

Changes in the Prevalence of Health-Risk Behaviors among Japanese Adolescents before and during the COVID-19 Pandemic: 2002-2021

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[Received January 19, 2023 ; Accepted April 6, 2023]

Background: Although many health-risk behaviors among adolescents have improved in the past several decades, the coronavirus disease 2019 (COVID-19) pandemic might have a significant impact on adolescent health and health-risk behaviors.

Objective: This study aimed to explore trends in the prevalence of health-risk behaviors among Japanese adolescents between 2002 and 2021 and to assess whether the COVID-19 pandemic period is associated with those changes.

Methods: A repeated cross-sectional study was conducted using data from prefecture-wide surveys of public high schools in Okinawa Prefecture, Japan, in 2002, 2005, 2008, 2012, 2016, and 2021. The study included 16,562 students in grades 10 to 12 (15-18 years). The behaviors studied included injury-related behaviors, cigarette use, alcohol use, sexual behaviors, dietary behaviors, and physical activity. Logistic regression models were performed separately for boys and girls, treating the survey year as a continuous independent variable and adjusting for grade, school type and region.

Results: During the 20-year period, there were significant improvements in multiple health-risk behaviors, such as traffic risk behaviors, cigarette and alcohol use, vegetable intake, TV watching, and sexual behaviors. On the other hand, persistent sad feelings, suicidal ideation and fasting in girls, fruit consumption and physical activity in boys, and video game/computer use among both sexes have worsened over time. In particular, during the COVID-19 pandemic, physical activity and video game/computer use in both sexes and persistent sad feelings and suicidal ideation in girls worsened significantly.

Conclusion: Many health-risk behaviors among adolescents improved between 2002 and 2021. Meanwhile, the COVID-19 pandemic might contribute to deteriorated physical activity and video game/computer use and worsened mental health and suicidality among girls.

Keywords: repeated cross-sectional study, time trend, high school students

[School Health Vol.19, 14-25, 2023]

I. Introduction

Health-risk behaviors contribute to increasing risks of death, illness, injury, and social problems among people in the short- and long-term^{1,2)}. These behaviors include injury-related behaviors, tobacco use, alcohol and other drug use, sexual behaviors, unhealthy dietary behaviors,

and physical inactivity¹⁾. Since health-risk behaviors often initiate during adolescence and extend into adulthood¹⁾, adolescence is a critical time for the prevention of health-risk behaviors. Understanding the current state of adolescent health-risk behaviors and monitoring their trends over time are needed to plan, implement, and assess effective prevention efforts.

In Western countries, ongoing national surveys on comprehensive adolescent health-risk behaviors have been conducted for decades, such as the Youth Risk Behavior Surveillance System and Health Behaviour in School-aged Children study³⁾⁴⁾, indicating recent downward trends in various risk behaviors, such as substance use, delinquent behaviors, obesity-related behaviors, and sexual behaviors⁵⁻¹⁰⁾. Similarly, in non-Western countries, several studies that used data from the Global School-based Health Survey¹¹⁾ have examined trends in adolescent health-risk behaviors, yielding mixed results¹²⁻¹⁴⁾: many domains of risk behaviors have improved while other behaviors have worsened; for example, current smoking in Moroccan adolescents and sexual experience in Argentine girls have increased¹³⁾¹⁴⁾. In addition, a Chinese study using data from the 2012 to 2017 School-based Chinese Adolescents Health Survey in one province also reported a decreasing trend in most health-risk behaviors, with the exceptions that lifetime smoking and drinking prevalence increased over time¹⁵⁾.

For Japanese adolescents, although continuous national surveys on individual risk behavior, such as smoking¹⁶⁾, drinking¹⁷⁾, and sexual behavior¹⁸⁾, have shown declining trends, no periodic survey on comprehensive health-risk behaviors has been reported, and trends in those behaviors over time are unclear. Hence, we have been monitoring the prevalence of these behaviors in high school students in Okinawa Prefecture since 2002. Our previous study showed that from 2002 to 2016, many adolescent health-risk behaviors improved, but sedentary behaviors, fruit consumption among boys, and fasting among girls deteriorated over this period¹⁹⁾.

The coronavirus disease 2019 (COVID-19) pandemic has forced young people to change their daily lives and has largely affected their health and health-related behaviors. Some systematic reviews have shown that during the COVID-19 pandemic, mental health has deteriorated, as evidenced by the incidence of anxiety and depression²⁰⁻²²⁾, physical activity was reduced²³⁾²⁴⁾, screen time had increased²³⁾²⁵⁾, and alcohol, cannabis, and tobacco use was reduced among adolescents²⁶⁾. Previous studies in Japan also found that suicide among Japanese young people increased during the COVID-19 pandemic²⁷⁻²⁹⁾. However, little is known about the changes in other health-risk behaviors among Japanese adolescents during the pandemic. Given the challenges in the COVID-19 pandemic, the need to monitor changes in adolescent risk behaviors before and during the pandemic is considerably increased.

This study aims to explore trends over time in the

prevalence of health-risk behaviors among Japanese adolescents between 2002 and 2021 and to assess whether the COVID-19 pandemic is associated with those changes. Specifically, using six waves of survey data since 2002 in Okinawa, we 1) determined overall changes over the past two decades (2002 to 2021) to describe the long-term trends in health-risk behaviors, and 2) determined changes during the prepandemic period (2002 to 2016) and between before and during the pandemic (2016 to 2021) to explore the impact of the COVID-19 pandemic on those behaviors.

II. Methods

1. Study design and data collection

A repeated cross-sectional study was conducted using data from six waves of prefecture-wide representative surveys of public high schools in Okinawa Prefecture, Japan, in 2002, 2005, 2008, 2012, 2016, and 2021. The Okinawa Prefecture, which is located in the southwesternmost part of Japan, has a population of 1.4 million and is divided into six regions (four are situated on Okinawa Island, while two are on remote islands). During the study period, there were approximately 60 public high schools in the prefecture. The surveys were designed to obtain comprehensive data on health, sociodemographic, and psychosocial information among high school students across the prefecture.

Each survey employed a cluster sampling method. Schools included in the survey were selected by using a sampling method that included at least one school from each school type with a probability that was proportional to the number of schools within school type and region in the prefecture. Schools were selected nonrandomly in 2002 and 2005 (proportional quota sampling) and were selected randomly after 2008. Due to the decrease in the number of schools, the two regions of remote islands were combined into one stratum in the 2021 survey. In each selected school, one class was chosen from each grade, except for one school in 2021 that included two grade 11 classes because the grade 12 class did not participate because of circumstances at the school. All students in the chosen classes were eligible to participate.

For all surveys, we used a similar data collection procedure. After permission to conduct the study was obtained from the principals of the study schools, classroom teachers distributed an anonymous self-administered questionnaire in classrooms during the second term. After students were informed about the

purpose and the ethical considerations of the study and that returning the questionnaire constituted informed consent, all students attending the class were requested to complete and return the questionnaire sealed in an unmarked envelope. The students were free to decline to participate in the study at any time during the survey. No follow-up was conducted on students who were absent from school when the survey was conducted. The study protocols were approved by the Institutional Review Board of the University of the Ryukyus.

2. Participants

During the survey periods, we recruited a total of 19,063 students (2,852 in 2002; 2,892 in 2005; 3,248 in 2008; 3,386 in 2012; 3,441 in 2016; 3,244 in 2021) enrolled in grades 10 through 12 (aged 15-18 years) in the study schools (25 schools in 2002 and 2005; 29 schools in 2008; 30 schools in 2012, 2016, and 2021). Among them, 16,782 students participated in the surveys (1,028 declined to participate and 1,253 were absent from school). Of these, we excluded 220 students who did not provide information about sex. Then, data for the remaining 16,562 students (2,540 in 2002; 2,472 in 2005; 2,850 in 2008; 3,034 in 2012; 3,058 in 2016; 2,608 in 2021), which accounted for 86.9% of the original sample, were used for analysis.

