Pulmonary effects of active smoking and secondhand smoke exposure among adolescent students in Juárez, Mexico

Yelena Bird1
Hugo Staines-Orozco2

1School of Public Health, University of Saskatchewan, Saskatoon, SK, Canada; 2Institute of Biomedical Sciences, Universidad Autónoma de Ciudad Juárez, Anillo Envolvente del PRONAF y Calle Estocolmo, Ciudad Juárez, Chihuahua, Mexico

Background: Youth smoking trends among Latin American countries, including Mexico, are on the rise. Notably, although the high prevalence of smoking in teens has been well documented in the literature, few studies have evaluated the impact of smoking and secondhand smoke (SHS) exposure on their respiratory system.

Objective: To investigate the effects of smoking and SHS exposure on the respiratory health and lung function among eighth-grade students in Juárez, Mexico.

Methods: A cross-sectional study was undertaken on a sample of convenience. The study outcomes centered on evaluating 300 students’ lung function by spirometry (forced expiratory volume in 1 second [FEV1], forced expiratory volume in 1 second/forced vital capacity ratio [FEV1/FVC], and forced mid-expiratory flow rate [FEF25%-75%]) and their respiratory health (smoking behavior and SHS exposure) by their self-reported responses to a standardized respiratory questionnaire. The study outcomes were compared among three distinct groups: 1) nonsmokers/nonexposed to SHS; 2) nonsmokers/exposed to SHS; and 3) smokers.

Results: The majority of the study participants were 14 years old (85%), females (54%), who attended eighth grade in a public school setting (56%). Approximately, half reported being of low socioeconomic status (49%) and nonsmokers/exposed to SHS (49%). The lung function parameters of smokers were found to be lower (FEV1=62.88±10.25; FEV1/FVC=83.50±14.15; and FEF25%-75%=66.35±12.55) than those recorded for the nonsmokers/exposed to SHS (FEV1=69.41±11.35; FEV1/FVC=88.75±15.75; and FEF25%-75%=78.90±14.65) and significantly reduced when compared to the nonsmokers/nonexposed to SHS (FEV1=79.14±13.61; FEV1/FVC=94.88±21.88; and FEF25%-75%=87.36±17.02) (P<0.001). Similarly, respiratory complaints were more prevalent among smokers and those exposed to SHS when compared to nonsmokers/nonexposed to SHS.

Conclusion: Our findings suggest that initiation of cigarette smoking and, to a lesser extent, exposure to SHS in adolescence leads to increased respiratory symptoms and reduction of pulmonary function test values. Public health initiatives that aim to prevent smoking initiation, assist in cessation, and lessen SHS exposure of adolescents need to be school-based and employed as early as middle school.

Keywords: adolescents, smoking, secondhand smoke exposure, respiratory symptoms, lung function

Introduction

The global tobacco epidemic is rapidly shifting from developed to developing countries.1 It is estimated that six million adults2 and ~100,000 adolescents3 die each year from tobacco-related causes. More than 80% of those deaths occur in developing
countries. Youth smoking trends among Latin American countries, including Mexico, are on the rise. In Mexico, even though the prevalence of tobacco use among adults has slowly decreased to 18.9%, smoking among adolescents (13–15 years old) has increased to 27.5%. Notably, the increases in rates are driven by increases in tobacco use by young females.

Tobacco smoke and its by-products affect the respiratory tract and lungs of adolescents, who either actively smoke or are exposed to secondhand smoke (SHS) produced by their parents, relatives, and/or friends. Active smoking and SHS are associated with multiple adverse respiratory health outcomes including higher rates of asthma, infections of the upper and lower respiratory tract, and reduced lung function. Adolescents may be especially at risk because their lungs are still developing and active cigarette smoke and/or SHS exposure are considered to be health hazards to their respiratory health and, therefore, pose a serious pediatric health problem.

To date, global studies have confirmed that cigarette smoking by adults is the major cause of both COPD and chronic respiratory symptoms, such as chronic cough, increased phlegm production, wheezing, and dyspnea. Additionally, active smoking by healthy adults has been reported to cause declines in lung function, as evidenced by the accelerated loss of forced expiratory volume in 1 second (FEV₁). and reductions in forced expiratory volume in 1 second/forced vital capacity ratio (FEV₁/FVC) and forced mid-expiratory flow rate (FEF₂⁵%-⁷⁵%).

