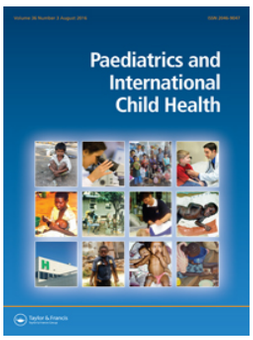

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Original Research Paper

Are active and passive smoking associated with cardiometabolic risk factors in adolescents? The CASPIAN-III Study

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Background: Smoking is an important risky behavior in adolescents worldwide. Active and passive smoking have adverse health effects at public and individual levels.
Objective: This study aimed to evaluate the association of active and passive smoking with cardiometabolic risk factors in a national sample of Iranian adolescents.
Methods: Participants consisted of 5625 students, aged 10–18 years, studied in the third survey of a national school-based surveillance system. Participants were classified into three groups based on smoking pattern: active smoker, passive smoker, and exposure to smoke (active or passive or both of them). Considering the Adult Treatment Panel III criteria modified for the paediatric age group, metabolic syndrome (MetS) was defined as the co-existence of three out of five components of abdominal obesity, elevated blood pressure, elevated fasting plasma glucose, high serum triglycerides, and depressed high-density cholesterol (HDL-C) levels.
Results: The mean (SD) age of participants was 14.7 (2.4) years. Mean level of HDL-C was significantly lower in all types of smoking compared to non-smokers. Low HDL-C and MetS had significant association with active smoking (OR 2.10, 95% CI 1.33–3.31 and OR 5.24, 95% CI 2.41–11.37), passive smoking (OR 1.19, 95% CI 1.01–1.43 and OR 1.79, 95% CI 1.09–2.96), and smoking exposure (OR 1.20, 95% CI 1.01–1.43 and OR 2.02, 95% CI 1.22–3.31), respectively.
Conclusion: This study confirms that both smoking and exposure to smoke are associated with an increased risk of MetS and some of the cardiometabolic risk factors in adolescents. Preventive measures against passive smoking should be considered as a health priority in the paediatric age groups.

Keywords: Smoking, Cardiometabolic risk factors, Adolescents

Introduction

The prevalence of cardiometabolic risk factors has increased in adolescents,[1] and are mainly linked to the adverse consequences of a sedentary lifestyle and the obesity epidemic.[1] The natural history of chronic diseases and underlying metabolic disorders starts in the first years of life, continues in adolescence and becomes symptomatic in adulthood. In recent years, it has become a considerable health priority.[2]

Smoking usually begins in adolescence and continues into adulthood, and the earlier it begins, the more difficult it is to stop.[3] Exposure to environmental tobacco smoke is also associated with various

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adverse health effects such as adolescent obesity[4] and cardiometabolic disturbances such as metabolic syndrome (MetS).[5,6] Passive smoking can affect endothelial function and increase the risk of atherosclerotic cardiovascular diseases (CVDs).[7,8] Moreover, smoking is associated with other risky behaviour and might increase the morbidity and mortality of various chronic diseases.[9–11]

MetS is defined as a pattern of metabolic disturbances including obesity, hyperglycaemia, hypertriglyceridaemia, depressed high-density lipoprotein cholesterol (HDL-C) and elevated blood pressure (BP); it dramatically increases the risk of chronic diseases including CVDs.[12] Abdominal obesity and MetS are more prevalent in Asians than in other ethnic groups,[13] and have become an important health problem in children in developing countries.[14] Nationwide studies of Iranian adolescents have documented prevalence rates of about 10% for MetS.[15,16] Given the impact of MetS in early life on the development of early stages of chronic diseases,[17] special attention has been focused on studying the modifiable determinants of MetS in the paediatric age group.

Most previous studies have evaluated the association of dietary habits and physical activity with MetS, but there have been few studies of the effects of smoking in this regard. This study aimed to assess the relationship of active and passive smoking with cardiometabolic risk factors in adolescents.

Subjects and Methods

This research is a part of the third national Iranian study (2009–2010) [Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN-III)] to determine the association between smoking and cardiometabolic risk factors. The methodology has been described fully elsewhere[18] and here is briefly outlined, as follows.

The study was conducted among school pupils aged 10–18 years living in urban and rural areas of 27 provinces in Iran. Eligible schools were stratified according to Ministry of Education data and then selected randomly. The pupils were also randomly selected.

