Tobacco use and second-hand smoke exposure in young adolescents aged 12–15 years: data from 68 low-income and middle-income countries

Bo Xi, Yajun Liang, Yunxia Liu, Yinkun Yan, Min Zhao, Chuanwei Ma, Pascal Bovet

Summary

Background Tobacco use is an important risk factor for non-communicable diseases worldwide. However, the global extent and prevalence of tobacco use in adolescents is poorly described. Using previously collected survey data, we aimed to assess tobacco use and second-hand smoke exposure in young adolescents aged 12–15 years in 68 low-income and middle-income countries.

Methods We used data from the Global School-based Student Health Survey (2006–13) and the China Global Tobacco Youth Survey (2013), which are school-based surveys of young adolescents aged 12–15 years that assess health behaviours using a standardised, anonymous, self-reported questionnaire. We calculated the prevalence of current tobacco use and exposure to second-hand smoke in young adolescents from 68 low-income and middle-income countries that collected these data in the surveys. We used a multilevel model to estimate the association between parental tobacco use, second-hand smoke, and adolescent tobacco use, adjusting for sex, age, school, school class, country's purchasing power parity, smoking initiation age, national prevalence of tobacco use among adults, year the WHO FCTC was ratified for each country, proxy of socioeconomic status, and survey year.

Findings The mean prevalence of current tobacco use was 13·6%, ranging from 2·8% in Tajikistan to 44·7% in Samoa. In most countries, the prevalence of tobacco use was higher for boys than girls, and higher for adolescents aged 14–15 years than for those aged 12–13 years. The overall prevalence of second-hand smoke exposure was 55·9%, ranging from 16·4% in Tajikistan to 85·4% in Indonesia. Parental tobacco use (as reported by the young adolescents), especially maternal use, was associated with tobacco use in young adolescents (odds ratio 2·06, 95% CI 1·93–2·19, for maternal and 1·29, 1·23–1·35 for paternal use). Second-hand smoke exposure was also a risk factor for young adolescents' tobacco use (2·56, 2·43–2·69). However, the prevalence of tobacco use was not associated with a country's purchasing power parity.

Interpretation Tobacco use and second-hand smoke exposure were frequent among young adolescents aged 12–15 years in low-income and middle-income countries. Parental tobacco use and second-hand smoke exposure were strongly associated with young adolescents' tobacco use. The data emphasise the need to strengthen tobacco control interventions and programmes in young adolescents from low-income and middle-income countries.

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Introduction

Tobacco use, mainly cigarette smoking, is the leading preventable cause of premature death, with about 6 million people worldwide dying from tobacco-related diseases every year.[1] Considerable global tobacco control efforts have been made worldwide, such as the ratification of the World Health Organization Framework Convention on Tobacco Control (WHO FCTC)—a legally binding treaty that commits countries to take important control measures—by around 180 countries so far.[2,3] The prevalence of tobacco use decreased from 1980 to 2012 worldwide but the number of smokers is rising because of increasing and ageing populations.[4] More than 80% of all smokers live in low-income and middle-income countries (LMICs).[5] Therefore, tobacco use continues to be a major public health concern, especially in LMICs.[4,6,7]

About 90% of smokers begin to consume tobacco before the age of 18 years, with nearly 100 000 young people starting to smoke every day.[8] Because of the strongly addictive nature of tobacco use, smoking during adolescence tends to track into adulthood.[9] In addition to long-term consequences of tobacco use on the main non-communicable diseases, smoking at a young age also increases the risk of many diseases among adolescents including respiratory illness, asthma, and reduced pulmonary function.[10] Smoking accounted for about 5·81 million deaths in 2013, mostly in LMICs.[11]

Research in context

Evidence before this study

We searched PubMed and Scopus to identify publications on tobacco use and second-hand smoke exposure in adolescents worldwide between Jan 1, 1980, and June 15, 2016, using the keywords: ("tobacco use" OR "cigarette smoking" OR "secondhand smoke") and ("adolescents" OR "youths"), with no language restrictions. Data were reported for several countries or regions but data in young adolescents from low-income and middle-income countries were scarce.

Added value of this study

Based on data collected in 68 low-income and middle-income countries between Jan 1, 2006, and Dec 31, 2013, the prevalence of tobacco use and exposure to second-hand smoke differed largely between regions and countries. The mean prevalence of tobacco use was 13·6% (18·0% for boys and 8·9% girls) and the mean prevalence of second-hand smoke exposure was 55·9% (57·6% for boys and 54·1% for girls). The prevalence of tobacco use was strongly associated with parental tobacco use and second-hand smoke exposure but not with a country's purchasing power parity.

Implications of all the available evidence

Tobacco use and second-hand smoke exposure in young adolescents remain major public health problems in low-income and middle-income countries. Our findings emphasise the need to strengthen tobacco control policy, including programmes that target young adolescents.

Exposure to second-hand smoke among adolescents is an important issue. Second-hand smoke accounted for around 331000 deaths in 2013[11] and up to 28% of all deaths caused by second-hand smoke occur in children.[12] Using the Global Youth Tobacco Survey (GYTS) data from 1999 to 2005, Warren and colleagues[13] reported that 44·1% of young adolescents aged 13–15 years in 131 countries were exposed to second-hand smoke at home and 54·2% in public places.[13] It is important to monitor the distribution of tobacco use and second-hand smoke exposure in young adolescents to guide tobacco control interventions worldwide, including the full enforcement of all provisions requested by the WHO FCTC.[14,15]

In this study, we aimed to calculate the prevalence of tobacco use in young adolescents in 68 LMICs; the prevalence of second-hand smoke exposure in adolescents in these countries; and the association of parental tobacco use and second-hand smoke exposure with adolescent tobacco use.

