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Commuting mode and pulmonary function in Shanghai, China

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Abstract

Introduction—Exposure to air pollution can be particularly high during commuting, and may depend on the mode of transportation. We investigated the impact of commuting mode on pulmonary function in Shanghai, China.

Material and methods—The Shanghai Putuo Study is a cross-sectional population-based study. Our primary outcomes were FEV_1 and FVC percent predicted, and the secondary outcome was spirometric airflow obstruction. We tested the association between mode of transportation and these outcomes after adjusting for confounders.

Results—The study population consisted of 20,102 subjects. After adjusting for confounders, the FEV_1 percent predicted was 2.15 lower (95% CI −2.88, −1.42) among walkers, 1.32 lower (95% CI −2.05, −0.59) among those taking buses without air-conditioning, 1.33 lower (95% CI −2.05, −0.61) among those taking buses with air-conditioning, and 2.83 lower (95% CI −5.56, −0.10) among subway-riders, as compared to cyclists (the reference group). The effects of mode on FVC percent predicted were in the same direction. Private car use had a significant protective effect on FVC percent predicted and the risk of airflow obstruction (defined by GOLD but not by LLN criteria).

Conclusions—Mode of transportation is associated with differences in lung function, which may reflect pollution levels in different transportation microenvironments.

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The authors declare no conflict of interest.

Author contributions: AWG participated in study design, statistical analysis, and interpretation of results, and was responsible for drafting the manuscript. DCC originated the study concept and design, advised analyses and interpretation of data, and revised the entire manuscript critically. MSL and JQH participated in study design, field collection, and interpretation. LS participated in study design, data collection, field and lab quality control, and interpretation. FYZ participated in data collection, analysis, and interpretation. All authors read and approved the final manuscript.

Introduction

Modern modes of transportation have revolutionized the movement of goods and people throughout the globe, while simultaneously imposing novel threats to the health of the public. In particular, a growing body of evidence implicates exposure to traffic-related air pollution (TRAP), as assessed by *residential location*, as a cause of adverse cardiopulmonary health effects.[1-6] However, there is also evidence to suggest that exposure to TRAP *during commuting* may constitute an additional environmental health hazard.

Pollution levels within what researchers refer to as the "transport microenvironment" during a commute, for instance, are substantially greater than the levels recorded by background urban monitors.[7,8] Furthermore, exposures to different commuting environments have short-term and potentially adverse biological effects in some studies.[9-12] The impact of the commuting exposure, however, may depend on the specific transport microenvironment utilized. One review, for instance, found a variable exposure to ultrafine particle concentration among various common modes of urban transportation.[13]

Overall, however, the implications of the mode of commute on pulmonary function remain unclear, and we are aware of no large-scale studies evaluating this association. The public health implications of this question are important, particularly in low and middle income-countries that are undergoing tremendous changes in their transportation infrastructure and motorization.[14,15] We therefore used data from a large population-based study in China to study the effect of commuting mode on pulmonary function and airflow obstruction.

Material and Methods

Study subjects and study design

All study subjects were enrolled in the Shanghai Putuo Study, a cross-sectional, population-based study performed in the Putuo District of Shanghai, China. The project is a collaboration between the Shanghai District People's Hospital and the Harvard T.H. Chan School of Public Health, and the Institutional Review Boards of both approved the study (Harvard T.H. Chan School of Public Health IRB Protocol #CR-14777-01). The study was performed in compliance with the 2013 revision of the Declaration of Helsinki. The details of the study have been previously published.[16,17] Briefly, participants were randomly selected on the basis of census tract. Study subjects were recruited between August 2007 and January 2010, and those who provided written performed consent underwent an interview and spirometry.

Of the 37,690 subjects contacted, 27,042 provided informed consent to participate. Of these, 1,819 were less than 18 years of age and were excluded (Figure 1). Of the remaining 25,223 subjects, we excluded 1,091 with missing spirometry and 380 with an unacceptably high coefficient of variation (>20%). 522 subjects with missing data on the main covariates (e.g. age, gender, height, second-hand smoke exposure, pack years or smoking status, biomass exposure, education, or occupation) were then excluded. Notably, only a minority of participants (n = 8684 at this stage in the cohort formation) answered a question about dust exposure at the workplace. We excluded the 86 subjects that answered in the affirmative.