A group of expert health-care professionals was responsible for assessing and monitoring the performance of the research teams and for calibrating equipment according to predefined standards in the study protocol. Quality control and assurance were carefully managed by the national Data and Safety Monitoring Board.

The students' questionnaire was written in Persian and was based the World Health Organization's Global School-based Student Health Survey (WHO-GSHS).[19] Another questionnaire was developed for parents. The latter consisted of questions regarding the pupils' birthweight, feeding history in infancy, family history of chronic diseases (hypertension, dyslipidaemia, diabetes, cancer and morbid obesity), parental education and occupation, ownership of a family car and type of home (rented or owned).

Physical examination

Trained health professionals measured height, weight and waist circumference by standard protocols using calibrated instruments.[18] Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured as the first and fifth Korotkoff sounds using standardized mercury sphygmomanometers on the right arm twice after 5 minutes of rest in a sitting position; the mean of the two measurements was recorded as the participant's blood pressure.[18]

Clinical and laboratory measurements

Blood samples were gathered from all participants after 12 hours overnight fasting. Fasting blood glucose (FBG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were measured enzymatically by auto-analyzers. HDL-C was determined after dextran sulfate-magnesium chloride precipitation of non-HDL-C.[20] Low-density lipoprotein cholesterol (LDL-C) was calculated in serum samples with TG $\leq$10.36 mmol/L according to the Friedewald equation.[21]

Definition of terms

According to the Adult Treatment Panel III (ATP-III) criteria modified for children and adolescents, participants were diagnosed with MetS if they had at least three of the five following criteria: abdominal obesity, elevated BP (either SBP or DBP $\geq$90th per centile for age, gender and height), low HDL-C ($<$1.29 mmol/L except in 15–19-year-old boys in whom the cut-off was $<$1.17 mmol/L), elevated TG ($\geq$2.59 mmol/L) and high FBG ($\geq$5.56 mmol/L). General obesity and elevated total and LDL cholesterol were also considered to be cardiometabolic risk factors. General obesity was considered to be age- and gender-specific BMI $>$95th per centile, and abdominal obesity was a waist-to-height ratio (WHtR) $>$0.5. Elevated LDL-C and total cholesterol were defined as $>$2.85 mmol/L and $\geq$5.18 mmol/L, respectively.[21,22]

Smoking status

Smoking habits were self-reported by participants and categorized into active, passive and exposure to smoke. A person who claimed to smoke at least one cigarette a day (i.e. seven a week) at the time of the study was considered to be an active smoker. Those who reported living with a smoker/s were considered to be passive smokers. Smoking exposure was defined as being an active or passive smoker, or both.

Statistical analyses

Quantitative and categorical variables are expressed as mean (SD) and percentages, respectively. These variables were compared across different types of smoking using Student's *t*-test and the Pearson χ^2 test. Multiple logistic regressions were used to calculate the adjusted odds ratios (OR) and 95% confidence intervals (CIs) for the associations between types of smoking and cardiometabolic risk factors. Initial models were crude (without adjustment), age and gender were adjusted in the second model, and the third model was additionally adjusted for other characteristics including socio-economic status, parental education, family history of chronic disease and sedentary lifestyle and, in the last model (Model IV), BMI was additionally adjusted for all risk factors except overweight and obesity. Data were analyzed using STATA 2011 software (Stata Statistical Software, Release 12, College Station, TX). $P<0.05$ was statistically significant.

Ethics

Participation in the survey was voluntary. The participants were enrolled for the survey after the study's objectives and protocols had been explained and after obtaining oral consent from the pupils and written consent from their parents. The study was approved by the research ethics committee of the Endocrine and Metabolism Research Center (EMRC) of Tehran University of Medical Sciences and the ethics boards of Isfahan University of Medical Sciences. All questionnaires and checklists were completed anonymously.

Results

In this survey, 5528 of 5625 invited pupils completed the study. The mean (SD) age was 14.7 (2.4) years, and there were 50.68% boys, 70.1% of them from an urban area. Table 1 presents the pupils' characteristics and anthropometric measurements according to the different types of smoking (passive, active and active or passive). The mean of the continuous variables including height, weight, waist circumference, age and BMI were significantly higher in the active smokers than in the non- active smokers ($P<0.001$). Mother's occupation was significantly associated with active smoking. A family history of chronic disease and lower socio-economic status was found more often in adolescents who were passive smokers than in those who were not ($P<0.05$).