Methods

Data sources

We used data on tobacco use and exposure to second-hand smoke from the Global School-based Student Health Survey (GSHS) done between Jan 1, 2006, and Dec 31, 2013, for all countries except for China, for which we used data from GYTS done in 2013. The GSHS is a school-based health survey administered to young adolescents aged 12–15 years, jointly developed by the WHO and the US Centers for Disease Control and Prevention (CDC), in collaboration with UNICEF, UNESCO, and UNAIDS. The GSHS uses the same procedure to select eligible participants in all countries—ie, a two-stage random cluster sampling of schools and classes that provides a sample representative of the general population aged 12–15 years in each country.[16] The GSHS questionnaire is made up of several modules of questions on different behaviours and protecting factors (eg, diet, HIV status, physical activity, etc), including one module on tobacco use. Although countries can choose the modules they wish to include in their GSHS, questions within a particular module cannot be altered so that findings are directly comparable between countries and over repeat surveys. Up to Dec 31, 2013, survey officers from more than 120 countries have been trained and 94 countries have completed at least one GSHS. However, because the module on the use of tobacco products was not included in the GSHS questionnaire in some countries, only 67 (71·3%) of 94 countries had data on tobacco use and second-hand smoke between Jan 1, 2006, and Dec 31, 2013. The questionnaire was translated into the local language in each country, and there was a pilot test for comprehension of participating students. We used data from the last available GSHS for countries that had done several GSHS. All GSHS surveys were approved, in each country, by both a national government administration (most often the Ministry of Health or Education) and an institutional review board or ethics committee. Verbal or written consent was also obtained from the participants and their parents.

Because GSHS data in China were last collected in 2003, we used data from the GYTS done in 2013 in China.[17] The GYTS is a school-based survey of tobacco use and associated factors among students aged 13–15 years, which is led by the CDC in collaboration with WHO. The selection of eligible students and the questions used to assess the prevalence of tobacco are similar in GYTS and in GSHS. Of note, data entry of all national datasets for all GSHS and GYTS surveys is done at the CDC using automatic optic character recognition and an electronic dataset and a factsheet of overall findings are subsequently sent back to countries. Both GYTS and GSHS are ongoing and countries are encouraged to repeat surveys at regular intervals to assess trends over time and guide policy and programme development.

	Survey year	Response rate (%)	Sample size	Boys (%)	Year WHO FCTC ratified*
Africa					
Algeria	2011	97·9%	3399	45·2%	2006
Benin	2009	99·3%	1153	66·2%	2005
Ghana	2012	97·9%	1302	48·8%	2004
Malawi	2009	97·4%	2128	51·0%	Not ratified
Mauritania	2010	95·4%	1213	52·8%	2005
Mauritius	2011	98·2%	3074	48·9%	2004
Namibia	2013	98·3%	1887	42·6%	2005
Seychelles	2007	92·8%	1063	48·4%	2003
Sudan	2012	96·4%	1346	52·4%	2005
Tanzania	2006	76·8%	1341	44·4%	Not ratified
Americas					
Anguilla	2009	96·7%	673	48·9%	Not ratified
Antigua and Barbuda	2009	97·5%	1168	51·2%	2006
Argentina	2012	97·5%	20787	47·6%	Not ratified
Bahamas	2013	97·2%	1267	47·1%	2009
Barbados	2011	97·8%	1469	51·0%	2005
Bolivia	2012	98·0%	2705	49·6%	2005
British Virgin Islands	2009	98·0%	1167	46·6%	Not ratified
Cayman	2007	94·2%	1077	50·8%	Not ratified
Chile	2013	97·4%	1306	49·3%	2005
Colombia	2007	95·7%	7619	43·5%	2008
Costa Rica	2009	99·5%	2248	49·6%	2008
Ecuador	2007	92·5%	4170	48·5%	2006
Grenada	2008	94·0%	1218	42·4%	2007
Guyana	2010	97·1%	1901	48·2%	2005
Honduras	2012	98·9%	1458	46·0%	2005
Jamaica	2010	97·6%	1167	49·1%	2005
Peru	2010	97·9%	2301	49·8%	2004
Saint Lucia	2007	97·0%	1038	44·8%	2005
Saint Vincent and the Grenadines	2007	95·6%	1132	45·6%	2010
Suriname	2009	98·8%	1030	45·3%	2008
Trinidad and Tobago	2011	97·5%	2294	49·2%	2004
Uruguay	2012	97·7%	2788	45·6%	2004
Eastern Mediterranean					
Djibouti	2007	97·2%	934	59·5%	2005
Egypt	2011	96·3%	2260	49·1%	2005
Iraq	2012	95·9%	1467	54·3%	2008
Jordan	2007	92·4%	1518	46·1%	2004
Kuwait	2011	97·6%	2236	50·8%	2006
Libya	2007	95·3%	1782	49·1%	2005
Morocco	2010	97·9%	2336	52·6%	Not ratified
Pakistan	2009	98·2%	4902	48·9%	2004
Palestine	2010	94·6%	4048	60·5%	Not ratified
Qatar	2011	86·3%	1522	45·7%	2004
Syria	2010	99·4%	2911	51·0%	2004
Tunisia	2008	95·3%	2408	48·6%	2010
United Arab Emirates	2010	97·1%	2229	39·7%	2005
Europe					
Macedonia	2007	96·0%	1476	51·3%	Not ratified
Tajikistan	2006	96·4%	7187	53·6%	2013
Southeast Asia					
Cambodia	2013	99·3%	1796	48·5%	2005
India	2007	97·4%	7107	57·3%	2004
Indonesia	2007	96·2%	2898	48·2%	Not ratified
Malaysia	2012	99·4%	16 147	49·3%	2005
Maldives	2009	95·6%	1884	47·6%	2004
Myanmar	2007	98·4%	2192	49·2%	2004
Thailand	2008	97·9%	2614	47·8%	2004
Western Pacific					
Cook	2011	98·8%	839	52·4%	2004
Fiji	2010	98·8%	1473	48·3%	2003
Kiribati	2011	97·8%	1308	45·3%	2005
Mongolia	2013	98·7%	3645	49·1%	2004
Nauru	2011	93·4%	337	46·8%	2004
Niue	2010	98·8%	81	55·7%	2005
Philippines	2011	99·0%	3796	48·2%	2005
Samoa	2011	92·1%	1983	46·0%	2005
Solomon	2011	96·7%	874	52·1%	2004
Tonga	2010	96·0%	1862	50·7%	2005
Tuvalu	2013	95·9%	647	48·5%	2005
Vanuatu	2011	98·3%	830	49·1%	2005
Vietnam	2013	99·1%	1726	46·5%	2005