By comparison, fewer studies have examined the effects of active smoking and SHS exposure on the respiratory system of adolescents. The scarcity of research conducted among adolescents may be attributed to several limiting factors including: ethical considerations which prohibit the use of minor-aged youth in acute smoking experiments, methodological difficulties inherent in health assessment studies of young people, and a developing but incomplete understanding of the exact mechanisms responsible for causing the adverse effects observed on the respiratory health of adolescent smokers and those exposed to SHS.

However, increases in respiratory symptoms and reductions in lung function have been historically documented in adolescents who smoke and are exposed to SHS. It has been reported that respiratory problems such as asthma, cough, phlegm, and wheezing are significantly more likely to occur among adolescent smokers and those exposed to SHS than their nonsmoking counterparts. More recent studies of schoolchildren who report actively smoking or being exposed to SHS have found increases in cough, phlegm production, wheezing, bronchial reactivity, IgE levels, eosinophilia, and sensitization to aeroallergens. Considering these findings and the strong relationship of atopy and IgE to asthma, active smoking and SHS exposure may not only alter the developing lungs structure and function but also augment the exposed adolescent’s level of atopy and subsequently increase their risk to develop asthma.

Similarly, active smoking and SHS exposure in adolescence can have a significant effect on several pulmonary function parameters, including reductions in FEV₁, FEV₁/FVC, and FEF₂⁵%-⁷⁵% in some cases by as much as 5%–10%. Moreover, a positive correlation has been reported between the respiratory symptoms and reduction in lung function of adolescents who do not smoke but are exposed to SHS and the number of cigarettes smoked by adults at their home.

These findings are important because lung function tests may be used to identify deterioration of respiratory function among adolescents prior to the appearance of clinical symptoms. The resulting information can then be used to implement health promotion strategies that help prevent or reduce the incidence of respiratory diseases. Thus, the objective of the present study was to investigate the effects of smoking and SHS exposure on the respiratory health and lung function among eighth-grade students in Juárez, Mexico.

### Methods

#### Study setting

The present study was conducted in Ciudad Juárez, Mexico. Ciudad Juárez stands on the Rio Grande, across the US border from its sister cities of El Paso, Texas, and Las Cruces, New Mexico. Ciudad Juárez is a growing industrial city in the state of Chihuahua and represents the eighth largest city in Mexico with a population of more than 1.3 million inhabitants, 42% of whom are reported to be less than 18 years old.

#### Study design, study population, and sampling strategy

A cross-sectional study was conducted on a sample of convenience. The population studied comprised 300 eighth-grade students (137 male and 163 female), ages 13 to 15 years, who attended middle schools in Juárez, Mexico. Students were systematically selected (every third of three) from existing clinical files and recruited to participate during their annual medical checkup visit at three main community clinics within the city limits of Juárez, Mexico.

A sample size of 100 participants was selected from each clinic for a total of 300. The three clinics were selected on
the basis of their organizational size (≥25 health care staff members including doctors and nurses), number of complete adolescent patient records (≥300), and geographical location (within 20 km from the center of city).

The three medical directors of the community-based clinics were contacted using a letter prepared by the investigators through the School of Medicine, Universidad Autónoma de Ciudad Juárez (UACJ). The letter asked the medical directors to grant permission to the investigators to seek parental consent to recruit eighth-grade student participants and to be given access to their medical records.

**Entry criteria**

Entry criteria for the student participants in the study included the following: 1) eighth-grade student status in one of the middle schools in Juárez, Mexico; 2) complete medical records; 3) willingness to complete a questionnaire and undergo pulmonary function tests (PFTs); and 4) absence of a diagnosis of atopy or asthma by a clinician.

**Data collection tools**

Data gathering took place in two stages. The first stage involved a nurse-administered questionnaire. The questionnaire used in this study was a modified version of the Global Youth Tobacco Survey (GYTS) questionnaire with an additional section on respiratory health. The GYTS questionnaire offered several advantages: it is a validated instrument; it is specifically developed for use with middle-school students; it could be completed in a short period of time (≤15 minutes); and the study investigators had used it in their previous research.

Section 1 of the survey contained three questions pertaining to the students’ demographic characteristics (additional information on socioeconomic status [SES] as determined by household income was extracted from administrative patient records). Section 2 contained three questions assessing the participating students’ smoking practices. Section 3 contained four questions dealing with the students’ self-reported exposure to SHS. Finally, Section 4 of the questionnaire contained eight questions on respiratory health. Questions in Sections 1–3 were categorical in nature and closed in format. Section 4 used a five-point Likert-type scale to score the eight respiratory symptoms (1 = “Never” to 5 = “Every day”). The questionnaire is shown in Table S1.