Mean HDL-C varied significantly between smoking categories, mean LDL-C was higher in smokers than in non-smokers, and mean TG was significantly higher in active smokers than in non-smokers (Table 2).

Table 3 shows the frequency of the various cardiometabolic risk factors according to types of smoking. Low HDL-C and MetS were significantly more frequent for all types of smoking than in non-smokers. LDL-C and TG were significantly higher in active smokers and in the smoke-exposed group. Abdominal obesity was more frequent in the active smoking group, and overweight was more frequent in the passive smoking and smoking exposure groups.

The associations of different categories of smoking status with cardiometabolic risk factors and MetS were studied by applying different models in logistic regression analysis. First, a crude model was applied without any adjustment. Model II was adjusted for age and gender. In Model III, additional adjustment was made for other variables including socio-economic status, parental education, family history of chronic diseases and sedentary lifestyle. In Model IV, additional adjustment was made for BMI for all risk factors except overweight and obesity (Web Appendix 1). The OR (95% CI) for cardiometabolic risk factors demonstrates that, in crude analysis, all types of smoking (active, passive and smoking exposure) were significantly associated with general obesity, low HDL-C and MetS.

In addition, the risk of raised LDL-C was significantly increased in the active smoking group (OR 2.33, 95% CI 1.15–4.70) and in the smoking exposure group (OR 1.36, 95% CI 1.01–1.84) in Model II, which was adjusted for age and gender. Moreover, in model III, passive smoking significantly increased the risk of overweight and general obesity (OR 1.57, 95% CI 1.214–2.039 and OR 1.39, 95% CI 1.14–1.69, respectively). A similar increase was seen in the smoking exposure group (OR 1.55, 95% CI 1.20–2.01 and OR 1.36, 95% CI 1.12–1.66, respectively). In Model IV, the risk of low HDL-C and MetS was significantly increased for all types of smoking.

Discussion

To the best of our knowledge, this is the first nationwide study in the Middle East and North Africa (MENA) region that has examined the association between smoking exposure and cardiometabolic risk factors in adolescents. The findings demonstrate that all types of smoking exposure increase the risk of low HDL-C and MetS. In line with some previous studies,[1,16,23,24] smoking was also associated with elevated LDL-C.

Exposure to tobacco smoke induces oxidative stress. In the presence of oxidative stress and free radicals owing to active smoking, LDL-C is converted into oxidized LDL which causes severe damage of vessel walls.[13] Moreover, exposure to tobacco smoke accelerates the rise of total serum cholesterol, reduces HDL-C and increases platelet aggregation, all of which are major CVD risk factors.[25]

Table 1 Participants' demographic characteristics and cardiometabolic risk factors according to smoking status