All data were from adolescents aged 12–15 years. WHO FCTC=World Health Organization Framework Convention on Tobacco Control. *Data were from http://www.who.int/fctc/signatories_parties/zh/.

***Table 1*: Survey characteristics of the Global School-based Student Health Surveys according to country, 2006–13**

Definitions of tobacco use and second-hand smoke exposure

In both GYTS and GSHS, current cigarette smoking was assessed with the question: "During the past 30 days, on how many days did you smoke cigarettes?" with current smoking defined as smoking on at least 1 day during the past 30 days. Current other tobacco use was assessed with the question: "During the past

	Current use of any tobacco product			Current cigarette smoking			Current use of other tobacco product		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Total	13·6% (12·2–14·9)	18·0% (16·2–19·9)*	8·9% (8·0–9·9)	10·0% (9·0–11·1)	13·3% (11·7–14·9)*	6·0% (5·5–6·6)	8·1% (7·2–9·1)	11·4% (10·0–12·8)*	4·5% (4·0–5·0)
Africa	12·3% (7·6–17·1)	16·5% (9·3–23·8)	7·9% (4·8–11·0)	8·7% (4·7–12·7)	11·8% (5·9–17·7)	5·6% (3·1–8·1)	7·5% (5·0–9·9)	10·3% (6·3–14·4)*	4·0% (2·7–5·2)
Americas	13·2% (11·3–15·1)	16·0% (14·1–17·9)*	10·5% (8·4–12·6)	10·6% (8·6–12·6)	12·4% (10·4–14·3)*	8·7% (6·7–10·8)	6·2% (5·4–7·1)	8·5% (7·3–9·6)*	4·2% (3·5–5·0)
Eastern Mediterranean	14·0% (11·2–16·8)	20·7% (16·5–25·0)*	7·5% (5·5–9·5)	8·5% (6·6–10·4)	13·3% (9·9–16·6)*	3·8% (2·8–4·8)	9·9% (7·8–12·1)	14·6% (11·5–17·7)*	5·2% (3·8–6·6)
Europe	6·3% (0–13·4)	5·9% (1·1–10·7)	6·6% (0·0–16·1)	5·3% (0·0–14·4)	4·6% (0·0–12·1)	5·9% (0·0–16·8)	2·6% (1·9–3·3)	3·3% (2·4–4·3)*	1·7% (1·2–2·3)
Southeast Asia	8·9% (5·6–12·3)	15·3% (8·5–22·0)*	2·7% (1·9–3·5)	6·5% (3·2–9·8)	11·7% (5·8–17·6)*	1·3% (0·7–2·0)	4·6% (3·7–5·6)	7·6% (5·3–9·8)*	1·8% (1·2–2·3)
Western Pacific	17·6% (14·5–20·7)	22·2% (18·2–26·3)*	12·8% (10·0–15·6)	13·9% (11·6–16·2)	17·5% (14·3–20·6)*	10·0% (7·9–12·1)	12·2% (9·7–14·6)	15·9% (12·2–19·6)*	8·1% (6·4–9·9)

Data are prevalence (95% CI). *p<0·05 for the difference between sexes.

Table 2: **Prevalence of tobacco use in young adolescents aged 12–15 years by WHO region and sex**

30 days, on how many days did you use any other form of tobacco other than cigarettes, such as pipe, water pipe, chewing tobacco, or other smokeless tobacco?" with current other tobacco use defined as use of any other tobacco product on at least 1 day in the past 30 days. Initiation of smoking was assessed with the question "How old were you when you first tried a cigarette?". Second-hand smoke exposure was assessed with the question "During the past 7 days, on how many days have people smoked in your presence in any place?", with exposure to second-hand smoke defined as exposure to second-hand smoke on at least 1 day during the past 7 days. The status of tobacco use in parents or guardians was assessed with the question "Which of your parents or guardians use any form of tobacco?". The corresponding answers were "Neither", "My father or male guardian only", "My mother or female guardian only", "Both", "I do not know". In our study, we generated a variable to account for father's smoking and mother's smoking separately, and an interaction term.

The purchasing power parity (PPP) of a country is an indicator of gross domestic product per person adjusted for living costs and inflation. We used PPP for each country, corresponding to the survey year as reported by the World Bank for most countries and as reported by Index Mundi for the few countries for which PPP was not listed in the World Bank list. We assessed a proxy variable of socioeconomic status of the young adolescents based on the question "During the past 30 days, how often did you go hungry because there was not enough food in your home?" with the answers "Never", "Rarely", "Sometimes", "Most of the time", "Always". We extracted the prevalence of tobacco use in adults in countries included in this study from a publication by Ng and colleagues.[4] We extracted the year that the WHO FCTC was ratified by each country from the WHO website.