Next, subjects with missing (n=335) or no (n=8) reported modes of transportation were also excluded. Finally, because the aim of the study was to compare the effect of specific modes of transportation against other modes, we excluded subjects that reported more than one mode of transportation (n=2,699), leaving 20,102 subjects for the final analysis.

Methods

All subjects underwent an interview, which involved completion of a health questionnaire administered by personnel who were trained and tested in its use. All subjects were asked (in Chinese) "How do you go to and come back from work," and could choose one or more of the following modes: bus without air conditioning, bus with air conditioning, bicycle, scooter, taxi, car from the company, private car, train, subway, and walking.

Spirometry was performed according to American Thoracic Society guidelines.[18] Measurement of forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and peak expiratory flow was performed with the subjects in the seated position. A hand-held spirometer (Micro plus, Micro Ltd., Rochester UK) was used for all measurements. Spirometers were calibrated daily using a 3L syringe. Spirometry was performed at the same time as questionnaire completion and physical exam, between the hours of 7 am and 4pm at the convenience of the study subject. The highest FEV_1 and FVC were recorded after performance of at least three acceptable efforts. FEV_1 and FVC were measured in liters, and then converted to percent predicted using a prediction equation validated for an adult Chinese population.[19] An acceptable FVC had to be sustained for at least six seconds. Personnel would repeat efforts if the two highest FEV1 and FVC maneuvers were not within 10% of each other. However, the reproducibility of efforts was also assessed retrospectively by the coefficient of variation, calculated by dividing the standard deviation of the FVC by its mean x 100. Following previous studies,[17,20,21] a coefficient of variation of less than < 20% was used as evidence of reproducibility. Subjects that did not meet this reproducibility criteria were excluded from our analysis, as detailed below. Of note, though study personnel performing spirometry were not specifically blinded to the results of the questionnaire, they were unaware of the specific hypothesis of this present study. Mode of transportation was one of a very large number of questions collected in the study questionnaire, and so there is no plausible way that mode of transportation would affect the personnel's performance of spirometry.

Analysis

All statistical analyses were performed using SAS Version 9.4 (SAS Institute Inc,. Carry, NC, USA). FEV_1 percent predicted and FVC percent predicted were the primary outcome measures. The mode of transportation was the predictor of interest. Multiple linear regressions were used to assess the association between the mode of transportation and the primary outcome measures. The absence or presence of airflow obstruction, defined both by GOLD criteria (FEV_1/FVC ratio < .70) and by lower limit of normal (LLN) criteria, was a secondary outcome assessed with logistic regression. Cyclists, who may have lower exposure to pollutants as compared to those in cars and buses[7,13,22,23] and perhaps also as compared to walkers,[13,22,23] constituted the largest commuting category and were chosen as the reference group for all regressions.

Multiple covariates were treated as potential confounders in the final models, including age (years), gender, second-hand smoke (SHS) exposure (yes/no), home biomass fuel use (yes/no), smoking status (current, former, or never), pack-years of smoking, education (elementary or less, middle or high school, or college and higher), and occupation (farmer, worker, professional, administrator, services, household, retired, and other). The logistic models for airflow obstruction were additionally adjusted for height. Adjustment for occupation was our primary method for controlling for workplace exposure.

We conducted a number of sensitivity analyses. For occupational status, we conducted three sensitivity analyses, excluding first retirees, then retirees and household workers, and finally retirees, household workers, and those with “other” occupation. We also conducted an analysis restricted to never smokers, an analysis that included those with more than one mode of transportation, and subgroup analyses looking at specific educational strata.