	Smoking status								
	Passive smoking			Active smoking			Smoking exposure†		
	No	Yes	*P*	No	Yes	*P*	No	Yes	*P*
Age, y	14.7 (2.4)	14.7 (2.5)	0.7	15.8 (1.8)	16.5 (1.7)	<0.001	14.7 (2.4)	14.8 (2.5)	0.1
Weight, kg	47.2 (15.1)	47.1 (14.9)	0.6	52.0 (13.8)	58.4 (15.4)	<0.001	47.0 (14.9)	47.5 (15.1)	0.2
Height, cm	154.5 (14.0)	153.5 (13.8)	0.01	159.7 (11.4)	163.9 (10.4)	<0.001	154.3 (14.0)	154.0 (13.9)	0.5
WC, cm	69.0 (24.2)	68.3 (11.8)	0.2	70.9 (22.9)	74.3 (11.7)	0.03	68.9 (24.4)	68.5 (11.9)	0.4
WHtR	0.4 (0.2)	0.4 (0.1)	0.5	0.4 (0.1)	0.5 (0.1)	0.3	0.4 (0.2)	0.4 (0.1)	0.5
BMI, kg/m^2	19.4 (4.1)	19.5 (4.1)	0.1	20.1 (4.0)	21.5 (4.4)	<0.001	19.3 (4.1)	19.6 (4.1)	0.01
Family history of (%):									
Diabetes	1000 (34.6)	548 (41.1)	<0.001	791 (33.2)	51 (31.5)	0.6	977 (34.5)	571 (40.9)	<0.001
Obesity	1054 (38.2)	569 (43.8)	0.001	871 (38.4)	61 (38.4)	0.9	1028 (38.1)	595 (43.8)	<0.001
Dyslipidaemia	1116 (38.5)	652 (47.8)	0.006	900 (38.0)	60 (38.0)	0.9	1091 (38.5)	677 (47.4)	<0.001
Hypertension	1390 (47.1)	783 (54.6)	<0.001	1086 (45.1)	77 (47.5)	0.5	1359 (47.0)	814 (54.4)	<0.001
Osteoporosis	442 (15.5)	262 (20.9)	<0.001	334 (14.0)	26 (15.6)	0.5	430 (15.4)	274 (20.7)	<0.001
Socio-economic status (%):									
Home-owner	2850 (82.5)	1462 (76.2)	<0.001	2219 (82.2)	145 (78.0)	0.1	2795 (82.5)	1517 (76.3)	<0.001
Rented home	605 (17.5)	457 (23.8)		41 (22.0)	480 (17.8)		470 (23.7)	592 (17.5)	
Has car	1778(50.5)	935 (48.2)	0.09	1350 (49.4)	106 (55.2)	0.1	1740 (50.4)	973 (48.4)	0.1
Father's education (%):									
>6 y	1453 (41.4)	838 (43.2)	<0.001	1208 (44.3)	79 (41.1)	0.7	1415 (41.1)	876 (43.5)	<0.001
6–9 y	818 (23.3)	512 (26.4)		651 (23.9)	52 (27.1)		523 (26.0)	807 (23.5)	
9–12 y	855 (24.4)	456 (23.5)		628 (23.0)	43 (22.4)		842 (24.5)	469 (23.3)	
>12 y	385 (11.0)	135 (7.0)		241 (8.8)	18 (9.4)		376 (10.9)	144 (7.2)	
Mother's education (%):									
<6 y	1102 (56.2)	1902 (53.7)	0.06	102 (54.0)	1582 (57.4)	0.2	1855 (53.4)	1149 (56.5)	0.04
6–9 y	728 (20.5)	400 (20.4)		575 (20.9)	351 (8.5)		718 (20.7)	410 (20.2)	
9–12 y	723 (20.4)	381(19.4)		489 (17.8)	402 (1.2)		712 (20.5)	392 (19.3)	
>12 y	191 (5.4)	78 (4.0)		108 (3.9)	12 (6.3)		187 (5.4)	82 (4.0)	
Mother's occupation (%):									
Housewife	3214 (90.7)	1788 (91.4)	0.1	2529 (92.0)	166 (86.5)	0.01	1853 (91.4)	3149 (90.7)	0.1
Worker/labourer	39 (1.1)	29 (1.5)		22 (0.8)	52 (0.6)		37 (1.1)	31 (1.5)	
Employed/office work	222 (6.3)	96 (4.9)		131 (4.8)	16 (8.3)		217 (6.3)	101 (5.0)	
Agricultural	6 (0.2)	5 (0.3)		9 (0.3)	0		6 (0.2)	5 (0.2)	
Other	61 (1.7)	38 (1.9)		57 (2.1)	5 (2.6)		61 (1.8)	38 (1.9)	
Father's occupation (%):									
Unemployed	122 (6.4)	220 (6.3)	<0.001	175 (6.5)	13 (7.1)	0.1	215 (6.3)	127 (6.4)	<0.001
Worker/labourer	724 (20.8)	466 (24.4)		577 (21.4)	35 (19.2)		715 (21.0)	475 (24.1)	
Employed/office work	867 (25.0)	378 (19.8)		626 (23.3)	33 (18.1)		854 (25.1)	391 (19.8)	
Agricultural	428 (12.3)	214 (11.2)		372 (13.8)	22 (12.1)		418 (12.3)	224 (11.4)	
Self-employed	1235 (35.5)	726 (38.1)		941 (35.0)	79 (43.4)		1206 (35.4)	755 (38.3)	

BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; data are mean (SD); † smoking exposure: active smoker or passive smoker or both of them.