For more on **PPP reported by the World Bank** see http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD/countries?display=default

For the **Index Mundi** see http://www.indexmundi.com/g/r.aspx?v=67

For more on the **ratification of the WHO FCTC** see http://www.who.int/fctc/signatories_parties/zh/

Statistical analysis

All data were weighted according to the cluster sampling design of the surveys using strata and primary sampling units at the country level to allow the samples to be nationally representative. We used the Complex Samples module in SPSS version 13.0 for data analyses. Weighted prevalence or mean estimates (with corresponding 95% CIs) were calculated by country and sex. We tested differences in prevalence with the χ^2 test, and tested mean estimates between sexes or age groups with the general linear model. The total and regional prevalences of tobacco use and second-hand smoke were estimated with meta-analysis (Stata versiom 11.0) using a random-effects model as there was significant heterogeneity between countries (I^2>95%). A multilevel model was used to estimate the association between parental tobacco use, second-hand smoke, and adolescent tobacco use, adjusting for sex, age, school, school class (model 1); for all variables in model 1 plus country's PPP (model 2); and for all variables in model 2 plus smoking initiation age, national prevalence of tobacco use among adults, year the WHO FCTC was ratified for each country, proxy of socioeconomic status, and survey year (model 3). We used a further linear regressions analysis to examine the association between adolescents' tobacco use and a country's PPP. A two-sided p value less than 0·05 was deemed statistically significant.

Role of the funding source

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

Results

Table 1 shows the characteristics of the included surveys and participants from the GSHS. We included

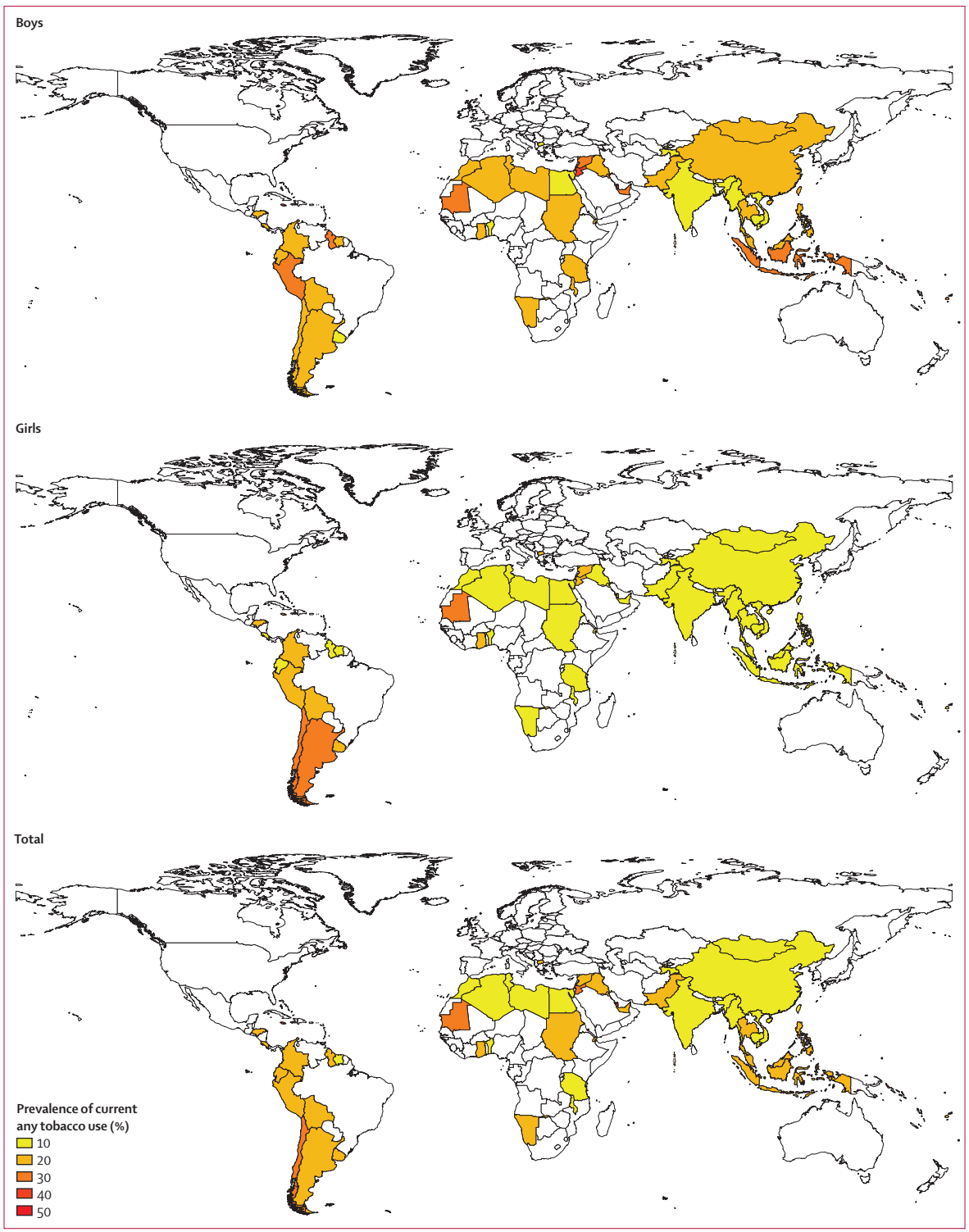

Figure 1: **Prevalence of current use of any tobacco product in young adolescents aged 12–15 years in 68 low-income and middle-income countries**
Data are from the Global School-based Student Health Survey, except for China, where data are from the China Global Tobacco Youth Survey in 2013.

