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TOBACCO CONSUMPTION AND SECONDHAND SMOKE EXPOSURE IN VEHICLES: A CROSS-SECTIONAL STUDY

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ABSTRACT

Objectives: To estimate the prevalence of tobacco smoking and secondhand smoke (SHS) exposure in private cars, commercial vehicles and taxis in the city of Barcelona (Spain).

Design: We performed an observational study with a cross-sectional design (2011). We selected a systematic sample of 2442 private cars, commercial vehicles and taxis in 40 public roads regulated by traffic lights in all districts of Barcelona. We calculated the prevalence rates and 95% confidence intervals (95%CI) of smoking and SHS exposure in cars, and the corresponding odds ratio adjusting for the potential confounding variables.

Results: The prevalence of tobacco consumption was 5.5% (95%CI: 4.6-6.4) and it was greater for the commercial vehicles (9.8%; 95%CI: 7.1-12.5). The total prevalence of SHS exposure was 5.2% (95%CI: 3.8-6.6). 2.2% (95%CI: 0.5-3.9) of the passengers under 14 years old were exposed to SHS in vehicles.

Conclusion: This study highlights the need to promote public health measures aimed at reducing tobacco consumption in vehicles, especially in present of children, as well as compliance with the current Spanish law on health measures against smoking in commercial vehicles and taxis.

ARTICLE FOCUS

- Tobacco consumption and secondhand smoke (SHS) exposure in transportation deserves special public health attention because they are places of reduced dimensions, where the concentrations of SHS reached can be much higher than other environments.
- Tobacco consumption while driving is also a distraction that increases the risk of traffic accidents.
- Few studies have studied the consumption of tobacco and SHS exposure in vehicles through direct observation.

KEY MESSAGES

- Reducing smoking in vehicles in the presence of children has to be prioritized.
- Enforcement of smoking laws in commercial vehicles and taxis is needed.
- Smoking in vehicles should be recognized in the legislation as other distraction factors.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The main limitation of this study derives from the inherent observer bias, especially in variables as age, where physical appearance can entail a misclassification by the observer.
- Also noteworthy is the difficulty of obtaining a truly random and representative sample of vehicles in circulation in a city.
- A strength of an observational study like this compared with studies based on the use of questionnaires is the lack of information bias that comes directly from the self-reported questionnaires.

- The feasibility of direct observations were tested through a pilot study, which concluded that direct observation studies are a good resource for monitoring smoking in the drivers of motor vehicles.

INTRODUCTION

Secondhand smoke (SHS) is a complex mixture of pollutants that includes toxic and irritant compounds, as well as carcinogenic substances.[1,2] SHS has been classified by the International Agency for Research on Cancer (IARC) as type I carcinogen to humans.[2] In 2004 it was estimated that 1% of global mortality (603000 deaths) was attributable to SHS exposure.[3] Specifically, in Spain, it is estimated that between 1228 and 3237 deaths from lung cancer and myocardial infarction were attributable to SHS exposure in 2002.[4] Although there is a dose-response effect and no level of SHS exposure can be considered safe,[5] the intensity of the exposure depends on how long you are exposed and the concentration of SHS in the air. In this way, tobacco consumption and SHS exposure in transportation deserves special attention because they are places of reduced dimensions, where the concentrations of SHS reached can be much higher than other environments (home, workplace or leisure as discos and bars).[6,7] Moreover, concentrations of particulate matter with diameter inferior to 2.5µm ($PM_{2.5}$) can be reached inside vehicles when there are people smoking [6-10] even exceeding the limits recommended by the Environmental Protection Agency (EPA).[11]

Few studies have studied the consumption of tobacco and SHS exposure in vehicles through direct observation.[12,13] To our knowledge, only a cross-sectional study using questionnaires has been done in Spain.[14] The objective of this study is to estimate the prevalence of tobacco consumption and SHS exposure in private cars, commercial vehicles, and taxis in the city of Barcelona.

METHODS

Sampling, sample size and site selection

A cross-sectional study was conducted through direct observation of the occupants of private cars, commercial vehicles, and taxis in the city of Barcelona. The fieldwork was conducted during April and May 2011. For each of the 10 districts of Barcelona, we randomly selected 2 public roads of the 15 with greater traffic flow rates and 2 public roads of the 5 with greater density of nurseries and primary and secondary education schools to ensure the presence of children in vehicles. For the selection of the public roads we consulted the "Araña de Tráfico" of 2011 of the Mobility Services Division of Barcelona City Council.[15] We selected a total of 40 public roads (4 per district, 2 with greater traffic flow rates and 2 with greater school density). For each of the public roads, a traffic light was selected as an observation point where a trained observer conducted the direct observation of the vehicles and recorded the variables of interest in an *ad hoc* designed data collection sheet.

The theoretical sample size was of 2401 vehicles assuming an expected prevalence of 50% with a 95% confidence interval and a precision of 2%. The strategy of selecting the sample size was expected to assume different prevalences in relation to two previous studies:[12,14] 10% in Italy and 20% in Spain. Finally we assume a 50% prevalence that maximizes the statistical power in order to stratify the results by type of vehicle. The final sample size was 2442 vehicles. The distribution of the number of observations was made in proportion to the traffic flow rates in each public road. The observations were made when the traffic light was red for vehicles. We systematically selected the first two vehicles in the adjacent lane to the observer. We excluded adjacent lanes which were exclusive for buses, taxis, and bicycles. The study included any private car, commercial vehicle (tourism derivative, adaptive mixed vehicle and vans with the presence of company logo or slogan) and taxi. We excluded from the study buses, coaches, trucks, motorcycles, bicycles and other public service vehicles (ambulances, police cars, driving school cars, etc.). We also excluded those cars that did not permit the visibility of the occupants because they have tinted windows. When the vehicles did not meet the inclusion criteria, we proceeded to the observation of the next vehicle in line. The observations were made continuously with an average duration of one hour within the fixed schedule (morning from 8 to 11h and afternoon from 17 to 19h) Monday through Friday.