Table 2 Comparison of participants' mean (SD) blood pressure, lipid profile and serum glucose level according to smoking status

	Smoking status								
	Passive smoking			Active smoking			Smoking exposure*		
	No	Yes	*P*	No	Yes	*P*	No	Yes	*P*
SBP, mmHg	103.2 (13.9)	103.1 (13.9)	0.8	104.88 (13.6)	106.5 (12.4)	0.1	103.1 (13.9)	103.3 (13.9)	0.6
DBP, mmHg	65.8 (10.8)	65.9 (10.9)	0.8	66.75 (10.7)	67.6 (10.1)	0.3	65.8 (10.8)	66.0 (10.9)	0.5
TC, mg/dl	147.9 (31.6)	149.1 (32.0)	0.2	147.52 (31.9)	150.2 (33.6)	0.2	147.9 (31.6)	149.1 (31.9)	0.2
HDL-C, mg/dl	47.1 (14.7)	44.4 (13.6)	<0.001	46.61 (13.9)	41.3 (12.2)	<0.001	47.2 (14.7)	44.4 (13.5)	<0.001
LDL-C, mg/dl	83.3 (26.9)	85.3 (28.4)	0.04	82.17 (26.2)	83.3 (30.9)	0.6	83.1 (26.9)	85.5 (28.4)	0.01
TG, mg/dl	91.9 (39.9)	93.8 (42.5)	0.1	93.30 (40.5)	101.8 (51.8)	0.01	91.9 (39.7)	93.9 (42.8)	0.1
FBS, mg/dl	87.6 (11.9)	87.8 (16.9)	0.6	88.60 (15.1)	90.2 (13.6)	0.1	87.6 (11.9)	87.7 (16.8)	0.7

$P<0.05$=significance. HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; TC, total cholesterol; FBS, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; * smoking exposure, active, passive or both.

Table 3 Frequency of adolescents' cardiometabolic risk factors according to smoking status

	Smoking status								
	Passive, *n* (%)			Active, *n* (%)			Exposure*, *n* (%)		
	No	Yes	*P*	No	Yes	*P*	No	Yes	*P*
Overweight	270 (7.5)	181 (9.0)	0.03	228 (8.1)	21 (10.2)	0.2	264 (7.4)	187 (9.0)	0.03
General obesity	315 (8.7)	186 (9.3)	0.4	235 (8.3)	25 (12.1)	0.06	308 (8.7)	193 (9.3)	0.4
Abdominal obesity	554 (15.3)	332 (16.6)	0.2	427 (15.2)	46 (22.3)	0.006	537 (15.2)	349 (16.8)	0.1
Elevated LDL-C	113 (5.4)	77 (6.6)	0.1	74 (4.5)	10 (8.8)	0.03	108 (5.2)	82 (6.8)	0.05
Elevated TC	164 (5.5)	105 (6.2)	0.2	129 (5.5)	14 (8.4)	0.1	160 (5.4)	109 (6.2)	0.2
Elevated TG	221 (7.5)	146 (8.9)	0.07	177 (7.6)	23 (13.9)	0.004	215 (7.4)	152 (9.0)	0.05
Low HDL-C	838 (32.8)	557 (39.3)	<0.001	655 (32.8)	66 (45.2)	0.002	817 (32.6)	578 (39.5)	<0.001
Elevated FBG	430 (14.8)	257 (16.3)	0.1	369 (16.2)	33 (21.2)	0.1	428 (15.0)	259 (15.9)	0.4
Elevated BP	182 (5.6)	118 (6.5)	0.1	177 (7.1)	19 (9.8)	0.1	175 (5.5)	125 (6.6)	0.09
MetS (+)	75 (3.3)	66 (5.3)	0.005	73 (4.2)	24 (18.0)	<0.001	70 (3.2)	71 (5.5)	0.001
No. of MetS components:									
0	1026 (45.7)	497 (40.0)	<0.001	760 (44.1)	48 (36.1)	<0.001	1010 (45.9)	513 (40.0)	<0.001
1	865 (38.6)	510 (41.1)		670 (38.9)	48 (36.1)		850 (38.6)	525 (41.0)	
2	277 (12.3)	168 (13.5)		221 (12.8)	13 (9.8)		272 (12.4)	173 (13.5)	
3	70 (3.1)	50 (4.0)		67 (3.9)	11 (8.3)		66 (3.0)	54 (4.2)	
4	5 (0.2)	15 (1.2)		6 (0.3)	12 (9.0)		4 (0.2)	16 (1.2)	
5	1 (0.1)	0		0	1 (0.8)		0	1 (0.1)	

$P<0.05$=significance. HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, triglycerides; TC, total cholesterol; FBG, fasting blood glucose; BP, blood pressure; MetS: metabolic syndrome.
Cardiometabolic risk factors were defined according to the Adult Treatment Panel III criteria modified for children and adolescents, as follows: overweight, body mass index BMI age- and sex-specific 85–95th percentile; general obesity, BMI higher than age- and sex-specific 95th percentile; abdominal obesity, waist–to-height ratio >0.5; low HDL-C, <50 mg/dl (except in 15–19-year-old boys in whom the cut-off was <45 mg/dl); elevated LDL-C, >110 mg/dl; elevated TG, ≥100 mg/dl; elevated TC, >200 mg/dl; elevated FBG, >100 mg/dl; elevated BP, >95th (adjusted for age, sex and height). * Exposure, active, passive or both.