3. Measures

Health-risk behaviors were assessed using questions adapted from the Youth Risk Behavior Surveillance (YRBS) conducted by the US Centers for Disease Control and Prevention (CDC)³⁰. We examined 32 question items, including seven questions for injury-related behaviors, six questions for cigarette use, five questions for alcohol and other drug use, five questions for sexual behaviors, six questions for dietary behaviors, and three questions for physical activity (since 2008) (**Table 2**). The responses to these questions were dichotomized based on the CDC's guide³⁰ (**Appendix 1**). For lifetime sexual intercourse with four or more partners, alcohol or drug use before last sexual intercourse, and condom use during last sexual intercourse, we used the number of students who had ever had sexual intercourse for the denominator to calculate the prevalence. We included the following demographic variables as covariates in our analysis: grade, region, and school type. In addition, we stratified participants by sex because of sex-based differences in the prevalence of some risk behaviors¹⁹.

4. Statistical analysis

We estimated the prevalence and the standard error of each risk behavior by survey year. For trend analyses, we conducted logistic regression models adjusted for covariates with survey year as a continuous variable³¹. Linear trends were examined to assess the changes in prevalence over time during three periods: the past two decades (2002 to 2021), the 14-year period before the pandemic (2002 to 2016), and the five-year period before and during the pandemic (2016 to 2021). Statistical significance was considered if the *P* value was less than 0.05. The *P* value was not adjusted for multiple comparisons since this study presented a descriptive and exploratory analysis³¹.

III. Results

Table 1 shows the distribution of the participants by demographic variables and survey years. There were yearly differences in the proportion of the participants by sex, school type, and region.

The prevalence of health-risk behaviors by survey year for boys and girls are shown in **Table 2** and **Table 3**, respectively. These tables also show differences in prevalence and *P* for trends during each time period. Furthermore, the trends are denoted by green (an improving direction), yellow (no change), or red (a worsening direction).

Between 2002 and 2021, there were significant increases in motorcycle helmet use and seatbelt use and a significant decrease in riding with a drunk driver among both sexes. The trends were similar until 2016 but were not statistically significant between 2016 and 2021. The number of boys who reported having been in a physical fight decreased significantly over time, and this trend was the same between 2002 and 2016 and between 2016 and 2021. Carrying a weapon and persistent sad feelings in boys decreased between 2016 and 2021 only. There were no significant changes in persistent sad feelings and suicidal ideation in girls between 2002 and 2016, but there were significant increases between 2016 and 2021, resulting in significant increases over the past two decades.

Between 2002 and 2021, lifetime cigarette use, early initiation of cigarette use, current cigarette use, current frequent cigarette use, and smoking more than 10 cigarettes per day among both sexes decreased significantly. The downward trend in smoking by boys was evident until 2016 and continued modestly until

Table 1 Demographic characteristics of the participants by survey year

		2002		2005		2008		2012		2016		2021		<i>P</i> *
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	
Grade	10th	903	(36)	874	(35)	993	(35)	1064	(35)	1020	(33)	900	(35)	0.136
	11th	887	(35)	819	(33)	974	(34)	989	(33)	1036	(34)	928	(36)	
	12th	750	(30)	779	(32)	883	(31)	981	(32)	1002	(33)	780	(30)	
Sex	Boys	1219	(48)	1057	(43)	1424	(50)	1437	(47)	1497	(49)	1299	(50)	<0.001
	Girls	1321	(52)	1415	(57)	1426	(50)	1597	(53)	1561	(51)	1309	(50)	
School type	General H.S.	1729	(68)	1709	(69)	1896	(67)	2072	(68)	2052	(67)	1832	(70)	0.044
	Vocational H.S.	811	(32)	763	(31)	954	(33)	962	(32)	1006	(33)	776	(30)	
Region	Okinawa Island	2142	(84)	2055	(83)	2446	(86)	2722	(90)	2742	(90)	2435	(93)	<0.001
	Remote islands	398	(16)	417	(17)	404	(14)	312	(10)	316	(10)	173	(7)	
Total		2540	(100)	2472	(100)	2850	(100)	3034	(100)	3058	(100)	2608	(100)	

* Chi-square test

2021, with the exception of heavy smoking more than 10 cigarettes per day. However, there were no significant decreases in smoking by girls between 2016 and 2021 except for lifetime cigarette use.

Lifetime alcohol use, early initiation of alcohol use, current alcohol use, and episodic heavy drinking among both sexes decreased significantly over time, including notable declines between 2002 and 2016 and gradual continued trends by 2021. Those who have been offered, sold, or given an illegal drug by someone also decreased.

A significant decrease in sexual experience among both sexes was reported during the study period, with a considerable decrease from 2002 to 2016 and some degree of decrease from 2016 to 2021. Between 2002 and 2021, there was a significant decrease in having consumed alcohol or used drugs before the last sexual intercourse and a significant increase in condom use during the last sexual intercourse among both sexes. These trends were the same between 2002 and 2016 but were not statistically significant between 2016 and 2021. Early initiation of sexual intercourse in girls also decreased.

Girls who described themselves as overweight decreased significantly over time. This trend was evident between 2002 and 2016 and modest between 2016 and 2021. While girls who used diet pills and vomited to try to lose weight decreased, girls who went without eating for over a day increased over time. These trends were observed between 2002 and 2016 but were not statistically significant between 2016 and 2021. Between 2002 and 2021, there was a significant decrease in fruit consumption and a significant increase in vegetable consumption among boys; this change was significant between 2002 and 2016, whereas there was no change between 2016 and 2021. Girls who ate vegetables daily

increased significantly between 2002 and 2016, and this trend continued through 2021.

There was no change in physical activity among boys between 2008 and 2016, but there was a significant decrease between 2016 and 2021, resulting in an overall significant decrease in the study period. Physical activity in girls decreased between 2016 and 2021 only. Between 2008 and 2021, watching TV for three hours or more per day decreased and playing video games or using a computer for three hours or more per day increased among both sexes. These changes occurred modestly between 2008 and 2016 and substantially between 2016 and 2021. As supplementary information, the detailed results of the trend analyses using the logistic regression model are presented in **Appendix 2** and **Appendix 3**.

IV. Discussion

This study found decreasing trends in the prevalence of many health-risk behaviors among high school students during the 20-year study period. Among both sexes, there were significant improvements in traffic risk behaviors, cigarette use, alcohol and other drug use, vegetable intake, TV watching, sexual behaviors, as well as physical fighting in boys and unhealthy weight loss behaviors in girls over time. We also found that most of these risk behaviors had already improved substantially between 2002 and 2016. These findings are consistent with reports from previous studies that showed descending trends in multiple risk behaviors among adolescents in Western countries⁵⁻¹⁰ as well as in drinking and smoking behaviors³² and sexual experience¹⁸ among Japanese adolescents. On the other hand, there were significant deteriorations in several health-risk behaviors, such as persistent feelings of sadness, suicidal ideation,