The second stage of data collection included the completion of PFTs by the adolescent participants in accordance with the American Thoracic Society/European Respiratory Society taskforce guidelines. The PFTs measured in this study were the FEV₁, FEV₁/FVC, and FEF₂₅₋₇₅. These tests were performed by a blinded, trained physician using a computerized spirometer, Spirotrac 6800 (Vitalograph, Lenexa, KS, USA) equipped with an electronic sensor. The spirometer was calibrated through the use of the appropriate software at the beginning of each testing day. The best of three successfully completed maneuvers was used for analysis. PFTs were measured with the students in standing position and as appropriate for their height, weight, age, and sex.

**Study outcomes**

The study outcomes centered on evaluating the students lung function by spirometry (FEV₁, FEV₁/FVC, and FEF₂₅₋₇₅) and their respiratory health (smoking behavior and SHS exposure) by their self-reported responses to a standardized, nurse-administered respiratory questionnaire. The study outcomes were compared among the three distinct student groups: 1) nonsmokers/nonexposed to SHS; 2) nonsmokers/exposed to SHS; and 3) smokers.

**Statistical analysis**

The investigators used χ² tests to determine the comparability between the three groups of students on sociodemographic variables and smoking-related characteristics. Multivariant analysis of variance (MANOVA) and follow-up univariate analysis of variance (ANOVA) were used to compare the three groups based on age, sex, school setting, SES, lung function parameters, and presence and frequency of respiratory symptoms. All data analyses were conducted using the SPSS 18.0 statistical software package and the results were considered statistically significant at a value of P<0.05.

**Ethical considerations**

All study procedures and instruments were reviewed and approved by the Ethics Committees of each participating community clinic as well as the Institutional Review Board at UACJ. Prior to the participants’ enrollment in the study, the investigators secured written parental informed consent and active student assent, as is culturally appropriate in Mexico. No monetary or nonmonetary incentive was offered to the participating students or their parents.

**Results**

**Study subjects**

There were 357 students invited to take part in the study; 300 (84%) agreed to participate, 52 refused, and five were ineligible because they had been previously diagnosed with asthma. Comprehensive recording of relevant medical
information took place for all 300 eighth-grade student participants. The participants’ sociodemographic characteristics are presented in Table 1. Briefly, the majority of the students were 14 years old (85%) and slightly more than half were female (54%). The majority attended public schools (56%) and were of low SES (49%).

Smoking prevalence
In the present study, the self-reported student smoking prevalence was 29.6% (n=89), with another 49.1% of the students being nonsmokers/exposed to SHS and only 21.3% being nonsmokers/nonexposed to SHS. Of the 89 students who were smokers, 43.8% (n=39) indicated they had initiated smoking at or before the age of 10 years. Over a third of male students reported being smokers (37%); the proportion was significantly lower among females (23%). Almost 33% of students attending public schools were smokers; the proportion was significantly lower for those attending private schools. Smoking prevalence varied by sex, school setting, and SES, with male students (P<0.001), attending a public school setting (P<0.001), and belonging to the low SES category (P<0.001) having a significantly higher smoking prevalence (Table 1).

SHS exposure
The overall SHS exposure of students was 49.1%. Approximately, 69% of the male students reported being exposed to SHS. Moreover, female students (P<0.001) attending a public school setting (P<0.001), and belonging to a high SES category (P<0.001) were significantly less likely to have been exposed to SHS than their male, public school attending, low SES counterparts (Table 1).

PFTs
PFTs were performed to determine if the adolescent smokers and the nonsmokers/exposed to SHS experienced any adverse respiratory health effects when compared to the nonsmokers/nonexposed to SHS. The PFT results for the three groups are presented in Table 2. A consistent trend was observed toward a significant reduction of all three pulmonary function parameters measured between the three groups (Table 2). Additionally, it is worthy to note that the decrease in FEF_{25%–75%} was significantly and inversely correlated with the number of cigarettes the adolescent students smoked per day (P<0.001). However, no statistically significant correlation was detected with FEV_{1} or FEV_{1}/FVC and the number of cigarettes smoked per day (P>0.430 and P>0.526, respectively).

Respiratory symptoms
The investigators tested for differences between the three distinct groups (ie, nonsmokers/nonexposed to SHS, nonsmokers/exposed to SHS, and smokers) based on their self-reported frequencies of eight respiratory symptoms. The results of the comparisons are shown in Table 3. “Morning cough”, “shortness of breath when walking”, “shortness of breath during exercise”, and “wheeze” (P<0.001) were more prevalent among smokers than the other groups. In addition, a significantly higher frequency of “coughing up sputum” (P<0.001) was reported among smokers than the other groups.