67 countries from six WHO regions (ten from Africa, 22 from the Americas, 13 from eastern Mediterranean, two from Europe, six from southeast Asia, and 14 from western Pacific) with complete data on tobacco use and second-hand smoke exposure between Jan 1, 2006, and Dec 31, 2013. 173 144 young adolescents (49·6% boys)

	Total	Boys	Girls
Total	55·9% (52·7–59·1)	57·6% (54·3–60·9)	54·1% (50·7–57·6)
Africa	50·1% (42·6–57·5)	52·4% (44·9–59·9)	47·8% (39·9–55·7)
Americas	56·7% (52·9–60·5)	57·1% (54·1–60·1)	56·3% (51·5–61·1)
Eastern Mediterranean	53·7% (47·6–59·8)	56·7% (50·5–62·8)	50·6% (43·9–57·2)
Europe	42·3% (0·0–93·1)	43·1% (0·0–87·4)	41·1% (0·0–99·3)
Southeast Asia	53·8% (33·0–74·6)	57·2% (38·3–76·1)	50·4% (27·4–73·3)
Western Pacific	63·5% (58·1–69·0)	65·3% (60·0–70·5)	61·9% (56·5–67·4)

Data are prevalence (95% CI).

Table 3: **Prevalence of second-hand smoke exposure in young adolescents aged 12–15 years by WHO region and sex**

aged 12–15 years from GSHS and 155 117 Chinese young adolescents (51·8% boys) aged 13–15 years from GYTS were included in our analysis. Median sample size per country (for GSHS data) was 1782 (IQR 1168–2614). All data were weighted according to the random cluster sampling design to provide nationally representative estimates for each country.

Table 2 shows the prevalence of tobacco use among young adolescents by WHO region and sex. 13·6% of assessed young adolescents were current tobacco users. The prevalence of tobacco use was highest in the western Pacific region (17·6%) and lowest in the European region (6·3%). 10% of the young adolescents were current cigarette smokers. The prevalence of cigarette smoking was highest in the western Pacific region (13·9%) and lowest in the European region (5·3%). 8·1% of young adolescents were using tobacco products other than cigarettes (eg, pipe, water pipe, chewing tobacco, smokeless tobacco). The prevalence of use of other tobacco products was highest in the western Pacific region (12·2%), and lowest in the European region (2·6%) region. The prevalence of use of any tobacco product, cigarettes, and tobacco products other than cigarettes was higher in boys than in girls in most WHO regions, with around double the prevalence in boys than in girls, overall (p<0·05, table 2).

The prevalence of current tobacco use ranged from 2·8% in Tajikistan to 44·7% in Samoa. It was more than 10% in 48 (70·6%) of the 68 countries (figure 1 and appendix). The prevalence of current cigarette smoking ranged from 0·7% in Tajikistan to 32·2% in Samoa (appendix). The prevalence of current use of a tobacco product other than cigarettes ranged from 2·2% in China to 38·6% in Samoa (appendix). The prevalence of use of any tobacco product, cigarettes alone, and other tobacco products was higher in boy than in girls in most countries (p<0·05, appendix).

See Online for appendix

Adolescents aged 14–15 years tended to use tobacco products more than adolescents aged 12–13 years in most countries (p<0·05). The ratio of the prevalence of using any tobacco product at age 14–15 years divided by the prevalence of using any tobacco product at age 12–13 years was 1·61 (95% CI 1·46–1·76) overall, suggesting an overall 61% increase in the prevalence of using any tobacco product at age 14–15 from age 12–13 years in young adolescents (appendix).

A large proportion of adolescents aged 12–15 years in each country reported that they used their first cigarette before the age of 11 years, with the proportion ranging from 23·1% in Macedonia to 81·2% in Ghana (appendix). More than 50% of smokers aged 12–15 years had tried a cigarette before the age of 11 years in 42 (63%) of 67 countries (except for China).

Table 3 shows the prevalence of exposure to second-hand smoke during the past 7 days in young adolescents by WHO region and sex. 55·9% of all participants reported that they had been exposed to second-hand smoke in any place, with the highest exposure in the western Pacific region (63·5%). Second-hand smoke exposure did not differ significantly between boys and girls. The prevalence of exposure to second-hand smoke in young adolescents ranged from 16·4% in Tajikistan to 85·4% in Indonesia (figure 2 and appendix). The prevalence of second-hand smoke exposure among young adolescents exceeded 50% in 47 (70%) of 68 countries. There was no difference in the prevalence of exposure to second-hand smoke between sexes in most countries, except that boys were more likely to have been exposed to second-hand smoke than girls in Algeria, Sudan, Honduras, Pakistan, United Arab Emirates, Tajikistan, India, Indonesia, Malaysia, China, Philippines, and Samoa, and an inverse pattern was observed in Argentina and Uruguay (appendix). The duration of exposure to second-hand smoke during the past 7 days ranged from 2·3 days in Cambodia to 4·9 days in Jamaica (appendix).

Table 4 shows the multivariate association between tobacco use in young adolescents and parental tobacco use and second-hand smoke exposure, by WHO region. Parental tobacco use was associated with tobacco use among young adolescents. The strength of the association was larger for maternal tobacco use (model 1 odds ratio [OR] 2·37, 95% CI 2·26–2·48) than paternal tobacco use (1·41, 1·36–1·45). There was no clear interaction between maternal and paternal tobacco use (p>0·05). Second-hand smoke exposure was also associated with tobacco use among young adolescents (3·42, 3·29–3·56). These associations were found in all WHO regions and did not substantially change upon adjustments for PPP, age of initiation of smoking, prevalence of adult's tobacco use, year the WHO FCTC was ratified by each country, proxy of socioeconomic status, or survey year. Of note, the prevalence of tobacco use was not associated with a country's PPP in this multilevel model (data not shown). In a separate linear regression analysis that compared the country-level prevalence of smoking among adolescents and the country's PPP, using data in the 67 countries (except for China), the regression coefficient was less than 0·1% change in prevalence of tobacco smoking for a US$1000 PPP increase (p>0·1).