Table 2 Prevalence and trends in health-risk behaviors among boys, 2002-2021

	2002		2005		2008		2012		2016		2021		2021-2002		2016-2002		2021-2016		
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	Prevalence difference	P for trend*	Prevalence difference	P for trend*	Prevalence difference	P for trend*	
Behaviors that contribute to injuries																			
Rarely or never wore a motorcycle helmet	13.2	(1.5)	12.3	(1.7)	8.8	(1.3)	7.7	(1.4)	8.1	(1.4)	4.5	(1.1)	-8.6	<0.001	-5.1	0.008	-3.5	0.064	
Rarely or never wore a seatbelt	45.6	(1.4)	35.6	(1.5)	26.7	(1.2)	26.9	(1.2)	27.3	(1.2)	25.6	(1.2)	-20.1	<0.001	-18.3	<0.001	-1.7	0.235	
Rode with a driver who had been drinking alcohol	11.2	(0.9)	9.7	(0.9)	4.2	(0.5)	2.9	(0.5)	1.9	(0.4)	1.4	(0.3)	-9.8	<0.001	-9.2	<0.001	-0.5	0.280	
Carried a weapon	3.7	(0.5)	6.3	(0.8)	6.3	(0.7)	4.3	(0.5)	6.6	(0.6)	3.3	(0.5)	-0.5	0.378	2.8	0.060	-3.3	<0.001	
Were in a physical fight	5.6	(0.7)	7.7	(0.8)	6.1	(0.6)	4.7	(0.6)	3.9	(0.5)	2.2	(0.4)	-3.4	<0.001	-1.7	0.001	-1.7	0.008	
Felt sad or hopeless	7.3	(0.7)	7.0	(0.8)	6.8	(0.7)	6.4	(0.7)	7.8	(0.7)	5.4	(0.6)	-1.9	0.192	0.6	0.660	-2.5	0.010	
Seriously considered attempting suicide	5.3	(0.6)	4.6	(0.6)	6.1	(0.6)	4.3	(0.5)	5.8	(0.6)	4.5	(0.6)	-0.8	0.594	0.5	0.713	-1.3	0.122	
Cigarette use																			
Ever tried cigarette smoking	52.9	(1.4)	41.0	(1.5)	35.0	(1.3)	25.7	(1.2)	19.0	(1.0)	9.6	(0.8)	-43.3	<0.001	-33.9	<0.001	-9.4	<0.001	
Smoked a whole cigarette before age 13 years	14.1	(1.0)	12.6	(1.0)	8.9	(0.8)	7.2	(0.7)	3.7	(0.5)	2.3	(0.4)	-11.9	<0.001	-10.4	<0.001	-1.4	0.025	
Current cigarette use	24.9	(1.2)	17.4	(1.2)	11.5	(0.9)	7.3	(0.7)	4.4	(0.5)	2.5	(0.4)	-22.4	<0.001	-20.4	<0.001	-2.0	0.004	
Current frequent cigarette use	18.6	(1.1)	12.1	(1.0)	8.4	(0.7)	5.2	(0.6)	2.7	(0.4)	1.4	(0.3)	-17.2	<0.001	-15.8	<0.001	-1.3	0.011	
Smoked >10 cigarettes/day	5.6	(0.7)	5.1	(0.7)	3.7	(0.5)	2.0	(0.4)	0.8	(0.2)	0.5	(0.2)	-5.1	<0.001	-4.7	<0.001	-0.4	0.192	
Tried to quit smoking cigarettes	76.7	(2.5)	72.5	(3.5)	68.6	(3.7)	73.5	(4.4)	60.3	(6.2)	66.7	(8.6)	-10.1	0.081	-16.4	0.058	6.3	0.526	
Alcohol and drug use																			
Ever drank alcohol	71.6	(1.3)	59.5	(1.5)	40.9	(1.3)	29.0	(1.2)	21.0	(1.1)	12.1	(0.9)	-59.5	<0.001	-50.6	<0.001	-8.9	<0.001	
Drank alcohol before age 13 years	17.2	(1.1)	18.4	(1.2)	12.2	(0.9)	8.2	(0.7)	5.6	(0.6)	2.7	(0.5)	-14.5	<0.001	-11.6	<0.001	-2.8	<0.001	
Current alcohol use	39.7	(1.4)	33.8	(1.5)	20.6	(1.1)	13.8	(0.9)	9.8	(0.8)	4.9	(0.6)	-34.7	<0.001	-29.9	<0.001	-4.8	<0.001	
Episodic heavy drinking	19.7	(1.1)	14.8	(1.1)	10.2	(0.8)	6.1	(0.6)	3.1	(0.5)	1.6	(0.4)	-18.0	<0.001	-16.6	<0.001	-1.4	0.012	
Offered, sold, or given an illegal drug by someone	1.3	(0.3)	3.0	(0.5)	2.8	(0.4)	2.2	(0.4)	2.0	(0.4)	0.5	(0.2)	-0.9	0.006	0.7	0.802	-1.6	<0.001	
Sexual behaviors																			
Ever had sexual intercourse	18.9	(1.1)	17.0	(1.2)	15.5	(1.0)	12.7	(0.9)	11.3	(0.8)	7.5	(0.7)	-11.4	<0.001	-7.5	<0.001	-3.8	<0.001	
Had first sexual intercourse before age 13 years	0.3	(0.1)	1.2	(0.3)	0.5	(0.2)	1.1	(0.3)	0.6	(0.2)	0.5	(0.2)	0.2	0.701	0.3	0.637	-0.1	0.692	
Had sexual intercourse with ≥ 4 persons during their life	15.2	(2.4)	16.2	(2.8)	11.8	(2.3)	16.8	(2.9)	15.4	(3.1)	14.8	(3.8)	-0.4	0.991	0.2	0.858	-0.7	0.790	
Used alcohol or drugs before last sexual intercourse	15.2	(2.4)	14.8	(2.7)	14.7	(2.5)	7.5	(2.1)	8.9	(2.4)	6.7	(2.6)	-8.6	0.003	-6.3	0.014	-2.2	0.441	
Used a condom during last sexual intercourse	63.0	(3.3)	82.5	(2.9)	75.4	(3.0)	75.8	(3.4)	81.9	(3.2)	77.5	(4.4)	14.5	0.010	18.9	0.002	-4.4	0.366	
Dietary behaviors																			
Described themselves as slightly or very overweight	32.5	(1.3)	29.0	(1.4)	30.3	(1.2)	26.3	(1.2)	27.1	(1.2)	29.3	(1.3)	-3.2	0.108	-5.4	0.003	2.2	0.158	
Went without eating for ≥ 24 hours to lose weight or to keep from gaining weight	1.5	(0.3)	2.4	(0.5)	2.3	(0.4)	2.4	(0.4)	2.6	(0.4)	2.2	(0.4)	0.7	0.225	1.1	0.080	-0.4	0.476	
Took diet pills, powders, or liquids to lose weight or to keep from gaining weight	0.5	(0.2)	1.0	(0.3)	0.6	(0.2)	0.9	(0.2)	0.4	(0.2)	0.4	(0.2)	-0.1	0.319	-0.1	0.688	0.0	0.946	
Vomited or took laxatives to lose weight or to keep from gaining weight	0.6	(0.2)	0.8	(0.3)	0.7	(0.2)	1.0	(0.3)	0.4	(0.2)	0.2	(0.1)	-0.4	0.074	-0.2	0.771	-0.3	0.234	
Ate fruits daily	11.3	(0.9)	15.5	(1.1)	12.1	(0.9)	10.5	(0.8)	10.3	(0.8)	10.8	(0.9)	-0.5	0.020	-1.0	0.020	0.5	0.624	
Ate vegetables daily	62.0	(1.4)	60.2	(1.5)	61.1	(1.3)	65.9	(1.3)	66.5	(1.2)	67.4	(1.3)	5.4	<0.001	4.5	0.001	0.9	0.537	
Physical activity†																			
Were physically active for 60 minutes/day on ≥ 5 days	43.0	(1.3)	43.0	(1.3)	43.4	(1.3)	43.4	(1.3)	43.4	(1.3)	39.2	(1.4)	-3.8	0.037	0.4	0.865	-4.2	0.027	
Watched TV ≥ 3 hours/day	37.5	(1.3)	37.5	(1.3)	37.5	(1.3)	22.8	(1.1)	17.5	(1.0)	9.5	(0.8)	-28.0	<0.001	-20.1	<0.001	-8.0	<0.001	
Played video games or used a computer ≥ 3 hours/day	11.2	(0.8)	11.2	(0.8)	11.2	(0.8)	13.0	(0.9)	22.2	(1.1)	40.5	(1.4)	29.2	<0.001	11.0	<0.001	18.3	<0.001	

* Adjusted for grade, school type, and region.