Results

Characteristics of the study population stratified by mode of transportation are reported in Table I. The overall study population of 20,102 subjects had a mean age of 49 and was 54% female. Bicycling was the most frequent form of transportation (n = 5154), followed by bus with AC (n = 3650) and then by walking (n = 3220). Some modes of transportation were utilized by very few study subjects, including taxi (n = 127), company car (n = 325), subway (n = 138) and train (n = 18). The reference group – cyclists – had an above-average mean age of 54, were comparatively frequent ever-users of biomass (90.4%), had a higher rate of current smoking (27.5%), and had a lower education level as compared to the overall population.

The adjusted estimates for percent predicted FEV_1 and FVC are reported in Table II. As compared with the reference group (cyclists), several groups had statistically significant reductions in FEV_1 percent predicted after adjusting for all confounders. The FEV_1 percent predicted was 2.15 lower (95% CI −2.88, −1.42) among walkers, 1.32 lower (95% CI −2.05, −0.59) among those taking the bus without AC, 1.33 lower (95% CI −2.05, −0.61) among those taking the bus with AC, and 2.83 lower (95% CI −5.56, −0.10) among subway riders. Private car use had a protective effect, with a 0.91 higher FEV_1 percent predicted (95% CI −0.02, 1.85) as compared to cyclists that trended towards statistical significance (p = 0.06). Effects of mode of transportation on FVC percent predicted were in the same direction. Statistically significant reductions in FVC percent predicted emerged among those taking the bus without AC (1.04 lower, 95% CI −1.73, −0.36), those taking the bus with AC (−1.54 lower, 95% CI −2.21, −0.87), and walkers (2.79 lower, 95% CI −3.48, −2.11). Private car use had statistically significant higher FVC percent predicted compared to cyclists (0.95 higher, 95% CI 0.07, 1.82).

The adjusted associations of mode of transportation with airflow obstruction are given in Table III. We found a reduced risk of airflow obstruction, defined as an FEV_1/FVC ratio < .70 [odds ratio (OR) 0.43, 95% CI 0.21, 0.86], among private car users as compared to cyclists. When obstruction was defined by LLN criteria, private car users also had a reduced risk of obstruction (OR 0.68, 95% CI 0.41, 1.12), though this was not statistically significant. No other statistically significant differences in airflow obstruction were noted between cyclists and the other groups.

A number sensitivity analyses were additionally conducted. Though only subjects who answered the question “How do you go to and come back from work” were included in our analysis, the meaning of this question for those with retired (n=8294), household duties (n=341), or “other” (n=1917) occupational status was not entirely clear. We therefore first conducted a sensitivity analysis excluding retirees only (E-Table I). In this analysis (n=11808), our overall results remained robust. Both groups of bus riders and walkers still had a statistically significant reduction in both FEV1 and FVC percent predicted as compared to cyclists. Private car use had a statistically significant protective effect on both FEV1 and FVC percent predicted as compared to cyclists, while the significant effect of subway riding was lost. After additionally excluding those with household duties (E-Table II), reductions in both FEV1 and FVC percent predicted remained significant for both bus riders and walkers. The protective effect of private car use was significant for FVC percent predicted only, while a significant reduction in FEV1 percent predicted was seen among company car users. Finally, after additionally excluding those with “other” occupational status (E-Table III), our overall results were again robust (n=9550). The significant reductions in both FEV1 and FVC percent predicted for both groups of bus riders and walkers remained, as did the protective effect of private car use on FVC percent predicted. A reduced FEV1 percent predicted was seen among those using company cars. The significant effect of subway use did not persist in any of these three sensitivity analyses.

When those who listed more than one mode of transport were treated as a separate group and included in the final model (total n = 22,801), the overall results were again generally stable (E-Table IV). When we restricted our analysis to never smokers (n = 14,719) to reduce the likelihood of residual confounding by smoking, most of the statistically significant associations remained for bus riders, walkers, and private car users (E-Table V). Of note, however, there was no effect of subway or company car use. We also performed an analysis restricting our analysis to each of the two larger educational categories separately (grade school or lower, and middle/high school), so as to reduce the likelihood of residual confounding by socioeconomic status (SES). When we confined our analysis to the lowest educational stratum (n = 7,643), the confidence intervals widened for many of our results, and the majority of the statistically significant associations were lost (E-Table VI). However, walking remained significantly associated with both a reduced FEV_1 and FVC percent predicted as compared to cyclists. When the analysis was restricted to subjects with intermediate education levels (n = 9080), the direction of the majority of the effects was stable compared to our primary analysis (E-Table VI). Walking and bus with AC (but not without AC) were still significantly associated with both reduced FEV1 and FVC percent predicted. The protective effect of private car use on FEV1 and FVC percent predicted was no longer statistically significant (p-values 0.06 and 0.08, respectively), while a significant protective effect of taxi use on FVC percent predicted emerged.