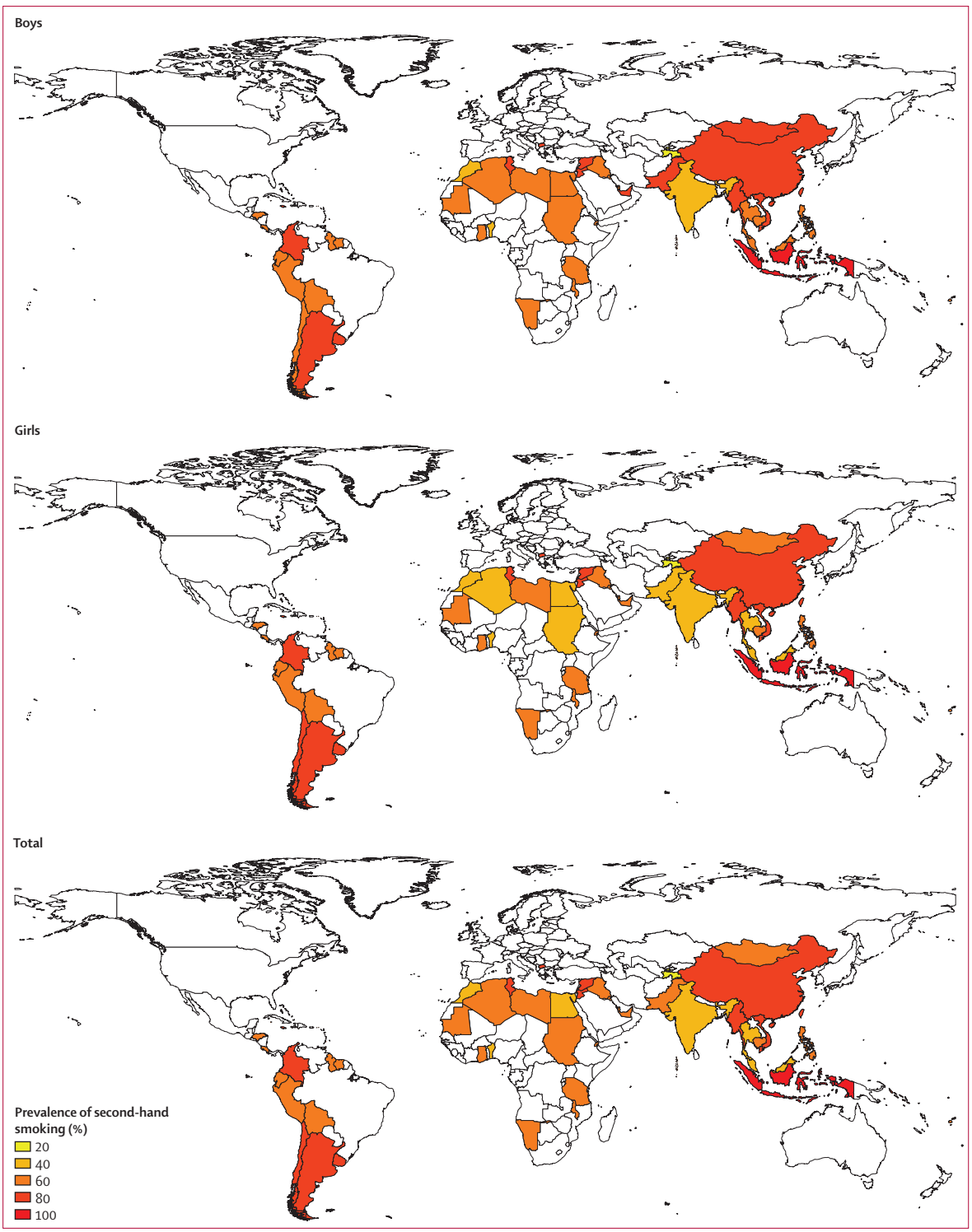

Figure 2: **Prevalence of second-hand smoke exposure in young adolescents aged 12–15 years in 68 low-income and middle-income countries**
Data are from Global School-based Student Health Survey, except for China, where data are from the China Global Tobacco Youth Survey in 2013.

Discussion

Although there was substantial difference between countries, there was an overall high prevalence of both tobacco use and exposure to second-hand smoke among adolescents aged 12–15 years. Tobacco use was, overall, around twice as prevalent in boys than in girls, and

approximately 1·6 times higher at age 14–15 years than at age 12–13 years. Many young adolescents who were using cigarettes reported to have started before the age of 11 years. Tobacco use in young adolescents was strongly associated with parental smoking and second-hand smoking.

As current tobacco use is defined as using any tobacco product on at least 1 day in the past 30 days, it might be argued that the estimate could include a proportion of experimenters who might not sustain their consumption and not become regular smokers. This could result in some overestimation of the estimates of regular smokers. Results of a previous study showed that about 10% of young experimenters became weekly smokers over 1 year of follow-up.[18] Another study[9] showed that smoking as little as one cigarette per month during adolescence was strongly associated with adult tobacco use, implying that many adult smokers could be avoided if smoking was not initiated in adolescence.[9]

Previous studies[13] have reported a high prevalence of active and passive smoking in young adolescents worldwide. The first review of GYTS results for the period 1999–2005 showed that, among young adolescents aged 13–15 years, the overall prevalence of current use of any tobacco product was 17·3% and the prevalence of second-hand smoke was 44·1% at home and 54·2% in public places.[13] A previous review of GSHS results from 44 countries from 2003–08[19] did not report on the prevalence of use of tobacco products and exposure to second-hand smoke. Our results indicate that the prevalence of active and passive smoking in young adolescents remained high in 2006–13, which suggests little progress in tobacco control among young adolescents, at least in LMICs, and that exposure to second-hand smoke among young adolescents is still a serious global issue.[20]