† Variables introduced in 2008.

Improving trend

No change

Worsening trend

Statistically significant trend is indicated in red.

Table 3 Prevalence and trends in health-risk behaviors among girls, 2002-2021

	2002		2005		2008		2012		2016		2021		2021-2002		2016-2002		2021-2016		
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	Prevalence difference*	P for trend†	Prevalence difference	P for trend†	Prevalence difference	P for trend†	
Behaviors that contribute to injuries																			
Rarely or never wore a motorcycle helmet	21.8	(2.2)	11.9	(2.0)	9.4	(1.7)	6.4	(1.5)	6.4	(1.4)	6.1	(1.6)	-15.7	<0.001	-15.5	<0.001	-0.3	0.769	
Rarely or never wore a seatbelt	42.3	(1.4)	32.0	(1.2)	23.1	(1.1)	23.8	(1.1)	24.0	(1.1)	22.0	(1.2)	-20.3	<0.001	-18.3	<0.001	-2.1	0.106	
Rode with a driver who had been drinking alcohol	14.9	(1.0)	10.8	(0.8)	4.8	(0.6)	2.6	(0.4)	2.2	(0.4)	1.2	(0.3)	-13.6	<0.001	-12.6	<0.001	-1.0	0.088	
Carried a weapon	3.8	(0.5)	3.6	(0.5)	5.5	(0.6)	3.9	(0.5)	3.3	(0.5)	3.2	(0.5)	-0.6	0.139	-0.5	0.463	-0.1	0.986	
Were in a physical fight	4.0	(0.5)	3.6	(0.5)	4.0	(0.5)	3.3	(0.5)	3.3	(0.5)	2.9	(0.5)	-1.0	0.111	-0.7	0.375	-0.3	0.592	
Felt sad or hopeless	10.1	(0.8)	9.5	(0.8)	9.4	(0.8)	8.7	(0.7)	9.4	(0.7)	13.7	(1.0)	3.6	0.003	-0.6	0.597	4.2	<0.001	
Seriously considered attempting suicide	9.9	(0.8)	9.3	(0.8)	11.2	(0.8)	9.5	(0.7)	9.8	(0.8)	13.2	(0.9)	3.3	0.010	-0.1	0.934	3.4	0.003	
Cigarette use																			
Ever tried cigarette smoking	32.9	(1.3)	23.6	(1.1)	21.6	(1.1)	12.2	(0.8)	8.6	(0.7)	3.8	(0.5)	-29.1	<0.001	-24.3	<0.001	-4.9	<0.001	
Smoked a whole cigarette before age 13 years	8.8	(0.8)	7.1	(0.7)	4.4	(0.5)	2.4	(0.4)	1.5	(0.3)	0.6	(0.2)	-8.2	<0.001	-7.3	<0.001	-0.9	0.051	
Current cigarette use	10.5	(0.8)	5.4	(0.6)	6.1	(0.6)	2.7	(0.4)	1.7	(0.3)	0.8	(0.2)	-9.8	<0.001	-8.8	<0.001	-1.0	0.063	
Current frequent cigarette use	5.6	(0.6)	2.9	(0.4)	3.3	(0.5)	1.5	(0.3)	1.0	(0.2)	0.4	(0.2)	-5.3	<0.001	-4.7	<0.001	-0.6	0.140	
Smoked >10 cigarettes/day	2.0	(0.4)	0.6	(0.2)	0.9	(0.3)	0.3	(0.1)	0.3	(0.1)	0.0	(0.0)	-2.0	<0.001	-1.7	<0.001	-0.3	0.988	
Tried to quit smoking cigarettes	71.9	(4.0)	82.4	(4.4)	74.7	(4.9)	80.5	(6.2)	70.4	(8.8)	90.0	(9.5)	18.1	0.340	-1.5	0.680	19.6	0.259	
Alcohol and drug use																			
Ever drank alcohol	70.8	(1.3)	60.6	(1.3)	43.0	(1.3)	25.4	(1.1)	19.1	(1.0)	9.5	(0.8)	-61.3	<0.001	-51.6	<0.001	-9.7	<0.001	
Drank alcohol before age 13 years	14.0	(1.0)	15.8	(1.0)	10.8	(0.8)	6.7	(0.6)	3.9	(0.5)	1.6	(0.3)	-12.4	<0.001	-10.1	<0.001	-2.4	<0.001	
Current alcohol use	41.8	(1.4)	32.3	(1.3)	20.5	(1.1)	12.6	(0.8)	8.6	(0.7)	4.5	(0.6)	-37.2	<0.001	-33.1	<0.001	-4.1	0.001	
Episodic heavy drinking	16.4	(1.0)	11.0	(0.8)	6.7	(0.7)	3.5	(0.5)	2.4	(0.4)	0.9	(0.3)	-15.5	<0.001	-14.0	<0.001	-1.5	0.017	
Offered, sold, or given an illegal drug by someone	1.9	(0.4)	2.0	(0.4)	3.3	(0.5)	1.0	(0.2)	1.2	(0.3)	0.3	(0.2)	-1.5	<0.001	-0.6	0.015	-0.9	0.016	
Sexual behaviors																			
Ever had sexual intercourse	27.8	(1.3)	24.0	(1.1)	21.2	(1.1)	14.4	(0.9)	13.4	(0.9)	8.6	(0.8)	-19.2	<0.001	-14.4	<0.001	-4.8	0.004	
Had first sexual intercourse before age 13 years	0.4	(0.2)	1.1	(0.3)	0.6	(0.2)	0.3	(0.1)	0.2	(0.1)	0.2	(0.1)	-0.2	0.014	-0.2	0.027	0.0	0.833	
Had sexual intercourse with ≥ 4 persons during their life	17.9	(2.1)	14.0	(1.9)	12.1	(2.0)	14.1	(2.4)	16.6	(2.8)	10.8	(3.1)	-7.1	0.176	-1.3	0.465	-5.8	0.163	
Used alcohol or drugs before last sexual intercourse	19.0	(2.1)	13.1	(1.9)	14.5	(2.1)	11.5	(2.2)	9.3	(2.1)	6.6	(2.4)	-12.4	<0.001	-9.7	0.002	-2.7	0.478	
Used a condom during last sexual intercourse	58.4	(2.6)	73.5	(2.4)	75.2	(2.6)	63.3	(3.3)	71.0	(3.3)	70.1	(4.4)	11.7	0.048	12.6	0.041	-0.9	0.964	
Dietary behaviors																			
Described themselves as slightly or very overweight	69.9	(1.3)	67.0	(1.3)	62.2	(1.3)	61.0	(1.2)	58.6	(1.3)	53.3	(1.4)	-16.6	<0.001	-11.2	<0.001	-5.4	0.011	
Went without eating for ≥ 24 hours to lose weight or to keep from gaining weight	3.5	(0.5)	3.2	(0.5)	4.7	(0.6)	4.0	(0.5)	5.1	(0.6)	5.4	(0.6)	1.8	0.001	1.6	0.017	0.2	0.557	
Took diet pills, powders, or liquids to lose weight or to keep from gaining weight	5.1	(0.6)	1.9	(0.4)	3.1	(0.5)	1.9	(0.3)	1.8	(0.3)	2.0	(0.4)	-3.1	<0.001	-3.3	<0.001	0.2	0.368	
Vomited or took laxatives to lose weight or to keep from gaining weight	5.9	(0.7)	2.4	(0.4)	3.9	(0.5)	3.4	(0.5)	2.5	(0.4)	3.3	(0.5)	-2.6	0.006	-3.4	<0.001	0.8	0.105	
Ate fruits daily	13.8	(1.0)	13.0	(0.9)	13.7	(0.9)	12.9	(0.8)	11.4	(0.8)	13.7	(1.0)	0.0	0.310	-2.3	0.070	2.3	0.146	
Ate vegetables daily	64.1	(1.3)	61.6	(1.3)	64.4	(1.3)	69.7	(1.2)	67.3	(1.2)	73.0	(1.2)	9.0	<0.001	3.3	<0.001	5.7	0.012	
Physical activity†																			
Were physically active for 60 minutes/day on ≥ 5 days					24.1	(1.1)	21.1	(1.0)	24.7	(1.1)	22.9	(1.2)	-1.2	0.630	0.7	0.336	-1.8	0.012	
Watched TV ≥ 3 hours/day					39.2	(1.3)	25.5	(1.1)	21.6	(1.0)	10.7	(0.9)	-28.4	<0.001	-17.6	<0.001	-10.9	<0.001	
Played video games or used a computer ≥ 3 hours/day					7.9	(0.7)	11.2	(0.8)	15.2	(0.9)	24.3	(1.2)	16.4	<0.001	7.4	<0.001	9.0	<0.001	