Discussion

Motor vehicles release a complex mixture of pollutants and serve as an important cause for spatial differences in air pollution within the urban environment.[1] In addition to the potential risks of *residential* TRAP exposure, it is plausible that *commuting* TRAP exposure may have additional adverse effects. This is supported by data demonstrating that commuting exposures may trigger both systemic and pulmonary inflammation. For instance, short-term traffic exposures have been associated with nonfatal myocardial infarction,[24] increased exhaled nitrous oxide,[25] elevated blood fibrinogen levels ,[10] reductions in FEV_1 and FVC, increased biomarkers of neutrophilic inflammation in sputum, reductions in exhaled breath condensate pH,[12] and increases in bronchoalveolar lavage cell counts.[26] On the other hand, one study performed in Australia found that lower versus higher pollution bike routes resulted in short-term differences in subject symptoms, but not in differences in peak flow or sputum neutrophilia, suggesting that not all differences in pollution exposure have immediate biological effects.[27]

The pollution exposure faced by a commuter can be conceived as the result of a complex interaction of multiple factors including site characteristics (e.g. background ambient pollution), mode of transportation, vehicle characteristics such as ventilation system[28-30] and fuel type,[8] and route characteristics (e.g. traffic density and route length). Given these multiple factors, it is not surprising that there is some inconsistency on the relationship between mode of transport and pollutant concentrations in the literature. One 2007 review, for instance, found that commuting within a vehicle, as opposed to via cycling or walking, seemed to be associated with higher levels of particulate matter exposure.[7] Cyclists in particular have had lower pollution exposures than those in cars and buses in several studies.[13,22,23,31] Although presumably exposed to the same ambient environment, the relative exposure of walkers seems more variable. In a review relying on data from 47 studies, for instance, Knibbs et al. found higher ultrafine particle exposures for walkers than for those using rail, automobile, bus, and, bicycle (which had the lowest).[13] A number of recent studies, including one in Hanoi, Vietnam, have similarly found walkers to be exposed to higher levels of particulate air pollution as compared with those in cars or buses,[28,32,33] though one earlier study found the opposite.[31] The pollutant concentration itself, however, is not the only factor. Because of the higher minute ventilation required for cycling (or walking), it is also possible that such commuters may actually be exposed to a higher *inhaled dose* of pollutants.[8]

Some of our findings are consistent with this incomplete literature. For instance, we found that those walking to work had consistent statistically significant reductions in FEV_1 and FVC, which may be the result of the higher pollution exposure in this microenvironment. For instance, one study in urban Guangzhou, China found that pedestrians were exposed to high concentrations of PM10 that exceeded the levels found in public transport.[34] Similarly, we found largely consistent significant reductions in lung function in those taking the bus as compared to cyclists, a finding which may again also be explained by elevated within-bus pollution as seen in some studies.[13,23] The cause for reduced lung function in walkers as compared to cyclists, however, is less apparent. One possibility is that walkers are somehow exposed to higher levels of certain pollutants than cyclists, which as discussed above has been demonstrated in some studies. Given that cycling may require greater coordination and health status than walking, it is also conceivable that the higher lung function of cyclists as compared to walkers is the result of a confounding "healthy cyclist" effect. Finally, the apparently protective effect of private car use as compared to cyclists is not clearly consistent with the literature on pollution concentrations. Indeed, we found that cyclists had an elevated risk of airflow obstruction as compared to those using a private car, although only when defined by GOLD and not by LLN criteria. One possibility, however, is that the increased minute ventilation required for cycling elevates the inhaled *dose* of pollutants so as to outweigh the lower pollutant *concentrations* seen by cyclists in some studies.[8] For instance, in one study that directly measured the respiratory parameters of study subjects, despite exposure to similar overall *concentrations* of pollutants, cyclists (as compared to car passengers) had much higher inhaled *quantities* of pollutants as a result of having a greater than four-fold higher minute ventilation.[35] Finally, it is important to emphasize that the significant differences that emerged in some analyses (but not others) for company car, taxi use, and subway use were variable and highly inconsistent in sensitivity analysis. Particularly in light of the very small numbers of users of these vehicles in this study, we do not believe that any conclusions should be drawn for those three modes of transportation from this study.