The long-term adverse health effects of childhood exposure to tobacco smoke have been documented.[26–29] Moreover; there is some evidence of an independent association of smoking in pregnancy with lower HDL-C and arterial wall thickness in adulthood.[27–30]

This study's findings are consistent with other epidemiological studies which have demonstrated that active[28,30] and passive smoking[2,9,21,25,31] might increase the risk of CVD in adults. They are also in line with studies which showed that passive smoking might increase the relative risk of CVD, but to a lesser extent than active smoking does. It is suggested that the increased risk of CVD associated with passive smoking might be owing to the confounding effects of lifestyle and diet.[32,33] Passive smokers consume high-fat diets with low amounts of vegetables and fruits and take lesser anti-oxidant vitamin supplements than their non-smoker counterparts do.[34,35] The finding of a previous large study revealed an association between passive smoking and MetS in adolescents.[36]

Based on these results, significant associations exist between smoking and cardio-metabolic risk factors in adolescents. The results of a large cohort of youth, demonstrated that current users of tobacco products were more likely to have high TG levels, as one the MetS components.[36]

There are some limitations to the study. Its cross-sectional design does not allow assessment of a causal relationship between smoking status and cardiometabolic risk factors. Longitudinal studies are necessary to clarify this relationship and its clinical significance. The association between smoking exposure and cardiometabolic markers may be confounded, at least partly, by residual confounding by ecological and lifestyle factors which were not considered in this study. Moreover, self-reported data were used without measuring any biochemical factors. The classification of smoking status was defined as a binary variable (active, passive and smoking exposure) because our questionnaire did not include the duration of exposure to smoking, and this limited the statistical analyses. Although the sample size was large, there were not enough pupils in the various groups to compare smoke exposure as 'none', 'active only', 'passive only', 'passive' and 'active', and it was therefore not possible to distinguish the independent effects of active and passive smoking on cardiometabolic risk factors.

The strengths of the study were its novelty in the adolescent age group, its nationwide coverage, which included a representative sample size, the population-based approach of the survey, the use of standard protocols and a validated questionnaire,[37,38] and adjustment of the statistical analyses for the main confounding factors.

The study confirms that smoking and exposure to smoke are associated with an increased risk of MetS and some cardiometabolic risk factors in adolescents. Many children and adolescents are

regularly exposed to smoke in the home or wider environment. To address this public health concern, widespread public health warnings and reinforcement of anti-tobacco regulations must be considered for public places, workplaces and in the home.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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Web Appendix 1. Association between smoking status and cardiometabolic risk factors in different models of logistic regression analysis: the CASPIAN-III Study