* Adjusted for grade, school type, and region.

† Variables introduced in 2008.

Improving trend

No change

Worsening trend

Statistically significant trend is indicated in red.

and fasting in girls, fruit consumption and physical activity in boys, and video game/computer use among both sexes over time.

Our study described the prevalence trends by using a repeated cross-sectional study, which limited causal inferences. However, we speculated that the overall declining trends in many risk behaviors over the 20-year period may be attributed to several factors. First, the trends may reflect a decline in the propensity to engage in multiple risk behaviors among adolescents. Borodovsky et al.⁹⁾ showed that multiple risk behaviors among American adolescents formed a single latent factor and that the mean value of the latent factor declined over time. As adolescent risk behaviors tend to cluster³³⁾, the reduction in each risk behavior may also be linked to decreases in other risk behaviors due to the reduction in the latent risk behavior factor.

Second, societal factors, including policies and programs targeting specific risk behaviors and societal changes such as economic conditions, social environments, and social media influences, may influence the changes in adolescent risk behaviors⁸⁾. During the study period, Japan enacted several new laws and policies, amended several laws and policies relevant to health-risk behaviors, and renewed educational programs and curricula. For example, the Road Traffic Law was revised several times to include stricter penalties for risky driving, cell-phone use while driving, drinking, and noncompliance with seatbelt use in the back seat. These changes and the related enlightenments and crackdowns may have influenced the decrease in traffic risk behaviors in adolescents. Likewise, stricter penalties for selling alcoholic beverages to minors, strengthening of age confirmation by the retailers selling tobacco and alcoholic beverages, the installation of age verification cigarette-vending machines using IC cards, increased tobacco and alcohol prices, and passive smoking prevention provided in the Health Promotion Act may have contributed to the downward trends in smoking and drinking behaviors. The enforcement of the Basic Act on Food and Nutrition Education and the implementation of food and nutrition education in schools may have also affected dietary behaviors, such as vegetable consumption and weight loss behaviors. In addition, the Japanese government has announced national health promotion policies, Health Japan 21 in 2000 and Health Japan 21 (the second term) in 2013, targeted at improving lifestyles, such as dietary behaviors, physical activity, rest, drinking, smoking, and oral health³⁴⁾. The implementation of these policies may have contributed to comprehensively improving multiple

risk behaviors. In 2002, these programs and curricula added acquired immunodeficiency syndrome/sexually transmitted diseases as a type of infectious disease and the effectiveness of condom use for prevention to the learning contents of “Health” in the course of study in junior high school. Revised reference materials for school-based smoking, drinking, and drug abuse prevention instructions were applied from 2010 to 2012. After that, these learning objectives may have been established in high school students and led to improved sexual behaviors and decreased substance use. Regarding societal changes, economic recessions have been noted to increase suicide and psychological distress through unemployment, unstable income, and reduced public spending while reducing smoking, drinking, and fruit consumption due to people having less income³⁵⁻³⁷⁾. For adolescents, recessions have largely influenced restricting tobacco and alcohol purchases because they had less spending money, especially those from low-income families³⁸⁾. Japan has experienced economic downturns due to the global financial crisis in 2008, the Great East Japan Earthquake in 2011, increased consumption taxes in 2019, and the COVID-19 pandemic in 2020. Thus, those impacts may have contributed to decreases in adolescent smoking, drinking, and fruit consumption. Although during the recessions, physical activity among adults was likely to increase due to an increase in leisure time by unemployment³⁶⁾, the adolescents in our study may have spent much more time using video games/computers instead of engaging in physical activity. Meanwhile, with the rapid development of social media in recent years, the use of electronic devices, including personal computers and mobile devices, has increased, while TV watching has decreased³⁹⁾. In addition, increased social media use and decreased face-to-face interaction with peers were associated with decreases in adolescent substance use⁴⁰⁾. Changes in the social environment, such as a decrease in smoking and drinking by adults around adolescents, including fathers and older brothers, and an increase in the number of those without friends, may have influenced the decrease in adolescent smoking and drinking⁴¹⁾⁴²⁾. As alcohol consumption tends to be associated with violence, the decrease in adolescent drinking may have led to a decrease in violence, such as physical fighting¹⁴⁾. These previous findings support our results. In particular, carrying a weapon and physical fighting among boys decreased during the pandemic.

For dietary behaviors, the trends for each of the weight loss behaviors among girls were inconsistent, with an increasing trend in fasting despite decreasing trends

in taking diet pills and vomiting. The YRBS showed that fasting and vomiting did not change between 1999 and 2013, while taking diet pills decreased⁴³), and their findings were only consistent with the trend in taking diet pills in this study. The recent economic downturn may have led to an increase in fasting, which is less costly than taking diet pills, which have a financial cost. Similarly, our results showed an increase in vegetable consumption and a decrease in fruit consumption among boys. The YRBS also reported no change in fruit and vegetable consumption between 2009 and 2019⁴⁴). However, the reasons for these discrepancies in trends are not clear.