Table 1 Sociodemographic variables by smoking status

| Sociodemographic variables | Smoking status | Nonsmokers/ nonexposed to SHS n=64 (21.3%) | Nonsmokers/ exposed to SHS n=147 (49.1%) | Smokers n=89 (29.6%) | Total n=300 (100%) | P-value* |
|----------------------------|----------------|------------------------------------------|------------------------------------------|----------------------|-------------------|----------|
| Age                        | <0.045         | <0.350                                   | <0.268                                   |                      | A                  | B        | C        |
| 13 years old               |                |                                          |                                          |                      |                   |          |
| 14 years old               |                |                                          |                                          |                      |                   |          |
| 15 years old               |                |                                          |                                          |                      |                   |          |
| Sex                        | <0.001         | <0.001                                   | <0.378                                   |                      |                   |          |
| Male                       |                |                                          |                                          |                      |                   |          |
| Female                     |                |                                          |                                          |                      |                   |          |
| School setting             | <0.001         | <0.001                                   | <0.484                                   |                      |                   |          |
| Public                     |                |                                          |                                          |                      |                   |          |
| Private                    |                |                                          |                                          |                      |                   |          |
| Socioeconomic status       | <0.001         | <0.001                                   | <0.325                                   |                      |                   |          |
| Low (<10,000 Mexican pesos)|                |                                          |                                          |                      |                   |          |
| Middle (10,001–25,000 Mexican pesos) | |                                          |                                          |                      |                   |          |
| High (≥25,000 Mexican pesos) |              |                                          |                                          |                      |                   |          |

Notes: *Sociodemographic distributions are significantly different at P<0.05 level using χ² tests. A, Test between nonsmokers/nonexposed to SHS and nonsmokers/exposed to SHS groups; B, test between nonsmokers/nonexposed to SHS and smokers groups; C, test between nonsmokers/exposed to SHS and smokers groups.

Abbreviation: SHS, secondhand smoke.
exercise”, and “getting tired easily” were more prevalent among the adolescent smokers and the nonsmokers/exposed to SHS when compared to the nonsmokers/nonexposed to SHS. No significant differences were discovered with “daytime cough”, “wheezing”, “phlegm production”, and “pain in the chest”, although a consistent trend of higher prevalence was observed when the nonsmokers/nonexposed to SHS students were compared with the ones who were nonsmokers/exposed to SHS and those who smoked (Table 3).

**Discussion**

Overall, ~30% of the eighth-grade students who participated in this study indicated they were smokers and close to 50% self-reported being nonsmokers/exposed to SHS. These smoking and SHS exposure prevalence rates are consistent with the findings reported by previous research among adolescent students in Juárez, Mexico, which found a smoking prevalence and SHS exposure of 26.1% and 53.2%, among adolescent students in Juárez, Mexico, which found a consistent with the findings reported by previous research that demonstrates the detrimental effects of smoking and SHS exposure on several pulmonary function parameters among adolescents.

Specifically, it was discovered that FEF\(_{25%–75%}\) leading to shortness of breath, getting tired easily, and reduction in exercise tolerance.\(^5\) This suggests that peripheral vasoconstriction, induced by the adrenergic effects of nicotine,\(^4\) along with the production of CO impair the body’s ability to efficiently diffuse and transport oxygen and act as added stressors in the precipitation of cardiovascular and respiratory disease.\(^4\)–\(^5\)

It is generally assumed that adolescent smokers may not have respiratory problems because of their relatively short smoking history. However, the results of the current study indicate that adolescents who were exposed to SHS and especially those who self-reported being smokers were at a substantially increased risk for developing smoking-related respiratory symptoms. Additionally, and even though smoking-related respiratory health problems do not fully manifest themselves until adulthood, the present study demonstrates the detrimental effects of smoking and SHS exposure on several pulmonary function parameters among adolescents.