Study variables

We defined variables of driver, passengers, and vehicle. The driver variables studied were: tobacco consumption (yes/no), approximate age (18-34/35-64/≥65 years old) and sex (male/female). Passenger variables were: the total number of passengers, number of passengers who smoked and the number of passengers under 14 years old. Vehicle variables collected were: the type (private car/commercial vehicle/taxi), the number of open windows of the vehicle, and whether the driver's window was open (yes/no). We also collected contextual variables (day of the week, district, time, weather, and number of lanes of the public road).

The two main variables of study, tobacco consumption in drivers and passengers, were defined as the presence of any burning tobacco product in the hand or mouth of the driver or passenger. From these variables, two new variables were created: one that recorded the total tobacco consumption (driver and/or passenger) and the other SHS exposure, that is, if one occupant (driver or passenger) was exposed to SHS. District variable was recoded into 3 groups according to district socioeconomic status of the district in question.[16]

Prior to the fieldwork, we conducted a pilot study [17] to evaluate the feasibility of the observations and standardize the data collection sheet, as well as to analyze the degree of agreement between 2 observers in obtaining information. This pilot study demonstrated the feasibility of the direct observation designed and a perfect inter-observer concordance (Kappa index of 1.0) for monitoring the consumption of tobacco.

Statistical analysis

We performed a descriptive analysis of tobacco consumption and SHS exposure stratified by variables of driver, passengers, vehicle, and context. We calculated the prevalence of smoking and SHS exposure and their confidence intervals at 95% (95%CI).[18] We performed chi-square test (χ^2) to compare the prevalence rates. We fitted a logistic regression model to obtain the adjusted odds ratio (OR) and 95%CI of smoking in cars by drivers. All analysis were performed using the statistical package SPSS v.15.

This research did not use personal data or biological samples, so approval was not required by the Ethics Committee of Bellvitge University Hospital.

RESULTS

We made 2442 observations, of which 71.1% were private cars, 19.7% commercial vehicles and 9.2% taxis. More than half of the observations (53.9%) were conducted on public roads with more than 2 lanes. 77.8% of drivers were men and most common age range was 36-64 years old (69.6%). Of all the vehicles observed, 62.6% went without passengers. There was a passenger under 14 years old in 29.7% of the vehicles with passengers (11.1% of all vehicles). 53.4% of vehicles observed had all the windows closed.

Table 1 shows the prevalence of smoking and SHS total exposure of the driver and/or passenger according to type of vehicle. The prevalence of tobacco consumption in vehicles (private, commercial, and taxis) was 5.5% (95%CI: 4.6-6.4). The prevalence of tobacco consumption was higher in commercial vehicles (9.8%, 95%CI: 7.1-12.5). The prevalence of tobacco consumption among drivers was 4.7% (95%CI: 3.9-5.5) and 2.4% (95%CI: 1.4-3.4) among the passengers, this difference was maintained according to vehicle type (table 1). The overall prevalence of SHS exposure was 5.2% (95%CI: 3.8-6.6). The commercial vehicle occupants were the most exposed to SHS (12.7%, 95%CI: 7.1-18.3), while in taxis was not observed exposure to SHS in any occupant (driver or passenger). Passengers were slightly more exposed to SHS than drivers (3.0% *vs*. 2.2%, p=0.283). This difference was three-fold in commercial vehicles (9.7% *vs*. 3.0%, p=0.024). The prevalence of passengers under 14 years old exposed to SHS in vehicles was 2.2% (95%CI: 0.5-3.9) (table 1).

Table 2 shows the prevalence of driver's tobacco consumption according to vehicle type, variables of driver, vehicle and context. The prevalence of smoking in drivers was almost twofold in men than in women (5.2% *vs*. 2.9%, p=0.031). There was a statistically significant downward trend in the consumption of tobacco according to the age of the driver, although this trend was not statistically significant in commercial vehicles and taxis. Although consumption of tobacco in drivers was higher in districts with more socioeconomic deprivation (5.2%, 95%CI: 3.8-6.6), this difference was not statistically significant. The overall prevalence of tobacco consumption was higher in the morning than in the afternoon (5.3% *vs*. 3.8%, p=0.097), especially in commercial vehicles (11.6% *vs*. 4.1%, p=0.006). The prevalence of tobacco consumption among drivers was greater on cloudy days than sunny or shinnies, regardless of vehicle type (table 2).

In bivariate logistic regression models we confirmed a stronger association of driver's tobacco consumption when the driver was a man (OR=1.79, 95%CI: 1.05-3.07), had an age range of 18-34 years old (OR=9.61, 95% CI: 1.31-70.53), was driving a commercial vehicle (OR=2.48, 95%CI: 1.66-3.69) and had his window open (OR=10.50, 95%CI: 5.86-18.82) (table 3). After adjusting a saturated model with all potential confounders, this association was statistically significant only for the driver's window open (OR=11.05, 95%CI: 6.08-20.09), time of the day (OR=1.83, 95%CI: 1.20-2.79) and weather (OR=1.69, 95%CI: 1.11-2.57) (table 3).

DISCUSSION

This is the first study in Spain that estimates the prevalence of tobacco consumption and SHS exposure in transportation through direct observation of vehicles. The results of this study show that the prevalence of tobacco consumption and SHS exposure in vehicles in the city of Barcelona is high, especially in commercial vehicles.

The prevalence of tobacco consumption in vehicles observed in our study is similar to that observed in studies carried out in Italy [12] and New Zealand,[13] which also made direct observation of vehicles. However, SHS exposure in vehicles in our study (5.2%) is much lower than that observed in the study of New Zealand (23.7%). The difference could be related to social and contextual differences such as the different population size between municipalities observed in Karori, Wainuiomata and Wellington, New Zealand (less than 410000 inhabitants) and Barcelona, Spain (about 1.6 millions of inhabitants) and also different year in which the studies were done.