This study also found that, during the COVID-19 pandemic, physical activity and video game/computer use in both sexes and persistent sad feelings and suicidal ideation in girls worsened significantly, despite no changes or small changes in those behaviors during the prepandemic period. Thus, the deteriorations in these behaviors can probably be associated with the disruptions caused by the COVID-19 pandemic. These findings are also in line with those from previous studies. A systematic review on global changes in child and adolescent physical activity during the COVID-19 pandemic found a considerable reduction in physical activity levels during the pandemic compared to the levels prior to the pandemic²⁴). Along with physical activity reduction, a meta-analysis reported a 52% increase in screen time during the pandemic among adolescents worldwide, with a marked increase in time spent on handheld devices and personal computers²⁵). Decreased physical activity and increased screen time may be attributed to restriction measures implemented during the pandemic, such as lockdowns and school closures²³⁻²⁵). Although Japan's schools reopened and activities reflected the "new normal" during the 2021 survey period, these behaviors may have been continuously affected by social distancing and voluntary limitation of activities. Regarding mental health, a meta-analysis suggested that the global prevalence of depression and anxiety among youth during COVID-19 was twice as high as the prepandemic prevalence and was higher in girls²²). A longitudinal study in Japanese youth also found that sex was associated with changes in psychological distress during the pandemic, indicating a significant increase among girls only⁴⁵). Meanwhile, Japanese youth, especially girls, showed an unusual increase in suicide during the pandemic²⁷)⁴⁶). Kikuchi et al.⁴⁶) reported that the number of suicides among Japanese women during the pandemic significantly exceeded the expected number based on

prepandemic data, with the highest excess suicide risk for female students due to school-related problems. These findings suggest that girls were strongly affected mentally by the disruption during the COVID-19 pandemic, and our results concur with these previous studies. In contrast, boys' persistent feelings of sadness decreased during the pandemic, which is consistent with the findings of a Korean adolescent study⁴⁷). They speculated that temporary relief from school-related stress due to school closure may have had a positive impact on mental health⁴⁷). In our study, boys may have been less likely to perceive a school-related burden during the pandemic.

The strength of this study is that it shows the trends in the prevalence of comprehensive health-risk behaviors among Japanese adolescents over a 20-year period, including the COVID-19 era, using data from prefecture-wide large-scale surveys. Nevertheless, this study had several limitations. First, as mentioned above, this was a descriptive study that can only speculate on the causes and explanations for changes in adolescent risk behaviors over time. Second, as the study participants were from public high schools in the Okinawa Prefecture, the generalizability of the findings to adolescents in Japan as a whole may be limited. Additionally, this study did not include those who were absent on the day of survey administration. Student dropout and absenteeism have been found to be associated with an increased likelihood of engaging in health-risk behaviors⁴⁸)⁴⁹). According to a Japanese government survey, the high school dropout rate in Okinawa Prefecture in the survey period ranged from 1.9% to 2.9% and did not change significantly⁵⁰), so it is unlikely that the improved trend in risk behaviors observed in this study was overestimated.

V. Conclusions

Multiple health-risk behaviors among Japanese adolescents in Okinawa Prefecture improved between 2002 and 2021. On the other hand, persistent sad feelings, suicidal ideation and fasting in girls, fruit consumption and physical activity in boys, and video game/computer use among both sexes have worsened over time. In particular, during the COVID-19 pandemic, physical activity and video game/computer use in both sexes and persistent sad feelings and suicidal ideation in girls worsened significantly.

Acknowledgments

The authors would like to thank all students and teachers who agreed to participate in this study.

This research was supported by Grants-in-Aid for Scientific Research (JSPS KAKENHI Grant Number JP12670365, JP16300222, JP19500579, JP23300246, JP15H03087, and JP20K10473) from the Japan Ministry of Education, Culture, Sports, Science and Technology and the Advanced Medical Research Support Project of University of the Ryukyus. The authors declare that they have no competing interests.

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- Takakura M, et al. The relative association of collective efficacy in school and neighborhood contexts with adolescent alcohol use. *Journal of Epidemiology* 29:384-390, 2019

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- Japanese Association of School Health
- Japanese Society of Health Education and Promotion
- Japan Epidemiological Association

Appendix 1 Criteria for dichotomizing health risk behaviors

Behaviors	Criteria
Behaviors that contribute to injuries	
Rarely or never wore a motorcycle helmet	Among students who had ridden a motorcycle during the 12 months preceding the survey
Rarely or never wore a seatbelt	When riding in a car driven by someone else
Rode with a driver who had been drinking alcohol	One or more times during the 30 days preceding the survey
Carried a weapon	On ≥ 1 of the 30 days preceding the survey
Were in a physical fight	One or more times during the 12 months preceding the survey
Felt sad or hopeless almost every day for two weeks or more in a row	During the 12 months preceding the survey
Seriously considered attempting suicide	During the 12 months preceding the survey
Cigarette use	
Lifetime cigarette use	Ever tried cigarette smoking, even one or two puffs
Smoked a whole cigarette before age 13 years	
Current cigarette use	Smoked cigarettes on ≥ 1 of the 30 days preceding the survey
Current frequent cigarette use	Smoked cigarettes on ≥ 20 of the 30 days preceding the survey
Smoked more than 10 cigarettes per day	On the days they smoked during the 30 days preceding the survey
Tried to quit smoking cigarettes	During the 12 months preceding the survey
Alcohol and drug use	
Lifetime alcohol use	Had at least one drink of alcohol on ≥ 1 day during their life
Drank alcohol before age 13 years	
Current alcohol use	Had at least one drink of alcohol on ≥ 1 of the 30 days preceding the survey
Episodic heavy drinking	Had ≥ 5 drinks of alcohol in a row on ≥ 1 of the 30 days preceding the survey
Offered, sold, or given an illegal drug by someone	During the 12 months preceding the survey
Sexual behaviors	
Ever had sexual intercourse	
Had first sexual intercourse before age 13 years	
Had sexual intercourse with ≥ 4 persons during their life	Among students who had sexual intercourse
Alcohol or drug use before last sexual intercourse	Among students who had sexual intercourse
Condom use during last sexual intercourse	Among students who had sexual intercourse
Dietary behaviors	
Described themselves as slightly or very overweight	
Went without eating for ≥ 24 hours to lose weight or to keep from gaining weight	During the 30 days preceding the survey
Took diet pills, powders, or liquids to lose weight or to keep from gaining weight	During the 30 days preceding the survey
Vomited or took laxatives to lose weight or to keep from gaining weight	During the 30 days preceding the survey
Ate fruits	Every days during the 7 days preceding the survey
Ate vegetables	Every days during the 7 days preceding the survey
Physical activity	
Were physically active for 60 minutes/day on ≥ 5 days	During the 7 days preceding the survey
Watched TV ≥ 3 hours/day	On an average school day
Played video games or used a computer ≥ 3 hours/day	On an average school day

Appendix 2 The detailed result of the trend analyses using logistic regression models during three periods (boys)