We acknowledge that our study has some strengths and some weaknesses. It is a large scale, population-based study with an objective outcome. We were able to control for multiple important potential confounders, including occupation. There were also proportionally few subjects excluded for missing data. The most important limitation of this study is its cross-sectional design, which limits our ability to draw causal inferences. Some of the findings, however, are unlikely to be explained by reverse causality. For instance, there is no obvious reason why individuals who developed reduced lung function or airflow obstruction would stop driving and start cycling (or walking) to work. Confounding by unmeasured variables is always an additional concern in observational studies. For instance, in this study we were unable to adjust for family history of lung disease, as this information was not in our questionnaire. However, for this genetic factor to function as a confounder, it would have to be related to not only lung function, but also to mode of commuting, which seems highly improbable. Another concern relates to the possibility of residual confounding by SES, which is known to be related to lung function.[36] Notably, despite substantial reductions in power, some of our results remained significant after restricting the analysis to individual SES categories, e.g. for walkers. Additionally, we would expect that residual SES confounding might have biased some (but not all) of our other findings towards the null (for instance, we found that cyclists had higher lung function than bus riders, despite being *less* educated). Another concern relates to the fact that the exposure was determined as the mode of commuting used to get to work as ascertained at the time the survey was performed; it therefore may not reflect modes of transportation previously used, as well as secular trends in ambient pollution exposure over the course of subjects' lives. It should be similarly emphasized that the differences we found may not necessarily be the result of the mode of commuting itself, but of various other factors associated with that mode, such as characteristics of the route used. Finally, given differences in the transportation and urban milieu among cities, it would be important to repeat this analysis in different urban environments.

It is important to note that although our results were statistically significant, many of the effect estimates for FEV1 and FVC percent predicted were small, and would be of marginal clinical significance on the *individual* level. However, even relatively small shifts in the *distribution* of a risk factor for disease – like blood pressure – can result in substantial aggregate harm or benefit on the *population* level.[37] Likewise, the impact on pulmonary function of a nearly ubiquitous exposure like commuting may, in aggregate, be substantial.

Thus, considered together with other studies, this investigation may have important public health ramifications. Urbanization is being accompanied by a tremendous trend towards motorization in nations such as China and India.[14,15,38] In addition to increasing the risk of road injury,[39] motorization will likely be accompanied by increasing TRAP production. Ironically, in this study, those contributing the least to roadway pollution (e.g. walkers and perhaps cyclists) may in fact be those most affected by it, while those contributing the most (e.g. private car users) may, in fact, be protected. At the same time, however, it is important to note that regular physical activity has beneficial effects for health on its own. Therefore, from our perspective, the solution lies not in the further acceleration of trends towards motorization, but instead in the reduction of TRAP production itself, so as to ensure a safe commuting environment for all.

Conclusions

In conclusion, in this large-scale, population based study, we found that the mode of transportation used to commute to work was associated with differences in lung function, which may reflect differing levels of pollutants faced in the diverse transportation microenvironments.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

95% CI	95% confidence interval
FEV_1	Forced expiratory volume in one second

FVC	Forced vital capacity
LLN	lower limit of normal
OR	odds ratio
SES	socioeconomic status
SHS	second hand smoke
TRAP	traffic related air pollution

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Brief Summary

In Shanghai, China, certain modes of commuting to work are associated with reductions in pulmonary function.