The prevalence rates obtained in studies using questionnaires [14,19] are considerably higher than those estimated in studies using direct observations as the present study. One possible reason could be the inability of observational studies to monitor the entire car trip of the driver, who could smoke at any time or even smoke more than one cigarette, which are however catched in classical cross-sectional studies using questionnaires. This limitation could lead to a potential underestimation of prevalence obtained in studies that use direct observations.

On the other hand, tobacco consumption in our study was higher when any of the windows of the vehicle was open, as in previous studies.[13] This may be due to the belief, on the part of smokers, that the adverse health effects of tobacco consumption in vehicles are minimized when a window is open.[20] However, although levels of $PM_{2.5}$ are lower in vehicle ventilation conditions, these levels are still unhealthy.[6,9,10]

The prevalence of SHS exposure in children was high compared to that observed in the Italian study (0.9%).[12] This difference could be attributed to the fact that in our study half of the public roads had high school density. This fact should be taken into account since children are inevitably more vulnerable to the effects of SHS exposure.[21] In this sense, a study conducted in Ireland [22] found an increased likelihood of developing respiratory and allergic symptoms in children aged 13-14 years old exposed to SHS in vehicles, with wheezing as the most obvious symptom. Therefore, it becomes clear the need to prioritize public health policies in Spain, aimed at reducing tobacco consumption in private cars if children are present. Moreover, a study conducted through telephone surveys in four countries (Australia, Canada, United Kingdom and United States of America) concluded that the majority of smokers (more than 60%) would ban smoking in vehicles if children are present,[23] with higher approval of smokers with less tobacco dependence and with young children (<5 years old) *versus* those without children. This support for restricting smoking in vehicles is also found in studies carried out among adolescents.[24,25]

The observed prevalence of tobacco consumption in commercial vehicles and taxis have been especially high considering that the current Spanish legislation on tobacco (Law 42/2010) [26] bans smoking in commercial vehicles and taxis because they are workplaces and even also public places. Furthermore, since in our study the prevalence of tobacco consumption and SHS exposure in commercial vehicles has been very high, like those seen in Italy,[12] enforcement measures of the current legislation should be promoted.

On the other hand, tobacco consumption in taxis was never observed in the presence of passengers. Although the passengers of taxis did not have direct SHS exposure, recent studies [27,28] have highlighted the possible effects of exposure to the deposit and accumulation of SHS particles on the surface of vehicle seats, air or dust. The involuntary inhalation, ingestion or skin absorption of these surface and air particles is known as thirdhand smoke exposure.[27] While there is still insufficient evidence to assess the health hazards from thirdhand smoke, further studies should investigate its potential for exposure and its health effects.

Tobacco consumption while driving is also a distraction that increases the risk of traffic accidents.[29-31] It is estimated that, compared with non-smoking drivers, drivers who smoked are 1.5 times more likely to have an accident.[32] Smoking distraction is associated, among others, to the decrease in manual dexterity with the steering wheel, the attention reduction when the cigarette is being lighted or put out and eye irritation caused by carbon monoxide present in SHS, not to mention the lower perception of risk that smokers have at wheel *versus* nonsmokers.[32] In this sense, a survey conducted by the Spanish National Road Safety Observatory of General Directorate of Traffic [33] in 2005 revealed that 83.8% of the interviewed drivers thought that tobacco consumption is a source of distraction while driving. In addition, 76.8% thought smoking is a fairly or very dangerous behavior while driving. Given the evidence of the health hazards of smoking while driving and the broad general perception of risk by the population, this habit should be approached the same way as other distraction factors recognized by the Spanish law as the use of mobile phones or other devices manualing operated, such as GPS systems.[34]

The main limitation of this study derives from the inherent observer bias, especially in variables as age, where the biological variability regarding physical appearance can entail a misclassification by the observer. However, the pilot study [17] carried out by two independent observers showed an almost perfect agreement in the observation. We cannot disregard selection bias, since the search for public roads with greater density of schools could over-represent the presence of children in vehicles.

We have used logistic regression as a measure of association in a cross-sectional study. However, the OR only overestimates the prevalence ratio when it is above 20%,[35] which is not the case of our data. Also noteworthy is the difficulty of obtaining a truly random and representative sample of vehicles in circulation in a city. Our sampling approach, designed to be representative of all districts of Barcelona, was directed to minimize this limitation. A strength of an observational study like this compared with studies based on the use of questionnaires is the lack of information bias that comes directly from the self-reported questionnaires.

In conclusion, this study provides an estimation of smoking in cars and highlights the need to promote public health measures aimed at reducing tobacco consumption in private cars, especially in the presence of children, as well as the enforcement of measures to control smoking in commercial vehicles and taxis.

CONTRIBUTORS

All authors contributed in the design of the study. AC collected the data, prepared the database and analyzed the data. JMMS and EF revised with her the results. All the authors contributed to the interpretation of results. AC drafted the manuscript, which was critically revised by JMMS and EF. All authors approved the final version.

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COMPETING INTERESTS

The authors have no competing interests.

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Table 1 Prevalence (%) of tobacco consumption and SHS exposure in vehicles in the city of Barcelona, Spain (2011).

	TOTAL			PRIVATE			COMMERCIAL			TAXI		
Tobacco consumption	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**
Driver and/or passenger	2442	5.5	(4.6-6.4)	1736	4.7	(3.7-5.7)	482	9.8	(7.1-12.5)	224	2.2	(0.3-4.1)
Driver	2442	4.7	(3.9-5.5)	1736	3.8	(2.9-4.7)	482	8.9	(6.4-11.4)	224	2.2	(0.3-4.1)
Passenger	913	2.4	(1.4-3.4)	685	2.6	(1.4-3.8)	134	3.0	(0.1-5.9)	94	0.0	(0.0-3.9)
SHS exposure												
Any occupant	913	5.2	(3.8-6.6)	685	4.3	(2.8-5.8)	134	12.7	(7.1-18.3)	94	0.0	(0.0-3.9)
Driver	913	2.2	(1.2-3.2)	685	2.3	(1.2-3.4)	134	3.0	(0.1-5.9)	94	0.0	(0.0-3.9)
Passenger	913	3.0	(1.9-4.1)	685	2.0	(1.0-3.0)	134	9.7	(4.7-14.7)	94	0.0	(0.0-3.9)
Passenger <14 years old	271	2.2	(0.5-3.9)	253	2.0	(0.3-3.7)	12	8.3	(1.5-35.4)	6	0.0	(0.0-39.0)

[a]95% confidence interval

Table 2 Prevalence (%) of driver's tobacco consumption by vehicle type and variables of driver, vehicle and context in the city of Barcelona, Spain.