	2002-2021					2002-2016					2016-2021				
	B	SE	P	OR	(95%CI)	B	SE	P	OR	(95%CI)	B	SE	P	OR	(95%CI)
Behaviors that contribute to injuries															
Rarely or never wore a motorcycle helmet	-0.049	0.012	<0.001	0.95	(0.93, 0.98)	-0.042	0.016	0.008	0.96	(0.93, 0.99)	-0.123	0.066	0.064	0.88	(0.78, 1.01)
Rarely or never wore a seatbelt	-0.041	0.004	<0.001	0.96	(0.95, 0.97)	-0.055	0.006	<0.001	0.95	(0.94, 0.96)	-0.021	0.018	0.235	0.98	(0.95, 1.01)
Rode with a driver who had been drinking alcohol	-0.135	0.011	<0.001	0.87	(0.86, 0.89)	-0.147	0.013	<0.001	0.86	(0.84, 0.89)	-0.066	0.061	0.280	0.94	(0.83, 1.06)
Carried a weapon	-0.007	0.008	0.378	0.99	(0.98, 1.01)	0.021	0.011	0.060	1.02	(0.999, 1.04)	-0.150	0.038	<0.001	0.86	(0.80, 0.93)
Were in a physical fight	-0.051	0.009	<0.001	0.95	(0.93, 0.97)	-0.036	0.011	0.001	0.96	(0.94, 0.99)	-0.125	0.047	0.008	0.88	(0.81, 0.97)
Felt sad or hopeless	-0.009	0.007	0.192	0.99	(0.98, 1.005)	0.004	0.010	0.660	1.00	(0.99, 1.02)	-0.082	0.032	0.010	0.92	(0.87, 0.98)
Seriously considered attempting suicide	-0.004	0.008	0.594	1.00	(0.98, 1.01)	0.004	0.011	0.713	1.00	(0.98, 1.03)	-0.054	0.035	0.122	0.95	(0.88, 1.01)
Cigarette use															
Ever tried cigarette smoking	-0.118	0.005	<0.001	0.89	(0.88, 0.90)	-0.112	0.006	<0.001	0.89	(0.88, 0.90)	-0.163	0.023	<0.001	0.85	(0.81, 0.89)
Smoked a whole cigarette before age 13 years	-0.103	0.008	<0.001	0.90	(0.89, 0.92)	-0.098	0.009	<0.001	0.91	(0.89, 0.92)	-0.105	0.047	0.025	0.90	(0.82, 0.99)
Current cigarette use	-0.143	0.007	<0.001	0.87	(0.85, 0.88)	-0.146	0.009	<0.001	0.86	(0.85, 0.88)	-0.130	0.045	0.004	0.88	(0.80, 0.96)
Current frequent cigarette use	-0.150	0.009	<0.001	0.86	(0.85, 0.88)	-0.151	0.010	<0.001	0.86	(0.84, 0.88)	-0.148	0.058	0.011	0.86	(0.77, 0.97)
Smoked >10 cigarettes/day	-0.137	0.014	<0.001	0.87	(0.85, 0.90)	-0.132	0.016	<0.001	0.88	(0.85, 0.90)	-0.132	0.101	0.192	0.88	(0.72, 1.07)
Tried to quit smoking cigarettes	-0.027	0.015	0.081	0.97	(0.94, 1.003)	-0.035	0.018	0.058	0.97	(0.93, 1.001)	0.061	0.096	0.526	1.06	(0.88, 1.28)
Alcohol and drug use															
Ever drank alcohol	-0.159	0.005	<0.001	0.85	(0.85, 0.86)	-0.169	0.006	<0.001	0.84	(0.83, 0.85)	-0.135	0.022	<0.001	0.87	(0.84, 0.91)
Drank alcohol before age 13 years	-0.104	0.007	<0.001	0.90	(0.89, 0.91)	-0.096	0.008	<0.001	0.91	(0.89, 0.92)	-0.150	0.041	<0.001	0.86	(0.79, 0.93)
Current alcohol use	-0.141	0.006	<0.001	0.87	(0.86, 0.88)	-0.143	0.007	<0.001	0.87	(0.86, 0.88)	-0.153	0.032	<0.001	0.86	(0.81, 0.91)
Episodic heavy drinking	-0.142	0.008	<0.001	0.87	(0.85, 0.88)	-0.141	0.010	<0.001	0.87	(0.85, 0.89)	-0.137	0.054	0.012	0.87	(0.78, 0.97)
Offered, sold, or given an illegal drug by someone	-0.037	0.013	0.006	0.96	(0.94, 0.99)	0.004	0.017	0.802	1.00	(0.97, 1.04)	-0.297	0.090	<0.001	0.74	(0.62, 0.89)
Sexual behaviors															
Ever had sexual intercourse	-0.056	0.006	<0.001	0.95	(0.93, 0.96)	-0.049	0.007	<0.001	0.95	(0.94, 0.97)	-0.096	0.028	<0.001	0.91	(0.86, 0.96)
Had first sexual intercourse before age 13 years	-0.009	0.022	0.701	0.99	(0.95, 1.04)	0.014	0.030	0.637	1.01	(0.96, 1.08)	-0.043	0.108	0.692	0.96	(0.77, 1.18)
Had sexual intercourse with ≥ 4 persons during their life	0.000	0.015	0.991	1.00	(0.97, 1.03)	0.004	0.020	0.858	1.00	(0.97, 1.04)	-0.021	0.078	0.790	0.98	(0.84, 1.14)
Used alcohol or drugs before last sexual intercourse	-0.054	0.018	0.003	0.95	(0.91, 0.98)	-0.054	0.022	0.014	0.95	(0.91, 0.99)	-0.081	0.105	0.441	0.92	(0.75, 1.13)
Used a condom during last sexual intercourse	0.034	0.013	0.010	1.03	(1.01, 1.06)	0.052	0.017	0.002	1.05	(1.02, 1.09)	-0.062	0.068	0.366	0.94	(0.82, 1.07)
Dietary behaviors															
Described themselves as slightly or very overweight	-0.006	0.004	0.108	0.99	(0.99, 1.001)	-0.017	0.006	0.003	0.98	(0.97, 0.999)	0.024	0.017	0.158	1.02	(0.99, 1.06)
Went without eating for ≥ 24 hours to lose weight or to keep from gaining weight	0.015	0.012	0.225	1.01	(0.99, 1.04)	0.030	0.017	0.080	1.03	(0.996, 1.07)	-0.036	0.051	0.476	0.96	(0.87, 1.07)
Took diet pills, powders, or liquids to lose weight or to keep from gaining weight	-0.024	0.024	0.319	0.98	(0.93, 1.02)	-0.013	0.031	0.688	0.99	(0.93, 1.05)	-0.008	0.122	0.946	0.99	(0.78, 1.26)
Vomited or took laxatives to lose weight or to keep from gaining weight	-0.043	0.024	0.074	0.96	(0.91, 1.004)	-0.009	0.030	0.771	0.99	(0.93, 1.05)	-0.195	0.164	0.234	0.82	(0.60, 1.13)
Ate fruits daily	-0.013	0.006	0.020	0.99	(0.98, 0.998)	-0.018	0.008	0.020	0.98	(0.97, 0.997)	0.012	0.025	0.624	1.01	(0.96, 1.06)
Ate vegetables daily	0.016	0.004	<0.001	1.02	(1.01, 1.02)	0.017	0.005	<0.001	1.02	(1.01, 1.03)	0.010	0.016	0.537	1.01	(0.98, 1.04)
Physical activity*															
Were physically active for 60 minutes/day on ≥ 5 days	-0.013	0.006	0.037	0.99	(0.98, 0.999)	0.002	0.010	0.865	1.00	(0.98, 1.02)	-0.036	0.016	0.027	0.96	(0.93, 0.996)
Watched TV ≥ 3 hours/day	-0.132	0.008	<0.001	0.88	(0.86, 0.89)	-0.135	0.011	<0.001	0.87	(0.85, 0.89)	-0.144	0.024	<0.001	0.87	(0.83, 0.91)
Played video games or used a computer ≥ 3 hours/day	0.145	0.008	<0.001	1.16	(1.14, 1.17)	0.110	0.014	<0.001	1.12	(1.09, 1.15)	0.177	0.017	<0.001	1.19	(1.15, 1.23)

B the regression coefficient, SE standard error, OR adjusted for grade, school type, and region, CI confidence interval

* Variables introduced in 2008.