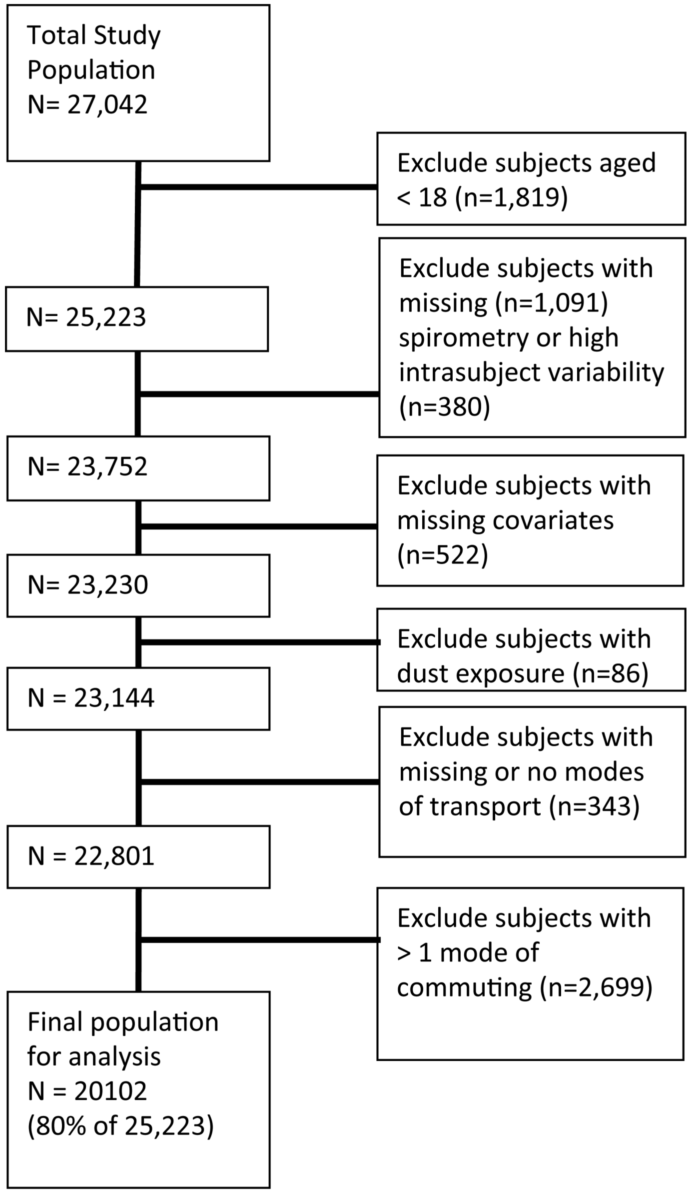

Figure 1.
Flowchart of study population formation

Table I

Characteristics of the study population, stratified by commuting mode (n = 20,102), n (%) or mean ± SD