	TOTAL (n=2442)		PRIVATE (n=1736)		COMMERCIAL (n=482)		TAXI (n=224)	
	% (95%CI)[a]	p	% (95%CI)[a]	p	% (95%CI)[a]	p	% (95%CI)[a]	p
Sex		0.031		0.223		0.351		0.708
Male	5.2 (4.2-6.2)		4.2 (3.1-5.3)		9.2 (6.5-11.9)		2.3 (0.3-4.3)	
Female	2.9 (1.5-4.3)		2.9 (1.4-4.4)		3.8 (0.7-18.9)		0 (0.0-39.0)	
Age		0.002		0.001		0.945		0.345
18-34 years	6.6 (4.6-8.6)		6.1 (3.9-8.3)		8.4 (3.6-13.2)		5.3 (0.9-24.6)	
35-64 years	4.3 (3.3-5.3)		3.2 (2.2-4.2)		9.4 (6.3-12.5)		2.0 (0.1-3.9)	
≥65 years	0.7 (0.1-4.0)		0.8 (0.1-4.4)		0 (0.0-27.8)		0 (0.0-65.8)	
Socioeconomic status[b]		0.628		0.277		0.585		0.268
Low	5.2 (3.8-6.6)		4.7 (3.1-6.3)		7.4 (3.7-11.1)		3.9 (0.1-7.7)	
Medium	4.3 (3.0-5.6)		3.1 (1.8-4.4)		9.3 (5.3-13.3)		1.2 (0.2-6.6)	
High	4.5 (2.7-6.3)		3.4 (1.5-5.3)		11.1 (4.6-17.6)		0 (0.0-8.8)	
Driver's open window		<0.001		<0.001		0.001		0.089
Yes	9.3 (7.6-11.0)		9.1 (6.9-11.3)		12.3 (8.6-16.0)		3.5 (0.5-6.5)	
No	1.0 (0.5-1.5)		0.6 (0.1-1.1)		3.3 (0.7-5.9)		0 (0.0-4.5)	
Time		0.097		0.947		0.006		0.150
Morning (8-11h)	5.3 (4.1-6.5)		3.8 (2.6-5.0)		11.6 (8.0-15.2)		0.9 (0.2-4.7)	
Afternoon (17-19h)	3.8 (2.6-5.0)		3.8 (2.4-5.2)		4.1 (1.1-7.1)		3.7 (0.1-7.3)	
Weather		0.230		0.506		0.855		0.004
Shiny-sunny	4.3 (3.3-5.3)		3.6 (2.6-4.6)		9.1 (5.9-12.3)		0.6 (0.1-3.3)	
Cloudy	5.4 (3.8-7.0)		4.3 (2.5-6.1)		8.6 (4.3-12.9)		7.1 (0.4-13.8)	

[a]95% confidence interval

[b]According to socioeconomic status of district

Table 3 Crude and adjusted odds ratio (OR) and 95% confidence intervals (95%CI) of smoking in cars by drivers.

	$_{c}$OR	(95%CI)[a]	p	$_{a}$OR	(95%CI)[a]	p
Sex						
Male	1.79	(1.05-3.07)	0.033	1.46	(0.83-2.59)	0.193
Female	1	-		1	-	
Age						
18-34 years old	9.61	(1.31-70.53)	0.026	6.85	(0.92-51.18)	0.061
35-64 years old	6.11	(0.84-44.30)	0.073	5.12	(0.69-37.81)	0.109
≥65 years old	1	-		1	-	
Vehicle type						
Private	1	-		1	-	
Commercial	2.48	(1.66-3.69)	<0.001	1.36	(0.89-2.10)	0.158
Taxi	0.58	(0.23-1.45)	0.242	0.34	(0.13-0.86)	0.023
Socioeconomic status[b]						
Low	1.15	(0.69-1.91)	0.605	1.18	(0.69-2.00)	0.548
Medium	0.93	(0.55-1.58)	0.801	0.98	(0.57-1.68)	0.930
High	1	-		1	-	
Driver's open window						
Yes	10.50	(5.86-18.82)	<0.001	11.05	(6.08-20.09)	<0.001
No	1	-		1	-	
Time						
Morning (8-11h)	1.40	(0.94-2.08)	0.099	1.83	(1.20-2.79)	0.005
Afternoon (17-19h)	1	-		1	-	
Weather						
Shiny-sunny	1	-		1	-	
Cloudy	1.27	(0.86-1.89)	0.231	1.69	(1.11-2.57)	0.014

$_{c}$OR: crude odds ratio

$_{a}$OR: adjusted OR derived from a logistic regression model adjusted for driver's sex, age and window, vehicle type, district, time and weather

[a]95% Confidence interval

[b]According to socioeconomic status of district

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

TOBACCO CONSUMPTION AND SECONDHAND SMOKE EXPOSURE IN VEHICLES: A CROSS-SECTIONAL STUDY

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TOBACCO CONSUMPTION AND SECONDHAND SMOKE EXPOSURE IN VEHICLES: A CROSS-SECTIONAL STUDY

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Keywords: tobacco consumption, secondhand smoke, private cars, commercial vehicles

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ABSTRACT

Objectives: To estimate the prevalence of tobacco smoking and secondhand smoke (SHS) exposure in private cars, commercial vehicles and taxis in the city of Barcelona (Spain).