Appendix 3 The detailed result of the trend analyses using logistic regression models during three periods (girls)

	2002-2021					2002-2016					2016-2021				
	B	SE	P	OR	(95%CI)	B	SE	P	OR	(95%CI)	B	SE	P	OR	(95%CI)
Behaviors that contribute to injuries															
Rarely or never wore a motorcycle helmet	-0.092	0.014	<0.001	0.91	(0.89, 0.94)	-0.114	0.018	<0.001	0.89	(0.86, 0.93)	-0.022	0.076	0.769	0.98	(0.84, 1.14)
Rarely or never wore a seatbelt	-0.046	0.004	<0.001	0.95	(0.95, 0.96)	-0.059	0.005	<0.001	0.94	(0.93, 0.95)	-0.029	0.018	0.106	0.97	(0.94, 1.01)
Rode with a driver who had been drinking alcohol	-0.160	0.010	<0.001	0.85	(0.84, 0.87)	-0.171	0.012	<0.001	0.84	(0.82, 0.86)	-0.105	0.062	0.088	0.90	(0.80, 1.02)
Carried a weapon	-0.013	0.009	0.139	0.99	(0.97, 1.004)	-0.009	0.012	0.463	0.99	(0.97, 1.02)	0.001	0.043	0.986	1.00	(0.92, 1.09)
Were in a physical fight	-0.015	0.009	0.111	0.99	(0.97, 1.003)	-0.011	0.013	0.375	0.99	(0.96, 1.01)	-0.024	0.044	0.592	0.98	(0.90, 1.06)
Felt sad or hopeless	0.017	0.006	0.003	1.02	(1.01, 1.03)	-0.004	0.008	0.597	1.00	(0.98, 1.01)	0.089	0.024	<0.001	1.09	(1.04, 1.15)
Seriously considered attempting suicide	0.015	0.006	0.010	1.01	(1.004, 1.03)	-0.001	0.008	0.934	1.00	(0.98, 1.02)	0.072	0.024	0.003	1.07	(1.03, 1.13)
Cigarette use															
Ever tried cigarette smoking	-0.123	0.006	<0.001	0.88	(0.87, 0.89)	-0.118	0.007	<0.001	0.89	(0.88, 0.90)	-0.161	0.035	<0.001	0.85	(0.80, 0.91)
Smoked a whole cigarette before age 13 years	-0.140	0.011	<0.001	0.87	(0.85, 0.89)	-0.137	0.013	<0.001	0.87	(0.85, 0.90)	-0.162	0.083	0.051	0.85	(0.72, 1.001)
Current cigarette use	-0.133	0.011	<0.001	0.88	(0.86, 0.89)	-0.131	0.013	<0.001	0.88	(0.86, 0.90)	-0.140	0.075	0.063	0.87	(0.75, 1.01)
Current frequent cigarette use	-0.129	0.015	<0.001	0.88	(0.85, 0.90)	-0.125	0.017	<0.001	0.88	(0.85, 0.91)	-0.154	0.104	0.140	0.86	(0.70, 1.05)
Smoked >10 cigarettes/day	-0.166	0.031	<0.001	0.85	(0.80, 0.90)	-0.151	0.033	<0.001	0.86	(0.81, 0.92)	-3.059	207.5	0.988	0.05	-
Tried to quit smoking cigarettes	0.025	0.026	0.340	1.03	(0.97, 1.08)	0.012	0.029	0.680	1.01	(0.96, 1.07)	0.271	0.240	0.259	1.31	(0.82, 2.10)
Alcohol and drug use															
Ever drank alcohol	-0.176	0.005	<0.001	0.84	(0.83, 0.85)	-0.184	0.006	<0.001	0.83	(0.82, 0.84)	-0.145	0.024	<0.001	0.87	(0.83, 0.91)
Drank alcohol before age 13 years	-0.114	0.007	<0.001	0.89	(0.88, 0.91)	-0.102	0.009	<0.001	0.90	(0.89, 0.92)	-0.173	0.053	<0.001	0.84	(0.76, 0.93)
Current alcohol use	-0.152	0.006	<0.001	0.86	(0.85, 0.87)	-0.158	0.007	<0.001	0.85	(0.84, 0.87)	-0.108	0.033	0.001	0.90	(0.84, 0.96)
Episodic heavy drinking	-0.159	0.010	<0.001	0.85	(0.84, 0.87)	-0.160	0.011	<0.001	0.85	(0.83, 0.87)	-0.161	0.068	0.017	0.85	(0.75, 0.97)
Offered, sold, or given an illegal drug by someone	-0.069	0.015	<0.001	0.93	(0.91, 0.96)	-0.044	0.018	0.015	0.96	(0.92, 0.99)	-0.267	0.111	0.016	0.77	(0.62, 0.95)
Sexual behaviors															
Ever had sexual intercourse	-0.074	0.005	<0.001	0.93	(0.92, 0.94)	-0.075	0.006	<0.001	0.93	(0.92, 0.94)	-0.074	0.026	0.004	0.93	(0.88, 0.98)
Had first sexual intercourse before age 13 years	-0.071	0.029	0.014	0.93	(0.88, 0.99)	-0.082	0.037	0.027	0.92	(0.86, 0.99)	0.035	0.164	0.833	1.04	(0.75, 1.43)
Had sexual intercourse with ≥ 4 persons during their life	-0.018	0.013	0.176	0.98	(0.96, 1.01)	-0.012	0.017	0.465	0.99	(0.96, 1.02)	-0.106	0.076	0.163	0.90	(0.77, 1.04)
Used alcohol or drugs before last sexual intercourse	-0.056	0.015	<0.001	0.95	(0.92, 0.97)	-0.054	0.017	0.002	0.95	(0.92, 0.98)	-0.066	0.094	0.478	0.94	(0.78, 1.12)
Used a condom during last sexual intercourse	0.020	0.010	0.048	1.02	(1.00, 1.04)	0.026	0.013	0.041	1.03	(1.001, 1.05)	-0.002	0.054	0.964	1.00	(0.90, 1.11)
Dietary behaviors															
Described themselves as slightly or very overweight	-0.034	0.004	<0.001	0.97	(0.96, 0.97)	-0.034	0.005	<0.001	0.97	(0.96, 0.98)	-0.039	0.015	0.011	0.96	(0.93, 0.99)
Went without eating for ≥ 24 hours to lose weight or to keep from gaining weight	0.028	0.008	0.001	1.03	(1.01, 1.05)	0.028	0.012	0.017	1.03	(1.01, 1.05)	0.020	0.034	0.557	1.02	(0.95, 1.09)
Took diet pills, powders, or liquids to lose weight or to keep from gaining weight	-0.049	0.012	<0.001	0.95	(0.93, 0.97)	-0.071	0.015	<0.001	0.93	(0.90, 0.96)	0.050	0.056	0.368	1.05	(0.94, 1.17)
Vomited or took laxatives to lose weight or to keep from gaining weight	-0.027	0.010	0.006	0.97	(0.96, 0.99)	-0.047	0.013	<0.001	0.95	(0.93, 0.98)	0.074	0.045	0.105	1.08	(0.98, 1.18)
Ate fruits daily	-0.005	0.005	0.310	0.99	(0.98, 1.005)	-0.013	0.007	0.070	0.99	(0.97, 1.001)	0.033	0.023	0.146	1.03	(0.99, 1.08)
Ate vegetables daily	0.022	0.004	<0.001	1.02	(1.01, 1.03)	0.019	0.005	<0.001	1.02	(1.01, 1.03)	0.042	0.017	0.012	1.04	(1.01, 1.08)
Physical activity*															
Were physically active for 60 minutes/day on ≥ 5 days	-0.003	0.007	0.630	1.00	(0.98, 1.01)	0.011	0.011	0.336	1.01	(0.99, 1.03)	-0.047	0.019	0.012	0.95	(0.92, 0.99)
Watched TV ≥ 3 hours/day	-0.121	0.007	<0.001	0.89	(0.87, 0.90)	-0.111	0.011	<0.001	0.89	(0.88, 0.91)	-0.157	0.022	<0.001	0.85	(0.82, 0.89)
Played video games or used a computer ≥ 3 hours/day	0.106	0.008	<0.001	1.11	(1.09, 1.13)	0.090	0.015	<0.001	1.09	(1.06, 1.13)	0.128	0.020	<0.001	1.14	(1.09, 1.18)

B the regression coefficient, SE standard error, OR adjusted for grade, school type, and region, CI confidence interval

* Variables introduced in 2008.