In our study, many young adolescents aged 12–15 years started to smoke before the age of 11 years, with more than half of smokers in more than half of countries reported to have tried a cigarette before the age of 11 years. This finding emphasises that effective measures to control tobacco use, including suitable information

	Paternal smoking		Maternal smoking		Second-hand smoking	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
Model 1						
Africa	2·01 (1·79–2·27)	<0·0001	4·94 (4·12–5·93)	<0·0001	3·16 (2·79–3·60)	<0·0001
Americas	1·41 (1·34–1·49)	<0·0001	1·70 (1·60–1·81)	<0·0001	3·56 (3·34–3·79)	<0·0001
Eastern Mediterranean	1·41 (1·30–1·52)	<0·0001	4·43 (3·92–5·00)	<0·0001	2·70 (2·48–2·94)	<0·0001
Europe	1·46 (1·13–1·89)	0·0034	2·23 (1·63–3·06)	<0·0001	4·14 (3·10–5·55)	<0·0001
Southeast Asia	1·50 (1·37–1·64)	<0·0001	4·88 (4·09–5·82)	<0·0001	4·79 (4·30–5·33)	<0·0001
Western Pacific	1·18 (1·08–1·30)	0·0003	2·29 (2·05–2·57)	<0·0001	2·92 (2·62–3·27)	<0·0001
Total	1·41 (1·36–1·45)	<0·0001	2·37 (2·26–2·48)	<0·0001	3·42 (3·29–3·56)	<0·0001
Model 2						
Africa	2·01 (1·78–2·26)	<0·0001	4·95 (4·13–5·94)	<0·0001	3·16 (2·78–3·59)	<0·0001
Americas	1·41 (1·34–1·49)	<0·0001	1·70 (1·60–1·81)	<0·0001	3·56 (3·33–3·79)	<0·0001
Eastern Mediterranean	1·41 (1·30–1·52)	<0·0001	4·43 (3·93–5·00)	<0·0001	2·70 (2·48–2·94)	<0·0001
Europe	1·46 (1·13–1·89)	0·0034	2·23 (1·63–3·06)	<0·0001	4·14 (3·10–5·55)	<0·0001
Southeast Asia	1·50 (1·36–1·64)	<0·0001	4·89 (4·10–5·84)	<0·0001	4·79 (4·30–5·33)	<0·0001
Western Pacific	1·18 (1·08–1·30)	0·0003	2·29 (2·05–2·57)	<0·0001	2·92 (2·62–3·27)	<0·0001
Total	1·41 (1·36–1·46)	<0·0001	2·37 (2·26–2·48)	<0·0001	3·42 (3·29–3·56)	<0·0001
Model 3						
Africa	1·65 (1·38–1·97)	<0·0001	3·29 (2·48–4·36)	<0·0001	2·44 (2·03–2·92)	<0·0001
Americas	1·32 (1·23–1·41)	<0·0001	1·52 (1·40–1·65)	<0·0001	2·52 (2·33–2·73)	<0·0001
Eastern Mediterranean	1·24 (1·12–1·37)	<0·0001	3·83 (3·27–4·48)	<0·0001	2·18 (1·95–2·43)	<0·0001
Europe	1·97 (1·08–3·59)	0·0270	0·79 (0·42–1·50)	0·4700	3·42 (1·19–9·88)	0·0229
Southeast Asia	1·28 (1·13–1·46)	0·0001	4·99 (3·94–6·32)	<0·0001	3·69 (3·21–4·24)	<0·0001
Western Pacific	1·15 (1·01–1·31)	0·0294	2·16 (1·84–2·54)	<0·0001	2·20 (1·90–2·56)	<0·0001
Total	1·29 (1·23–1·35)	<0·0001	2·06 (1·93–2·19)	<0·0001	2·56 (2·43–2·69)	<0·0001

Model 1 was adjusted for sex, age, school, and school class. Model 2 was model 1 plus country's purchasing power parity. Model 3 was model 2 plus age of initiation of smoking, prevalence of adult's tobacco use, year WHO FCTC ratified by the country, socioeconomic status of children, and survey year. WHO FCTC=World Health Organization Framework Convention on Tobacco Control.

Table 4: **Association between parental tobacco use, second-hand smoke exposure, and tobacco use in young adolescents aged 12–15 years**

about use of tobacco and other addictive substances, should be started at an early age. There are examples of successful programmes. For instance, the Truth Initiative—a large national campaign aimed at limiting youth tobacco use in the USA—is reported to have avoided about 450 000 youths starting smoking in the USA between 2000 and 2004,[21] and saved between $1·9 and $5·4 billion in medical care costs between 2000 and 2002.[22] LMICs could build on successful experiences when developing their own national anti-tobacco campaigns to reduce tobacco use among adolescents.

Boys were more likely to use tobacco than girls in most of the countries in our study. The ratio was about 2:1 in our study, which is somewhat higher than the 1·4:1 reported in an analysis of GYTS data between 1999 and 2005.[13] However, the ratio of men to women smoking is about 4:1 in adults.[4,6] If the pattern in adolescents tracks into adulthood, an increasing disease burden related to tobacco use can be expected.[13] We also found that the prevalence of tobacco use increased markedly between age 12–13 years and age 14–15 years, consistent with adolescence being a crucial age at which to adopt smoking habits. This finding stresses the crucial importance of tobacco control interventions targeting young adolescents.