Table 2 Pulmonary function test variables by smoking status

| Pulmonary variables | Smoking status | | |
|--------------------|----------------|-----------------|-----------------|
|                    | Nonsmokers/nonexposed to SHS n=64 | Nonsmokers/exposed to SHS n=147 | Smokers n=89 | P-value* |
| FEV\(_1\)          | 79.14±13.61 | 69.41±11.35 | 62.88±10.25 | <0.010 |
| FEV\(_1\)/FVC      | 94.88±21.88 | 88.75±15.75 | 83.50±14.15 | <0.290 |
| FEF\(_{25%–75%}\)  | 87.36±17.02 | 78.90±14.65 | 66.35±12.55 | <0.010 |

Notes: *Mean ± standard deviation. *Pulmonary function test distributions are significantly different at P<0.05 level using \(\chi^2\) tests. A, Test between the nonsmokers/nonexposed to SHS and nonsmokers/exposed to SHS groups; B, test between the nonsmokers/nonexposed to SHS and smokers groups; C, test between the nonsmokers/exposed to SHS and smokers groups.

Abbreviations: SHS, secondhand smoke; FEV\(_1\), forced expiratory volume in 1 second; FVC, forced vital capacity; FEF\(_{25%–75%}\), forced mid-expiratory flow rate.

Table 3 Respiratory symptom variables by smoking status

| Respiratory variables                  | Smoking status | | |
|----------------------------------------|----------------|-----------------|-----------------|
|                                       | Nonsmokers/nonexposed to SHS n=64 | Nonsmokers/exposed to SHS n=147 | Smokers n=89 | P-value* |
| Morning cough                          | 1.92±1.12 | 3.64±1.34 | 4.38±1.42 | <0.001 |
| Daytime cough                          | 2.25±1.50 | 3.15±1.55 | 4.10±1.26 | <0.180 |
| Wheezing                               | 1.45±0.46 | 2.74±1.08 | 3.20±1.24 | <0.010 |
| Phlegm production                      | 2.02±1.17 | 3.00±0.92 | 3.26±1.34 | <0.120 |
| Shortness of breath when walking       | 1.28±0.98 | 3.10±1.25 | 3.90±1.38 | <0.001 |
| Shortness of breath during exercise    | 1.64±0.79 | 3.25±1.10 | 4.36±1.26 | <0.001 |
| Getting tired easily                   | 1.40±0.88 | 3.10±1.28 | 3.60±1.16 | <0.001 |
| Pain in the chest                      | 1.20±0.85 | 1.34±0.78 | 1.50±0.90 | <0.380 |

Notes: *Mean ± standard deviation (1= Never, … , 5= Every day). *Respiratory symptoms distributions are significantly different at P<0.05 level using \(\chi^2\) tests. A, Test between the nonsmokers/nonexposed to SHS and nonsmokers/exposed to SHS groups; B, test between the nonsmokers/nonexposed to SHS and smokers groups; C, test between the nonsmokers/exposed to SHS and smokers groups.

Abbreviation: SHS, secondhand smoke.
significantly and inversely correlated with SHS exposure. Our results are in agreement with the findings of Casale et al,31 who investigated the effect of SHS exposure on the pulmonary function of 143 children, ages 6–11 years old, and found the FEF25%–75% to be significantly reduced in the exposed group. Similarly, Dold et al32 demonstrated an inverse correlation between the number of cigarettes smoked per day by parents and the pulmonary test results of their 9–11-year-old children. These results corroborate the more recent findings reported by Merghani and Saeed,53 who studied 135 young male students (9–14 years old) in Khartoum, Sudan, and found the FEV1 and FVC to be significantly lower in the SHS-exposed group than the nonsmoker control group.

Our study also found the FEF25%–75% to be significantly and inversely correlated with the number of cigarettes our adolescent participants smoked per day. Other studies confirm our findings. In 2005, Urrutia et al conducted a cross-sectional, multicenter survey of a general population of young adults in Europe. The authors reported FEV1, FEV1/FVC, and FEF25%–75% values that were significantly lower among young smokers.54 Additionally, in 2008, Vianna et al studied the effects of smoking on the lung functions of 2,063 young people in Brazil and found a significant association between smoking and lower FEV1/FVC ratio and respiratory symptoms.55

The present study has a number of significant strengths. Our results show that initiation of cigarette smoking and, to a lesser extent, exposure to SHS in adolescence leads to increased respiratory symptoms and reduction of PFT values. This is explained by virtue of the fact that cigarette smoke is known to elicit acute changes in respiratory function including alterations in resistance to airflow, coughing, and irritation of the airways.5–10 Therefore, our research findings provide much-needed evidence in support of the need to implement tobacco reduction and cessation counseling for adolescents.

