle behaviors to ensure they get good sleep [21].

Nevertheless, this study showed that 90% of Japanese adolescents had insufficient sleep duration. East Asian adolescents are known to sleep less and have later bedtimes than adolescents from Western countries [17]. In East Asian countries such as China, Korea, and Japan, many children face severe academic pressure emphasizing study time [43, 44], In Japan, "we tried hard without sleeping" is desirable, resulting in the term "Shitougoraku" (sleep 4 hours and pass, sleep 5 hours and fail [when cramming for university entrance exams]). Thus, sleep health in Japan has been neglected by the people and the magnitude of sleep problems is more remarkable than that in Western countries. Shortened sleep duration in adolescence occurs as a result of progressive delays in bedtimes, not as a result of a change in wake-up time [45]. Certainly, later night electronic media use is associated with delayed bedtimes and shortened sleep duration [18, 27]. However, the present study showed that the link of Internet usage time with sleep duration was not strong. Our data also showed lower smoking and drinking alcohol prevalence and higher breakfast intake, which suggests that adolescents tend to exhibit healthy lifestyle behaviors. Thus, other daily activities such as school work, cram school, extracurricular activities, and part-time employment may be associated with later bedtime and shorter sleep duration.

Gender differences emerged regarding sleep problems, except insomnia. Some previous studies showed opposite directions

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[46–48]. For example, a cross-sectional study in Norway showed that girls had a higher prevalence of insomnia than boys while boys reported later bedtimes [46]. The mechanisms leading to these gender differences are not yet known [47]. Previous studies showed that the gender differences could be related to pubertal development. This difference between Japan and Western countries may be related to cultural aspects or Internet usage time.

This study has several noteworthy limitations. First, all data were self-reported. Future studies should use more objective measures of both Internet use and sleep. Moreover, researchers should collect more characteristics associated with Internet use that can lead to behavioral changes (e.g. timing, duration, device, and application). However, several studies have indicated that self-reported sleep data had a moderate agreement with laboratory studies [49]. Second, although we adjusted for several potential confounding variables, we did not control for regional aspects (urban vs. rural), economic status, and other screen devices such as TVs and gaming machines. These factors were associated with sleep problems [9, 10, 25, 50, 51]. Thus, future research should include these factors. Third, owing to the cross-sectional study design, causal relationships cannot be examined. To do so, longitudinal studies with better measures of Internet use and sleep are needed. Fourth, our study could not investigate the difference in sleep duration between weekdays and weekends. A study has shown that different bedtime and wake-up habits during school days and weekends are associated with increased screen time [52]. Despite these limitations, this study suggests that assessing the time adolescents spend on the Internet and their sleep habits may be valuable indicators for healthcare providers.

In conclusion, the findings from these large-scale, repeated cross-sectional surveys of Japanese adolescents suggest that longer Internet time, especially at least 5 h/day, is associated with worse sleep problems. The findings also suggest that future interventions should specifically target social media use and online gaming for adolescents. Teachers, parents, and adolescents must be aware of the possible negative impact of Internet use on adolescent sleep. These results would be useful in developing more effective interventions. For example, students should be educated in school about the advantages and disadvantages of the Internet and how to use it safely, and parents need to develop rules for Internet use at home. Teachers and parents should be aware of gender-specific patterns of Internet services and sleep problems. Future studies need to expand upon the present study by examining both weekday and weekend sleep duration, bedtime, and wake-up times and any other screen time such as watching TV, playing video games, and studying on a tablet.

Supplementary material

Supplementary material is available at *SLEEP* online.

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Disclosure Statement

None declared.

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Data availability

The datasets generated used in the current study are not publicly available because it is necessary to obtain permission from the Ministry of Health, Labour and Welfare in Japan. Related documents will be available from https://mhlw-grants.niph.go.jp/niph/search/NIST00.do.

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