In this study, the highest prevalence of tobacco use among adolescents was found in Samoa, Kiribati, Jamaica, and Qatar. The prevalence of second-hand smoke was highest in Indonesia, Chile, Kiribati, and Argentina. The prevalence of adult tobacco use in these countries was 29·0% in Indonesia, 28·8% in Chile, 42·6% in Kiribati, and 19·8% in Argentina,[4] which is high by international standards. This is also consistent with the association between parents' smoking prevalence and adolescent tobacco use prevalence. Of these four countries, Indonesia and Argentina have not yet ratified the WHO FCTC. However, ratification of the FCTC is not necessarily a strong proxy of comprehensive tobacco control measures, if the main provisions of the treaty are not actually implemented or enforced. In addition to interventions targeting children and adolescents, interventions should also target adult smoking and create an environment that motivates all people to abstain from smoking and encourages smokers of all ages to quit.[23] Such an approach, as advocated by the WHO FCTC, includes high taxation on tobacco products; a total ban on tobacco advertising, promotion, and sponsorship; a total ban on smoking in enclosed places and selected public places; and provision of effective programmes to assist smokers to quit.

Exposure to second-hand smoke was associated with increased risk of tobacco use in young adolescents in our study, consistent with results of a previous review showing that second-hand smoke was positively associated with smoking susceptibility, smoking initiation, and nicotine dependence; and negatively associated with smoking cessation.[24] This association might relate to several factors. First, second-hand smoke exposure can be a proxy for social cues and pressures to smoke from peers, siblings, teachers, or parents or guardians. Second, nicotine exposure from second-hand smoke might activate neural pathways, which increases the brain sensitivity to nicotine and promotes an urge to smoke.[24]

About 40% of men and 10% of women worldwide are tobacco users.[4,6] As a result, many never-smokers, including women, children, and adolescents, are exposed to second-hand smoke. One previous study[25] reported that 88% of smoking parents were smoking at home and that more than 80% of these parents smoked at home in the presence of their children. Although the WHO FCTC requests countries to ban smoking in enclosed public premises, regulations cannot extend to private homes. Therefore, abstention from smoking at home mainly relies on non-regulatory measures, including education and clean air social norms, which might empower smoking parents to abstain from smoking at home and reduce second-hand smoke exposure.[12]

We found that adolescent smoking was associated more strongly with maternal than paternal smoking, consistent with findings from another study[26] based on GYTS data from 2002–11 in 17 Arabic countries. The reasons for the apparently more important role of mothers' than fathers' smoking on adolescent smoking are unclear, but might be related to the facts that fathers tend to be less present at home than mothers, or that many young adolescents might be closer to their mother than their father. This finding underlines the importance of considering the role of mother's smoking when developing policies and interventions for tobacco control in young adolescents.[26]

There was no association between an indicator of economic development of countries (PPP) and smoking prevalence at the country level. Admittedly, this analysis did not include high-income countries, which would have provided more variability in both smoking prevalence and PPP. It might be anticipated that prevalence of tobacco use would have been higher in LMICs with higher PPP in which children might potentially have more resources to purchase tobacco products. On the other hand, tobacco products tend to be much cheaper in several LMICs than in high-income countries, in which there are often much higher taxes on tobacco products. Also, the prevalence of smoking in children and adolescents is defined for consumption as smoking only one cigarette or using a tobacco product only once during the past 30 days. Smoking only a few cigarettes per month (eg, experimentation) might not incur high costs, and low consumption of tobacco products might therefore not need to be strongly dependent on the cost. The absence of an association between the prevalence of tobacco use and the country's PPP also indirectly suggests that the prevalence of tobacco use among young adolescents also depends on various non-economic factors, such as social and cultural norms, peer pressure, promotion and advertising, and

policies for tobacco control. Further studies should examine the relation between the prevalence of smoking in children and these factors in different countries, including consideration of the national enforcement of tobacco control measures.

Our study has several strengths. The GSHS relies on standard procedures for the selection of participants and the same questions were applied in all countries, which makes results between countries directly comparable. Moreover, our study included a large sample size from 68 LMICs. However, several limitations should also be noted. First, the use of tobacco products and exposure to second-hand smoke were self-reported, which might not necessarily reflect the true prevalence. However, studies have substantiated the validity of self-reported smoking in young adolescents using the objective measure of urinary cotinine.[27,28] Second, data were collected in different years between 2006 and 2013 and a direct comparison of prevalence between countries should be made with caution. In addition, surveys were done before 2010 in several countries, therefore these data are relatively old, which emphasises the need for countries to strengthen surveillance of tobacco use, including by repeating surveys at regular intervals to assess trends and help guide national policy. Third, smoking prevalence might be underestimated because the prevalence of smoking can be higher in non-participants than in participants in school surveys.[29] However, the participation rates were generally high in most countries (more than 90%), which tends to reduce this possible bias. Fourth, although we considered whether a country had ratified the FCTC as a proxy measure of national tobacco control policy in our multivariate model to predict prevalence of tobacco use among adolescents, we did not have information on whether the main provisions of the treaty were actually implemented and enforced. Finally, regional and global estimates in this study should be interpreted with caution as the prevalence of tobacco use and second-hand smoke largely differed across countries and WHO regions.

In conclusion, we found that tobacco use and exposure to second-hand smoke remain major public health issues among young adolescents in LMICs. We also substantiated that parental tobacco use, especially maternal tobacco use, and second-hand smoke exposure are strongly associated with young adolescents' tobacco use. Our findings emphasise the need to strengthen tobacco control policy and programmes in LMICs with a particular focus on young adolescents, as smoking is often initiated early.

Contributors

BX did the statistical analysis and had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. BX and PB contributed to the design of the study. YL, CM, MZ, and YY collated and analysed the data. BX and PB contributed to the writing of the manuscript. BX is the principal investigator and the guarantor of the study.

Declaration of interests

We declare no competing interests.

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