	Total	Commuting Mode									
		Bus w/o AC	Bus w/ AC	Scooter	Taxi	Company Car	Private Car	Train	Subway	Walk	Bike
Subjects, n (%)	20102 (100)	2945 (14.7)	3650 (18.2)	2612 (13.0)	127 (0.6)	325 (1.6)	1913 (9.5)	18 (0.1)	138 (0.7)	3220 (16.0)	5154 (25.6)
Age, years	49.0 ± 16.4	52.0 ± 17.7	41.6 ± 15.8	41.0 ± 11.5	39.7 ± 9.6	47.4 ± 12.1	37.8 ± 9.6	28.8 ± 5.9	30.2 ± 8.9	61.3 ± 15.5	54.1 ± 13.0
Female	10880 (54.1)	1947 (66.1)	2391 (65.5)	943 (36.1)	30 (23.6)	43 (13.2)	665 (34.8)	7 (38.9)	70 (50.7)	2377 (73.8)	2407 (46.7)
Smoking											
current	4613 (23.0)	401 (13.6)	520 (14.3)	1015 (38.9)	67 (52.8)	169 (52.0)	617 (32.3)	4 (22.2)	16 (11.6)	387 (12.0)	1417 (27.5)
former	770 (3.8)	87 (3.0)	63 (1.7)	76 (2.9)	3 (2.4)	18 (5.5)	46 (2.4)	0 (0.0)	1 (0.7)	146 (4.5)	330 (6.4)
never	14719 (73.2)	2457 (83.4)	3067 (84.0)	1521 (58.2)	57 (44.9)	138 (42.5)	1250 (65.3)	14 (77.8)	121 (87.7)	2687 (83.5)	3407 (66.1)
Pack-years *	26.3 ± 36.4	25.5 ± 26.7	22.6 ± 35.4	21.4 ± 25.3	28.4 ± 46.1	31.0 ± 59.9	19.9 ± 29.4	20.9 ± 32.9	14.0 ± 11.1	33.9 ± 53.6	30.5 ± 36.4
Education											
≤elementary	7643 (38.0)	1154 (39.2)	690 (18.9)	679 (26.0)	26 (20.5)	53 (16.3)	168 (8.8)	0.0 (0.0)	5 (3.6)	2247 (69.8)	2621 (50.9)
middle/high	9080 (45.2)	1321 (44.9)	2002 (54.9)	1549 (59.3)	70 (55.1)	188 (57.9)	928 (48.5)	10 (55.6)	59 (42.8)	800 (24.8)	2153 (41.8)
≥college	3379 (16.8)	470 (16.0)	958 (26.3)	384 (14.7)	31 (24.4)	84 (25.9)	817 (42.7)	8 (44.4)	74 (53.6)	173 (5.4)	380 (7.4)
SHS ever	14985 (74.5)	2134 (72.5)	2590 (71.0)	2068 (79.2)	92 (72.4)	248 (76.3)	1388 (72.6)	14 (77.8)	77 (55.8)	2337 (72.6)	4037 (78.3)
Biomass ever users	16212 (80.7)	2442 (82.9)	2617 (71.7)	2012 (77.0)	94 (74.0)	264 (81.2)	1133 (59.2)	9 (50.0)	71 (51.5)	2913 (90.5)	4657 (90.4)
Occupation											
Farmer	108 (0.5)	3 (0.1)	2 (0.1)	4 (0.2)	0 (0.0)	0 (0.0)	2 (0.1)	0 (0)	0 (0)	80 (2.5)	17 (0.3)
Worker	1199 (6.0)	131 (4.5)	167 (4.6)	307 (11.8)	3 (2.4)	14 (4.3)	34 (1.8)	0 (0)	1 (0.72)	112 (3.5)	430 (8.3)
Professional	4338 (21.6)	501 (17.0)	1002 (27.5)	963 (36.9)	79 (62.2)	150 (46.2)	778 (40.7)	10 (55.6)	60 (43.5)	186 (5.8)	609 (11.8)
Administrator	2560 (12.7)	243 (8.3)	504 (13.8)	497 (19.0)	20 (15.8)	88 (27.1)	800 (41.8)	4 (22.2)	41 (29.7)	99 (3.1)	264 (5.1)
Services	1345 (6.7)	119 (4.0)	246 (6.7)	371 (14.2)	14 (11.0)	4 (1.2)	52 (2.7)	1 (5.6)	9 (6.5)	133 (4.1)	396 (7.7)
Household	341 (1.7)	24 (0.8)	71 (2.0)	19 (0.7)	0 (0)	0 (0)	4 (0.2)	0 (0)	0 (0)	138 (4.3)	85 (1.7)
Retired	8294 (41.3)	1639 (55.7)	1140 (31.2)	250 (9.6)	1 (0.8)	57 (17.5)	44 (2.3)	0 (0.0)	2 (1.5)	2312 (71.8)	2849 (55.3)
Other	1917 (9.5)	285 (9.7)	518 (14.2)	201 (7.7)	10 (7.9)	12 (3.7)	199 (10.4)	3 (16.7)	25 (18.1)	160 (5.0)	504 (9.8)
% FEV_1	97.8 ± 16.4	97.9 ± 17.6	98.9 ± 14.7	98.0 ± 14.0	98.6 ± 11.9	96.7 ± 13.9	99.8 ± 13.2	96.0 ± 14.0	97.7 ± 12.7	96.2 ± 19.6	97.3 ± 16.9
% FVC	89.0 ± 16.1	88.9 ± 17.2	91.6 ± 14.7	90.4 ± 14.2	92.2 ± 14.2	88.4 ± 14.3	93.5 ± 13.5	90.9 ± 12.8	94.1 ± 14.0	84.3 ± 18.0	87.6 ± 16.3