The findings of the present study are also constrained by a few limitations. Our study design was cross-sectional in nature, and thus, it can only imply association but not causation. The study used a convenience sampling of eighth-grade students, who attended one of the three participating community clinics. Consequently, the participants may not be representative of all students or even persons in this age group and the findings may not be generalizable. The data were collected only from adolescents who were current students. Therefore, the rates reported in this study may be underestimates. It has been well established in the literature that smoking rates among student dropouts are much higher than the rates of students who attend school regularly.56

The majority of the primary outcome measures such as smoking behaviors, SHS exposure, and respiratory symptom scores were based on self-reporting by adolescents and, therefore, subject to under- or overreporting. However, the scientific literature has examined the validity of adolescents’ self-reported smoking behaviors when compared to biological indicators (eg, cotinine) and found it to be in agreement.57 Finally, our study did not account for the possible confounding effect that environmental pollution exposure may have played among the study participants.

Conclusion
Smoking prevalence and SHS exposure was high among eighth-grade students, especially among males, who resided in a low socioeconomic setting in Ciudad Juárez, Mexico. Our findings suggest that initiation of cigarette smoking and, to a lesser extent, exposure to SHS in adolescence leads to increased respiratory symptoms and reduction of PFT values. To be most effective, public health initiatives that aim to prevent smoking initiation, assist in cessation, and lessen SHS exposure of adolescents need to be school-based and employed as early as middle school.

Acknowledgments
The authors want to sincerely thank the students and their parents for kindly agreeing to participate in this study and the medical staff of the community clinics for their expert assistance and support with the project.

Disclosure
The authors report no conflicts of interest in this work.

References
1. World Health Organization. Report on the Global Tobacco Epidemic, 2008. The MPOWER Package. Available from: http://www.who.int/tobacco/mpower/mpower_report_full_2008.pdf. Accessed September 1, 2015.
2. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 2006;11:e442.
3. Schwab JV. The epidemiology and health effects of tobacco use. Curr Pediatr Rev. 2011;7(2):81–87.
4. Mexico Informe 2012. Epidemiological Surveillance System of Addictions. Secretaría de Salud. Subsecretaría de Prevención y Promoción de la Salud. Dirección General de Epidemiología. Available from: http://www.epidemiologia.salud.gob.mx/doctype/inf_sisvea/informes_sisvea_2012.pdf. Accessed October 14, 2015.
5. Gibbs K, Collaco JM, McGrath-Morrow SA. Impact of tobacco smoke and nicotine exposure on lung development. Chest. Epub 2015 Oct 22.
6. Jawed S, Ejaz S, Rehman R. Influence of smoking on lung functions in young adults. J Pak Med Assoc. 2012;62(8):772–775.
7. Abbasi IN, Ahsan A, Naefes AA. Correlation of respiratory symptoms and spirometric lung patterns in a rural community setting, Sindh, Pakistan: a cross sectional survey. BMC Pulm Med. 2012;12:81.
8. U.S. Department of Health and Human Services. The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. Atlanta (GA): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2006.

9. Treysta Z, Gitterman B. Second hand smoke exposure in children: environmental factors, physiological effects, and interventions within pediatrics. Rev Environ Health. 2011;26(3):187–195.

10. Moshammer H, Hoek G, Luttmann-Gibson H, et al. Parental smoking and lung function in children: an international study. Am J Respir Crit Care Med. 2006;173:1255–1263.

11. Gidding SS, Schydlower M. Active and passive tobacco exposure: a serious pediatric health problem. Pediatrics. 1994;94:750–751.

12. Forey BA, Thornton AJ, Lee PN. Systematic review with meta-analysis of the epidemiological evidence relating smoking to COPD, chronic bronchitis and emphysema. BMC Pulm Med. 2011;11:36.

13. Rennard S, Decramer M, Calverley PMA, et al. Impact of COPD in North America and Europe in 2000: subjects’ perspective of Confronting COPD International Survey. Eur Respir J. 2002;20:799–805.

14. Fukuchi Y, Nishimura M, Ichinose M, et al. COPD in Japan: the Nippon COPD epidemiology study. Respiratory. 2004;9:458–465.

15. Liu Y, Pleasants RA, Croft JB, et al. Smoking duration, respiratory symptoms, and COPD in adults aged ≥45 years with a smoking history. Int J Chron Obstruct Pulmon Dis. 2015;10:1409–1416.

16. James AL, Palmer LJ, Kicic E, et al. Decline in lung function in the Busselton Health Study: the effects of asthma and cigarette smoking. Am J Respir Crit Care Med. 2005;171:109–114.

17. Tager IB. The effects of second-hand and direct exposure to tobacco smoke on asthma and lung function in adolescence. Paediatr Respir Rev. 2008;9(1):29–37.