Design: We performed an observational study with a cross-sectional design (2011). We selected a systematic sample of 2442 private cars, commercial vehicles and taxis in 40 public roads regulated by traffic lights in all districts of Barcelona. We calculated the prevalence rates and 95% confidence intervals (95%CI) of smoking and SHS exposure in cars, and the corresponding odds ratio adjusting for the potential confounding variables.

Results: The prevalence of tobacco consumption was 5.5% (95%CI: 4.6-6.4) and it was greater for the commercial vehicles (9.8%; 95%CI: 7.1-12.5). The total prevalence of SHS exposure was 5.2% (95%CI: 3.8-6.6). 2.2% (95%CI: 0.5-3.9) of the passengers under 14 years old were exposed to SHS in vehicles.

Conclusions: This study highlights the need to promote public health measures aimed at reducing tobacco consumption in vehicles, especially in the presence of children, as well as compliance with the current Spanish law on health measures against smoking in commercial vehicles and taxis.

ARTICLE FOCUS

- Tobacco consumption and secondhand smoke (SHS) exposure in transportation deserves special public health attention because they are places of reduced dimensions, where the concentrations of SHS reached can be much higher than other environments.
- Tobacco consumption while driving is also a distraction that increases the risk of traffic accidents.
- Few studies have studied the consumption of tobacco and SHS exposure in vehicles through direct observation.

KEY MESSAGES

- Reducing smoking in vehicles in the presence of children has to be prioritized.
- Enforcement of smoking laws in commercial vehicles and taxis is needed.
- Smoking in vehicles should be recognized in the legislation as other distraction factors.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The main limitation of this study derives from the inherent observer bias, especially in variables as age, where physical appearance can entail a misclassification by the observer.
- Also noteworthy is the difficulty of obtaining a truly random and representative sample of vehicles in circulation in a city.
- A strength of an observational study like this compared with studies based on the use of questionnaires is the lack of information bias that comes directly from the self-reported questionnaires.

- The feasibility of direct observations were tested through a pilot study, which concluded that direct observation studies are a good resource for monitoring smoking in the drivers of motor vehicles.

INTRODUCTION

Secondhand smoke (SHS) is a complex mixture of pollutants that includes toxic and irritant compounds, as well as carcinogenic substances.[1,2] SHS has been classified by the International Agency for Research on Cancer (IARC) as type I carcinogen to humans.[2] In 2004 it was estimated that 1% of global mortality (603000 deaths) was attributable to SHS exposure.[3] Specifically, in Spain, it is estimated that between 1228 and 3237 deaths from lung cancer and myocardial infarction were attributable to SHS exposure in 2002.[4]

Although there is a dose-response effect and no level of SHS exposure can be considered safe,[5] the intensity of the exposure depends on how long you are exposed and the concentration of SHS in the air. In this way, tobacco consumption and SHS exposure in transportation deserves special attention because they are places of reduced dimensions, where the concentrations of SHS reached can be much higher than other environments (home, workplace or leisure settings such as discos and bars).[6,7] Moreover, concentrations of particulate matter with diameter inferior to 2.5μm ($PM_{2.5}$) can be reached inside vehicles when there are people smoking [6-10] even exceeding the limits recommended by the Environmental Protection Agency (EPA).[11]

Few studies have studied the consumption of tobacco and SHS exposure in vehicles through direct observation.[12,13] To our knowledge, only a cross-sectional study using questionnaires has been done in Spain.[14] The objective of this study is to estimate the prevalence of tobacco consumption and SHS exposure in private cars, commercial vehicles, and taxis in the city of Barcelona.

METHODS

Sampling, sample size and site selection

A cross-sectional study was conducted through direct observation of the occupants of private cars, commercial vehicles, and taxis in the city of Barcelona. The fieldwork was conducted during April and May 2011. For each of the 10 districts of Barcelona, we randomly selected 2 public roads of the 15 with greater traffic flow rates and 2 public roads of the 5 with greater density of nurseries and primary and secondary education schools to ensure the presence of children in vehicles. For the selection of the public roads we consulted the "Araña de Tráfico" of 2011 of the Mobility Services Division of Barcelona City Council.[15] We selected a total of 40 public roads (4 per district, 2 with greater traffic flow rates and 2 with greater school density). For each of the public roads, a traffic light was selected as an observation point where a trained observer conducted the direct observation of the vehicles and recorded the variables of interest in an *ad hoc* designed data collection sheet.

The theoretical sample size was of 2401 vehicles assuming an expected prevalence of 50% with a 95% confidence interval and a precision of 2%. The strategy of selecting the sample size was expected to assume different prevalences in relation to two previous studies:[12,14] 10% in Italy and 20% in Spain. Finally we assume a 50% prevalence that maximizes the statistical power in order to stratify the results by type of vehicle. The final sample size was 2442 vehicles. The distribution of the number of observations was made in proportion to the traffic flow rates in each public road. The observations were made when the traffic light was red for vehicles. We systematically selected the first two vehicles in the adjacent lane to the observer. We excluded adjacent lanes which were exclusive for buses, taxis, and bicycles. The study included any private car, commercial vehicle (tourism derivative, adaptive mixed vehicle and vans with the presence of company logo or slogan) and taxi. We excluded from the study buses, coaches, trucks, motorcycles, bicycles and other public service vehicles (ambulances, police cars, driving school cars, etc.). We also excluded those cars that did not permit the visibility of the occupants because they have tinted windows. When the vehicles did not meet the inclusion criteria, we proceeded to the observation of the next vehicle in line. The observations were made continuously with an average duration of one hour within the fixed schedule (morning from 8 to 11h and afternoon from 17 to 19h) Monday through Friday.

Study variables

We defined variables of driver, passengers, and vehicle. The driver variables studied were: tobacco consumption (yes/no), approximate age (18-34/35-64/≥65 years old) and sex (male/ female). Passenger variables were: the total number of passengers, number of passengers who smoked and the number of passengers under 14 years old. Vehicle variables collected were: the type (private car/commercial vehicle/taxi), the number of open windows of the vehicle, and whether the driver's window was open (yes/no). We also collected contextual variables (day of the week, district, time, weather, and number of lanes of the public road).