	Smoking status					
	Active smoking		Passive smoking		Smoking exposure**	
Cardiometabolic risk factors	OR	CI	OR	CI	OR	CI
Overweight:						
Model I†	1.28	0.80–2.06	1.23	1.01–1.50*	1.22	1.01–1.49*
Model II‡	1.33	0.81–2.18	1.21	0.98–1.48	1.21	0.99–1.48
Model III§	1.73	0.93–3.22	1.57	1.21–2.03*	1.55	1.20–2.01*
General obesity:						
Model I†	1.46	1.03–2.05*	1.16	1.01–1.34*	1.16	1.008–1.34*
Model II‡	1.39	0.96–2.02	1.15	0.99–1.33	1.14	0.98–1.32
Model III§	1.35	0.81–2.25	1.39	1.14–1.69*	1.36	1.12–1.66*
Abdominal obesity:						
Model I†	1.6	1.13–2.26*	1.1	0.94–1.27	1.13	0.97–1.30
Model II‡	1.46	1.02–2.11*	1.13	0.97–1.32	1.14	0.98–1.32
Model III§	1.29	0.79–2.12	1.14	0.93–1.39	1.18	0.96–1.44
Model IV††	1.09	0.58–2.06	0.98	0.75–1.27	1.04	0.81–1.36
Elevated LDL-C:						
Model I†	2.05	1.02–4.09*	1.25	0.92–1.68	1.33	0.99–1.79
Model II‡	2.33	1.15–4.70*	1.27	0.94–1.71	1.36	1.01–1.84*
Model III§	1.81	0.67–4.84	1.15	0.78–1.70	1.29	0.88–1.88
Model IV††	1.8	0.67–4.81	1.15	0.78–1.70	1.29	0.88–1.89
Elevated TC:						
Model I†	1.57	0.88–2.80	1.14	0.89–1.47	1.15	0.90–1.48
Model II‡	1.79	0.99–3.24	1.15	0.89–1.49	1.17	0.91–1.52
Model III§	1.42	0.65–3.09	1.1	0.80–1.50	1.16	0.85–1.57
Model IV††	1.38	0.63–3.01	1.09	0.79–1.48	1.14	0.84–1.56
Elevated TG:						
Model I†	1.95	1.22–3.11*	1.21	0.97–1.51	1.23	0.99–1.53
Model II‡	1.86	1.12–3.08*	1.24	0.99–1.55	1.24	0.99–1.55
Model III§	1.87	0.99–3.51	1.2	0.90–1.61	1.25	0.94–1.66
Model IV††	1.73	0.89–3.35	1.16	0.86–1.55	1.2	0.89–1.61
Low HDL-C:						
Model I†	1.68	1.20–2.37*	1.32	1.16–1.52*	1.34	1.18–1.54*
Model II‡	1.68	1.17–2.42*	1.37	1.19–1.58*	1.37	1.19–1.57*
Model III§	2.15	1.36–3.38*	1.2	1.01–1.43*	1.21	1.01–1.44*
Model IV††	2.1	1.33–3.31*	1.19	1.003–1.42*	1.2	1.01–1.43*
High FBG:						
Model I†	1.38	0.93–2.07	1.12	0.94–1.32	1.07	0.90–1.26
Model II‡	1.26	0.83–1.91	1.17	0.98–1.39	1.1	0.93–1.31
Model III§	1.11	0.66–1.86	1.28	1.04–1.58*	1.19	0.97–1.46
Model IV††	1.11	0.66–1.87	1.28	1.04–1.58*	1.19	0.97–1.46
Elevated BP:						
Model I†	1.42	0.86–2.34	1.17	0.92–1.49	1.22	0.96–1.54
Model II‡	0.92	0.53–1.60	1.24	0.97–1.59	1.2	0.94–1.54
Model III§	0.97	0.48–1.95	1.17	0.86–1.59	1.14	0.84–1.55
Model IV††	0.87	0.42–1.79	1.13	0.83–1.55	1.11	0.81–1.52
MetS (+):						
Model I†	4.98	3.02–8.21*	1.62	1.15–2.27*	1.78	1.27–2.50*
Model II‡	4.25	2.52–7.16*	1.69	1.20–2.40*	1.75	1.24–2.48*
Model III§	4.4	2.22–8.72*	1.59	1.00–2.52*	1.78	1.13–2.82*
Model IV††	5.24	2.41–11.37*	1.79	1.09–2.96*	2.017	1.22–3.31*

OR, odds ratio; CI, confidence interval; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, triglycerides; TC, total cholesterol; FBG, fasting blood glucose; BP, blood pressure; MetS, metabolic syndrome; *$P<0.05$; † without adjustment (crude model); ‡ adjusted for age and sex; § additionally adjusted for other characteristics including socio-economic status, parental educations, family history of chronic diseases, sedentary lifestyle; †† additionally adjusted for BMI for all risk factors except overweight and obesity.Cardiometabolic risk factors were defined according to the Adult Treatment Panel III criteria modified for children and adolescents, as follows: overweight, body mass index BMI age- and sex-specific 85–95th percentile; general obesity, BMI higher than age- and sex-specific 95th percentile; abdominal obesity, waist–to-height ratio >0.5; low HDL-C, <50 mg/dl (except in 15–19-year-old boys in whom the cut-off was <45 mg/dl); elevated LDL-C, >110 mg/dl; elevated TG, ≥100 mg/dl; elevated TC, >200 mg/dl; elevated FBG, >100 mg/dl; elevated BP, >95th (adjusted for age, sex and height).**Smoking exposure, active, passive or both