18. Simmons MS, Connett JE, Nides MA, et al. Smoking reduction and the rate of decline in FEV1(1): results from the Lung Health Study. Eur Respir J. 2005;25:1011–1017.

19. Oron S, Jones LL, Cooper S, et al. Predictors of children’s secondhand smoke exposure at home: a systematic review and narrative synthesis of the evidence. PLoS One. 2014;9(11):e12690.

20. Corbo GM, Agabiti N, Forastiere F, et al. Lung function in children and adolescents with occasional exposure to environmental tobacco smoke. Am J Respir Crit Care Med. 1996;154:695–700.

21. Einarsdóttir J. Research with children: methodological and ethical challenges. Eur Early Child Educ. 2007;15(2):197–211.

22. Kirk S. Methodological and ethical issues in conducting qualitative research with children and young people: a literature review. Int J Nurs Stud. 2007;44(7):1250–1260.

23. U.S. Department of Health and Human Services. The Health Consequences of Smoking: A Report of the Surgeon General. Atlanta (GA): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2004.

24. Office on Smoking and Health (US). The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention (US); 2006.

25. Cook DG, Strachan DP, Carey JM. Health effects of passive smoking: parental smoking and spirometric indices in children. Thorax. 1998;53:884–893.

26. Bur M, Anderson HR, Austin JB, et al. Respiratory symptoms and home environment in children: a national survey. Thorax. 1999;54:376.

27. Gold DR, Wang X, Wypij D, et al. Effects of cigarette smoking on lung function in adolescent boys and girls. N Engl J Med. 1996;335:931–937.

28. Yoo S, Kim HB, Lee SY, et al. Effect of active smoking on asthma symptoms, pulmonary function, and BHR in adolescents. Pediatr Pulmonol. 2009;44(10):954–961.

29. Valsamis C, Krishnan S, Dozor AJ. The effects of low-level environmental tobacco smoke exposure on pulmonary function tests in preschool children with asthma. Asthma. 2014;51(7):685–690.

30. Yamell JW, Stevenson MR, MacMahon J, et al. Smoking, atopy and certain furry pets are major determinants of respiratory symptoms in children: the International Study of Asthma and Allergies in Childhood Study (Ireland). Clin Exp Allergy. 2003;33:96–100.

31. Janson C, Chinn S, Jarvis D, et al. Effect of passive smoking on respiratory symptoms, bronchial responsiveness, lung function, and total serum IgE in the European Community Respiratory Health Survey: a cross-sectional study. Lancet. 2001;358:2103–2109.

32. Rizzi M, Sergi M, Andreoli A, et al. Environmental tobacco smoke may induce early lung damage in healthy male adolescents. Chest. 2004;125:1387–1393.

33. Gilliland FD, Islan T, Berthane K, et al. Regular smoking and asthma incidence in adolescents. Am J Respir Crit Care Med. 2006;174:1094–1100.

34. Strine TW, Balluz LS, Ford ES. The associations between smoking, physical inactivity, obesity, and asthma severity in the general US population. J Asthma. 2007;44:651–658.

35. Haby MM, Peat JK, Woolcock AJ. Effect of passive smoking, asthma and respiratory infection on lung function in Australian children. Pediatr Pulmonol. 1994;18:323–329.

36. Mannino DM, Moorman JE, Kingsley B, Rose D, Repace J. Health effects related to environmental tobacco smoke exposure in children in the United States: data from the Third National Health and Nutrition Examination Survey. Arch Pediatr Adolesc Med. 2001;155:36–41.

37. Venners SA, Wang X, Chen C, et al. Exposure-response relationship between paternal smoking and children’s pulmonary function. Am J Respir Crit Care Med. 2010;184:973–986.

38. Chen Y, Rennie DC, Lockinger LA, Dosman JA. Gender, environmental tobacco smoke, and pulmonary function in rural children and adolescents: the Humboldt study. J Agric Saf Health. 2005;11(2):167–173.

39. Dirección General de Epidemiología (SSCH). Database 2010, by entity and municipalities. Secretaria de Salud. Subsecretaria de Prevención y Protección de la Salud Centro Nacional de Vigilancia Epidemiológica. Dirección General de Epidemiología; 2012.

40. Centers for Disease Control and Prevention. Global Tobacco Surveillance System Data (GTSSData). Global Youth Tobacco Survey (GYTS) – Overview. Available from: http://nccdc.cdc.gov/gtssdata/ Ancillary/Documentation.aspx?SUID=1&DOCT=1. Accessed, September 7, 2015.