The two main variables of study, tobacco consumption in drivers and passengers, were defined as the presence of any burning tobacco product in the hand or mouth of the driver or passenger. From these variables, two new variables were created: one that recorded the total tobacco consumption (driver and/or passenger) and the other SHS exposure, that is, if one occupant (driver or passenger) was exposed to SHS. District variable was recoded into 3 groups according to district socioeconomic status of the district in question.[16]

Prior to the fieldwork, we conducted a pilot study [17] to evaluate the feasibility of the observations and standardize the data collection sheet, as well as to analyze the degree of agreement between 2 observers in obtaining information. This pilot study demonstrated the feasibility of the direct observation designed and a perfect inter-observer concordance for monitoring the consumption of tobacco and number of passengers under 14 years old (simple inter-observer agreement = 100% and Kappa coefficient = 1.0). The driver's age presented however the lowest inter-observer concordance (simple inter-observer agreement = 94.3% and Kappa coefficient = 0.865) [17].

Statistical analysis

We performed a descriptive analysis of tobacco consumption and SHS exposure stratified by variables of driver, passengers, vehicle, and context. We calculated the prevalence of smoking and SHS exposure and their confidence intervals at 95% (95%CI).[18] We performed chi-square test (χ^2) to compare the prevalence rates. We fitted a logistic regression model to obtain the adjusted odds ratio (OR) and 95%CI of smoking in cars by drivers. All analysis were performed using the statistical package SPSS v.15.

This research did not use personal data or biological samples, so approval was not required by the Ethics Committee of Bellvitge University Hospital.

RESULTS

We made 2442 observations, of which 71.1% were private cars, 19.7% commercial vehicles and 9.2% taxis. More than half of the observations (53.9%) were conducted on public roads with more than 2 lanes. 77.8% of drivers were men and most common age range was 36-64 years old (69.6%). Of all the vehicles observed, 62.6% went without passengers. There was a passenger under 14 years old in 29.7% of the vehicles with passengers (11.1% of all vehicles). 53.4% of vehicles observed had all the windows closed.

Table 1 shows the prevalence of smoking and SHS total exposure of the driver and/or passenger according to type of vehicle. The prevalence of tobacco consumption in vehicles (private, commercial, and taxis) was 5.5% (95%CI: 4.6-6.4). The prevalence of tobacco consumption was higher in commercial vehicles (9.8%, 95%CI: 7.1-12.5). The prevalence of tobacco consumption among drivers was 4.7% (95%CI: 3.9-5.5) and 2.4% (95%CI: 1.4-3.4) among the passengers, this difference was maintained according to vehicle type (table 1). The overall prevalence of SHS exposure was 5.2% (95%CI: 3.8-6.6). The commercial vehicle occupants were the most exposed to SHS (12.7%, 95%CI: 7.1-18.3), while in taxis there was no observed tobacco consumption or occupant exposure to SHS. Passengers were slightly more likely to be exposed to SHS than drivers (3.0% *vs*. 2.2%, p=0.283). This difference was three-fold in commercial vehicles (9.7% *vs*. 3.0%, p=0.024). The prevalence of passengers under 14 years old exposed to SHS in vehicles was 2.2% (95%CI: 0.5-3.9) (table 1).

Table 2 shows the prevalence of driver's tobacco consumption according to vehicle type, variables of driver, vehicle and context. The prevalence of smoking in drivers was almost twofold in men than in women (5.2% *vs*. 2.9%, p=0.031). There was a statistically significant downward trend in the consumption of tobacco according to the age of the driver, although this trend was not statistically significant in commercial vehicles and taxis. Although consumption of tobacco in drivers was higher in districts with more socioeconomic deprivation (5.2%, 95%CI: 3.8-6.6), this difference was not statistically significant. The overall prevalence of tobacco consumption was higher in the morning than in the afternoon (5.3% *vs*. 3.8%, p=0.097), especially in commercial vehicles (11.6% *vs*. 4.1%, p=0.006). The prevalence of tobacco consumption among drivers was greater on cloudy days than sunny, regardless of vehicle type (table 2).

In bivariate logistic regression models we confirmed a stronger association of driver's tobacco consumption when the driver was a man (OR=1.79, 95%CI: 1.05-3.07), had an age range of 18-34 years old (OR=9.61, 95% CI: 1.31-70.53), was driving a commercial vehicle (OR=2.48, 95%CI: 1.66-3.69) and had his window open (OR=10.50, 95%CI: 5.86-18.82) (table 3). After adjusting a saturated model with all potential confounders, this association was statistically significant only for the driver's window open (OR=11.05, 95%CI: 6.08-20.09), time of the day (OR=1.83, 95%CI: 1.20-2.79) and weather (OR=1.69, 95%CI: 1.11-2.57) (table 3).

DISCUSSION

This is the first study in Spain that estimates the prevalence of tobacco consumption and SHS exposure in transportation through direct observation of vehicles. The results of this study show that the prevalence of tobacco consumption and SHS exposure in vehicles in the city of Barcelona is high, especially in commercial vehicles.

The prevalence of tobacco consumption in vehicles observed in our study is similar to that observed in studies carried out in Italy [12] and New Zealand,[13] which also made direct observation of vehicles. However, SHS exposure in vehicles in our study (5.2%) is much lower than that observed in the study of New Zealand (23.7%). The difference could be related to social and contextual differences such as the different population size between municipalities observed in Karori, Wainuiomata and Wellington, New Zealand (less than 410000 inhabitants) and Barcelona, Spain (about 1.6 millions of inhabitants) and also different year in which the studies were done.

The prevalence rates obtained in studies using questionnaires [14,19] are considerably higher than those estimated in studies using direct observations as the present study. One possible reason could be the inability of observational studies to monitor the entire car trip of the driver, who could smoke at any time or even smoke more than one cigarette. However, the driver's consumption of tobacco during the entire journey can be obtained in classical cross-sectional studies using questionnaires. This limitation could lead to a potential underestimation of prevalence obtained in studies that use direct observations as it happens in studies based on direct observations in bars, which have reported an almost three-fold greater actual number of smokers in comparison with the number of smokers found through direct observations.[20] This aspect should worthy be addressed in future studies.