*Excludes never smokers

Table II

Adjusted estimates for percent predicted FEV_1 and FVC associated with mode of transportation

	FEV_1 % Predicted		FVC% Predicted	
Mode of Transport	**Effect Estimate (95% CI)**	**P-Value**	**Effect Estimate (95% CI)**	**P-Value**
Bus without AC	−1.32 (−2.05, −0.59)	<0.01	−1.04 (−1.73, −0.36)	<0.01
Bus with AC	−1.33 (−2.05, −0.61)	<0.01	−1.54 (−2.21, −0.87)	<0.01
Scooter	−0.13 (−0.93, 0.67)	0.76	−0.63 (−1.38, 0.11)	0.10
Taxi	0.87 (−1.96, 3.69)	0.55	1.19 (−1.46, 3.83)	0.38
Company Car	0.11 (−1.71, 1.92)	0.91	0.10 (−1.59, 1.80)	0.90
Private Car	0.91 (−0.02, 1.85)	0.06	0.95 (0.07, 1.82)	0.03
Train	−3.90 (−11.27, 3.47)	0.30	−4.53 (−11.42, 2.37)	0.20
Subway	−2.83 (−5.56, −0.10)	0.04	−1.72 (−4.27, 0.84)	0.19
Walk	−2.15 (−2.88, −1.42)	<.01	−2.79 (−3.48, −2.11)	<.01
Bicycle	Reference		Reference	

† Adjusted for age, gender, second-hand smoke exposure (yes or no), pack years, smoking status (current, former, and never), biomass exposure (yes or no), education (≤elementary, middle or high school, ≥ college), mode of transport, and occupational category (farmer, worker, professional, administrator, services, household duties, retired, or other).

Table III

Adjusted risk of airway obstruction (FEV_1/FVC < 70% and FEV_1/FVC < lower limit of normal) associated with mode of transportation (n=20,102)

	FEV_1/FVC < 70%		FEV1/FVC < LLN	
	Odds Ratio (95% CI) †	**P-Value**	**Odds Ratio (95% CI)** †	**P-Value**
Bus without AC	1.04 (0.76, 1.43)	0.81	1.12 (0.79, 1.59)	0.51
Bus with AC	0.79 (0.54, 1.15)	0.21	1.06 (0.75, 1.49)	0.76
Scooter	0.71 (0.44, 1.13)	0.15	0.85 (0.56, 1.27)	0.42
Taxi	2.11 (0.64, 6.91)	0.22	2.21 (0.78, 6.25)	0.14
Company Car	0.72 (0.26, 2.01)	0.53	1.10 (0.43, 2.77)	0.85
Private Car	0.43 (0.21, 0.86)	0.02	0.68 (0.41, 1.12)	0.13
Train	*	*	*	*
Subway	0.82 (0.11, 6.09)	0.85	1.50 (0.53, 4.28)	0.44
Walk	0.92 (0.67, 1.25)	0.57	1.00 (0.70, 1.42)	0.98
Bicycle	Reference	Reference		

†Adjusted for age, height, gender, SHS (yes or no), smoking history (current, former, and never), pack years of smoking, biomass exposure (yes or no), education (≤ elementary, middle or high school, ≥ college), mode of transport, and occupational category (farmer, worker, professional, administrator, services, household duties, retired, or other).

*Exhibited non-convergence, odds ratio/95% CI/p-value not reported.