41. Bird Y, Moraros J, Olsen LK, et al. Smoking practices, risk perception of smoking, and environmental tobacco smoke exposure among 6th-grade students in Ciudad Juárez, Mexico. Nicotine Tob Res. 2007;9(2):195–203.

42. Bird Y, Staines-Orozco H, Moraros J. Adolescents’ smoking experiences, family structure, parental smoking and socio-economic status in Ciudad Juárez, Mexico. Int J Equity Health. 2016;15:1:29.

43. Miller MR, Hankinson J, Brussasco V, et al. Standardisation of spirometry. Eur Respir J. 2005;26(2):319–338.

44. American Thoracic Society. Lung function testing: selection of reference values and interpretative strategies. Am Rev Respir Dis. 1991;144:1202–1218.

45. Whiteford L. Nicotine, CO and HCN: the detrimental effects of smoking tissue oxygen. Am Rev Respir Dis. 1991;144:1131–1134.

46. Simmons TW, Balluz LS, Ford ES. The associations between smoking, physical inactivity, obesity, and asthma severity in the general US population. J Asthma. 2007;44:651–658.

47. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. J Am Coll Cardiol. 2004;43(10):1731–1737.

48. Vines P, Airoldi L, Veglia F, et al. Environmental tobacco smoke and risk of respiratory cancer and chronic obstructive pulmonary disease in former smokers and never smokers in the EPIC prospective study. BMJ. 2005;330(7486):277.

49. Fischer F, Kraemer A. Meta-analysis of the association between second-hand smoke exposure and ischaemic heart diseases, COPD and stroke. BMC Public Health. 2015;15:1202.
51. Casale R, Colantonio D, Cialente M, et al. Impaired pulmonary function in school children exposed to passive smoking: detection by questionnaire and urinary cotinine levels. *Respiration*. 1991;58:198–203.

52. Dold S, Reitmeir P, Wjst M, et al. Auswirkungen des Passivrauchens auf den kindlichen Respiration-strakt. [Effects of passive smoking on the pediatric respiratory tract]. *Monatsschr Kinderheilkd*. 1992;140:763–768. German.

53. Merghani TH, Saeed AM. The relationship between regular second-hand smoke exposure at home and indicators of lung function in healthy school boys in Khartoum. *Tob Control*. 2013;(5):315–318.

54. Urrutia I, Capelastegui A, Quintana JM, et al; Spanish Group of the European Community Respiratory Health Survey (ECRHS-I). Smoking habit, respiratory symptoms and lung function in young adults. *Eur J Public Health*. 2005;(2):160–165.

55. Vianna EO, Gutierrez MR, Barbieri MA, et al. Respiratory effects of tobacco smoking among young adults. *Am J Med Sci*. 2008;336(1):44–49.

56. Pirie PL, Murrya DM, Luepker RV. Smoking prevalence in a cohort of adolescents, including absentees, dropouts, and transfers. *Am J Public Health*. 1988;78:176–178.

57. Dolcini MM, Adler NE, Lee P, et al. An assessment of the validity of adolescent self-reported smoking using three biological indicators. *Nicotine Tob Res*. 2003;5(4):473–483.
Supplementary material

Table S1 Adaptation of the Global Youth Tobacco Survey questionnaire

Demographic characteristics
How old are you? _______ years old
What is your sex? a. Male   b. Female
What kind of school do you attend? a. Public   b. Private

Smoking behaviors
Ever smoked a full cigarette? a. Yes   b. No
Started smoking at or before 10 years old? a. Yes   b. No
If yes, how old were you when you started? _______ years old
Currently smoke? a. Yes   b. No
Have you smoked a cigarette, even if only one puff, in the last 30 days? a. Yes   b. No

Secondhand smoke exposure
Do you have one or more parents who smoke? a. Yes   b. No
If yes, who? a. Father   b. Mother   c. Both
Do you have one or more close friends who smoke? a. Yes   b. No
Do you live in a home where in the last 30 days others smoked in your presence? a. Yes   b. No
In the last 30 days, were you around others who smoked in places outside your home? a. Yes   b. No

Respiratory symptoms*
In the last 30 days, have you experienced one of the following? Never (1) Rarely (2) Sometimes (3) Often (4) Everyday (5)
Morning cough
Daytime cough
Wheezing
Phlegm production
Shortness of breath when walking
Shortness of breath during exercise
Getting tired easily
Pain in the chest

Notes: *All items are weighted equally. Mean score is calculated across all items within each domain.