On the other hand, tobacco consumption in our study was higher when any of the windows of the vehicle was open, as in previous studies.[13] This may be due to the belief, on the part of smokers, that the adverse health effects of tobacco consumption in vehicles are minimized when a window is open.[21] However, although levels of $PM_{2.5}$ are lower in vehicle ventilation conditions, these levels are still unhealthy.[6,9,10,22]

The prevalence of SHS exposure in children was high compared to that observed in the Italian study (0.9%).[12] This difference could be attributed to the fact that in our study half of the public roads had high school density. This fact should be taken into account since children are inevitably more vulnerable to the effects of SHS exposure.[23] In this sense, a study conducted in Ireland [24] found an increased likelihood of developing respiratory and allergic symptoms in children aged 13-14 years old exposed to SHS in vehicles, with wheezing as the most obvious symptom. Therefore, it becomes clear the need to prioritize public health policies in Spain, aimed at reducing tobacco consumption in private cars if children are present. Moreover, a study conducted through telephone surveys in four countries (Australia, Canada, United Kingdom and United States of America) concluded that the majority of smokers (more than 60%) would ban smoking in vehicles if children are present,[25] with higher approval of smokers with less tobacco dependence and with young children (<5 years old) *versus* those without children. This support for restricting smoking in vehicles is also found in studies carried out among adolescents.[26,27]

The observed prevalence of tobacco consumption in commercial vehicles and taxis have been especially high considering that the current Spanish legislation on tobacco (Law 42/2010) [28] bans smoking in commercial vehicles and taxis because they are workplaces and even also public places. Furthermore, since in our study the prevalence of tobacco consumption and SHS exposure in commercial vehicles has been very high, like those seen in Italy,[12] enforcement measures of the current legislation should be promoted.

On the other hand, tobacco consumption in taxis was never observed in the presence of passengers. Although the passengers of taxis did not have direct SHS exposure, recent studies [29,30] have highlighted the possible effects of exposure to the deposit and accumulation of SHS particles on the surface of vehicle seats, air or dust. The involuntary inhalation, ingestion or skin absorption of these surface and air particles is known as thirdhand smoke exposure.[29] While there is still insufficient evidence to assess the health hazards from thirdhand smoke, further studies should investigate its potential for exposure and its health effects.

Tobacco consumption while driving is also a distraction that increases the risk of traffic accidents.[31-33] It is estimated that, compared with non-smoking drivers, drivers who smoked are 1.5 times more likely to have an accident.[34] Distraction caused by smoking is associated to, among others, the decrease in manual dexterity with the steering wheel and the reduction of attention to the road (when the cigarette is being lighted or put out and the eye irritation caused by carbon monoxide present in SHS), not to mention the lower perception of risk that smokers have at wheel *versus* nonsmokers.[34] In this sense, a survey conducted by the Spanish National Road Safety Observatory of General Directorate of Traffic [35] in 2005 revealed that 83.8% of the interviewed drivers thought that tobacco consumption is a source of distraction while driving. In addition, 76.8% thought smoking is a fairly or very dangerous behavior while driving. Given the evidence of the health hazards of smoking while driving and the broad general perception of risk by the population, this habit should be approached the same way as other distraction factors recognized by the Spanish law as the use of mobile phones or other manually operated devices, such as GPS systems.[36]

The main limitation of this study derives from the inherent observer bias, especially in variables as age, where the biological variability regarding physical appearance can entail a misclassification by the observer. However, the pilot study [17] carried out by two independent observers showed an almost perfect agreement in the observation. We cannot disregard selection bias, since the search for public roads with greater density of schools could over-represent the presence of children in vehicles. Other potential limitations of the study derive from the fact that fieldwork was conducted only in spring and in a precise time-window of the day. The Spanish National Health Interview Surveys conducted among several waves during one year have not shown seasonality in tobacco consumption (prevalence rates by waves for several years are available at www.ine.es). Moreover, similar prevalence rates of smoking in vehicles have been reported in autumn [12], which also suggests no seasonal differences. Finally, we are not completely able to discern whether the time-window used for sampling in our study is representative of the 24 hours of a whole day. While it is clear that during night time there are less vehicles circulating, we do not know whether drivers who circulate during our time-window for sampling smoke less or more than drivers circulating during the rest of the day or night.

We have used logistic regression as a measure of association in a cross-sectional study. However, the OR only overestimates the prevalence ratio when it is above 20%,[37] which is not the case of our data. Also noteworthy is the difficulty of obtaining a truly random and representative sample of vehicles in circulation in a city. Our sampling approach, designed to be representative of all districts of Barcelona, was directed to minimize this limitation. A strength of an observational study like this compared with studies based on the use of questionnaires is the lack of information bias that comes directly from the self-reported questionnaires.

In conclusion, this study provides an estimation of smoking in cars and highlights the need to promote public health measures aimed at reducing tobacco consumption in private cars, especially in the presence of children, as well as the enforcement of measures to control smoking in commercial vehicles and taxis.

CONTRIBUTORS

All authors contributed in the design of the study. AC collected the data, prepared the database and analyzed the data. JMMS and EF revised with her the results. All the authors contributed to the interpretation of results. AC drafted the manuscript, which was critically revised by JMMS and EF. All authors approved the final version.

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COMPETING INTERESTS

The authors have no competing interests.

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Table 1 Prevalence (%) of tobacco consumption and SHS exposure in vehicles in the city of Barcelona, Spain (2011).

	TOTAL			PRIVATE			COMMERCIAL			TAXI		
Tobacco consumption	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**	**n**	**%**	**(95%CI)[a]**
Driver and/or passenger	2442	5.5	(4.6-6.4)	1736	4.7	(3.7-5.7)	482	9.8	(7.1-12.5)	224	2.2	(0.3-4.1)
Driver	2442	4.7	(3.9-5.5)	1736	3.8	(2.9-4.7)	482	8.9	(6.4-11.4)	224	2.2	(0.3-4.1)
Passenger	913	2.4	(1.4-3.4)	685	2.6	(1.4-3.8)	134	3.0	(0.1-5.9)	94	0.0	(0.0-3.9)
SHS exposure												
Any occupant	913	5.2	(3.8-6.6)	685	4.3	(2.8-5.8)	134	12.7	(7.1-18.3)	94	0.0	(0.0-3.9)
Driver	913	2.2	(1.2-3.2)	685	2.3	(1.2-3.4)	134	3.0	(0.1-5.9)	94	0.0	(0.0-3.9)
Passenger	913	3.0	(1.9-4.1)	685	2.0	(1.0-3.0)	134	9.7	(4.7-14.7)	94	0.0	(0.0-3.9)
Passenger <14 years old	271	2.2	(0.5-3.9)	253	2.0	(0.3-3.7)	12	8.3	(1.5-35.4)	6	0.0	(0.0-39.0)

[a]95% confidence interval

Table 2 Prevalence (%) of driver's tobacco consumption by vehicle type and variables of driver, vehicle and context in the city of Barcelona, Spain.

	TOTAL (n=2442)		PRIVATE (n=1736)		COMMERCIAL (n=482)		TAXI (n=224)	
	% (95%CI)[a]	p	% (95%CI)[a]	p	% (95%CI)[a]	p	% (95%CI)[a]	p
Sex		0.031		0.223		0.351		0.708
Male	5.2 (4.2-6.2)		4.2 (3.1-5.3)		9.2 (6.5-11.9)		2.3 (0.3-4.3)	
Female	2.9 (1.5-4.3)		2.9 (1.4-4.4)		3.8 (0.7-18.9)		0 (0.0-39.0)	
Age		0.002		0.001		0.945		0.345
18-34 years	6.6 (4.6-8.6)		6.1 (3.9-8.3)		8.4 (3.6-13.2)		5.3 (0.9-24.6)	
35-64 years	4.3 (3.3-5.3)		3.2 (2.2-4.2)		9.4 (6.3-12.5)		2.0 (0.1-3.9)	
≥65 years	0.7 (0.1-4.0)		0.8 (0.1-4.4)		0 (0.0-27.8)		0 (0.0-65.8)	
Socioeconomic status[b]		0.628		0.277		0.585		0.268
Low	5.2 (3.8-6.6)		4.7 (3.1-6.3)		7.4 (3.7-11.1)		3.9 (0.1-7.7)	
Medium	4.3 (3.0-5.6)		3.1 (1.8-4.4)		9.3 (5.3-13.3)		1.2 (0.2-6.6)	
High	4.5 (2.7-6.3)		3.4 (1.5-5.3)		11.1 (4.6-17.6)		0 (0.0-8.8)	
Driver's open window		<0.001		<0.001		0.001		0.089
Yes	9.3 (7.6-11.0)		9.1 (6.9-11.3)		12.3 (8.6-16.0)		3.5 (0.5-6.5)	
No	1.0 (0.5-1.5)		0.6 (0.1-1.1)		3.3 (0.7-5.9)		0 (0.0-4.5)	
Time		0.097		0.947		0.006		0.150
Morning (8-11h)	5.3 (4.1-6.5)		3.8 (2.6-5.0)		11.6 (8.0-15.2)		0.9 (0.2-4.7)	
Afternoon (17-19h)	3.8 (2.6-5.0)		3.8 (2.4-5.2)		4.1 (1.1-7.1)		3.7 (0.1-7.3)	
Weather		0.230		0.506		0.855		0.004
Sunny	4.3 (3.3-5.3)		3.6 (2.6-4.6)		9.1 (5.9-12.3)		0.6 (0.1-3.3)	
Cloudy	5.4 (3.8-7.0)		4.3 (2.5-6.1)		8.6 (4.3-12.9)		7.1 (0.4-13.8)	

[a]95% confidence interval

[b]According to socioeconomic status of district

Table 3 Crude and adjusted odds ratio (OR) and 95% confidence intervals (95%CI) of smoking in cars by drivers.

	$_c$OR	(95%CI)[a]	p	$_a$OR	(95%CI)[a]	p
Sex						
Male	1.79	(1.05-3.07)	0.033	1.46	(0.83-2.59)	0.193
Female	1	-		1	-	
Age						
18-34 years old	9.61	(1.31-70.53)	0.026	6.85	(0.92-51.18)	0.061
35-64 years old	6.11	(0.84-44.30)	0.073	5.12	(0.69-37.81)	0.109
≥65 years old	1	-		1	-	
Vehicle type						
Private	1	-		1	-	
Commercial	2.48	(1.66-3.69)	<0.001	1.36	(0.89-2.10)	0.158
Taxi	0.58	(0.23-1.45)	0.242	0.34	(0.13-0.86)	0.023
Socioeconomic status[b]						
Low	1.15	(0.69-1.91)	0.605	1.18	(0.69-2.00)	0.548
Medium	0.93	(0.55-1.58)	0.801	0.98	(0.57-1.68)	0.930
High	1	-		1	-	
Driver's open window						
Yes	10.50	(5.86-18.82)	<0.001	11.05	(6.08-20.09)	<0.001
No	1	-		1	-	
Time						
Morning (8-11h)	1.40	(0.94-2.08)	0.099	1.83	(1.20-2.79)	0.005
Afternoon (17-19h)	1	-		1	-	
Weather						
Sunny	1	-		1	-	
Cloudy	1.27	(0.86-1.89)	0.231	1.69	(1.11-2.57)	0.014

$_c$OR: crude odds ratio

$_a$OR: adjusted OR derived from a logistic regression model adjusted for driver's sex, age and window, vehicle type, district, time and weather

[a]95% Confidence interval

[b]According to socioeconomic status of district

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.