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Questionnaire-based second-hand smoke assessment in adults

Mónica Pérez-Ríos[1,2,3], Anna Schiaffino[4], María José López[3,5,6], Manel Nebot[3,5,6,7], Iñaki Galán[8], Marcela Fu[9,10,11], José María Martínez-Sánchez[9,10,11], Albert Moncada[4], Agustín Montes[1,3], Carles Ariza[3,5,6], Esteve Fernández[9,10,11]

1 Department of Preventive Medicine and Public Health, University of Santiago de Compostela, Santiago de Compostela, Spain
2 Epidemiology Unit, Galician Directorate for Public Health, Galician Health Authority, Santiago de Compostela, Spain
3 Biomedical Research Centre Network for Epidemiology and Public Health (CIBERESP), Spain
4 Community Health Unit, Terrassa City Council, Terrassa, Spain
5 Public Health Agency of Barcelona, Barcelona, Spain
6 Institute of Biomedical Research (IIB Sant Pau), Barcelona, Spain
7 Department of Experimental and Health Sciences, Pompeu Fabra University, Barcelona, Spain
8 National Centre for Epidemiology, Instituto de Salud Carlos III, Madrid, Spain
9 Tobacco Control Unit, Cancer Control and Prevention Programme, Institut Català d'Oncologia - ICO, L'Hospitalet de Llobregat, Barcelona, Spain
10 Cancer Control and Prevention Group, Institut d'Investigació Biomèdica de Bellvitge - IDIBELL, L'Hospitalet de Llobregat, Barcelona, Spain
11 Department of Clinical Sciences, Universitat de Barcelona, Barcelona, Spain

Correspondence: Mónica Pérez-Ríos, Department of Preventive Medicine and Public Health, University of Santiago de Compostela, Santiago de Compostela, A Coruña, Spain, tel: +0034 881 540044, fax: +0034 881 542943, e-mail: monica.perez.rios@usc.es

Background: Numerous studies have assessed second-hand smoke (SHS) exposure but a gold standard remains to be established. This study aimed to review how SHS exposure has been assessed in adults in questionnaire-based epidemiological studies. **Methods:** A literature search of original papers in English, French, Italian or Spanish published from January 2000 to May 2011 was performed using PubMed. The variables recorded for each study included target population, sample size, validation of the SHS questions, study design and phrasing of every question used to assess SHS exposure. For each item, information such as the setting where exposure was assessed or the indicator used to ascertain SHS exposure was extracted. **Results:** We retrieved 977 articles, of which 335 matched the inclusion criteria. The main objective of 75.8% of the studies was to assess SHS exposure.The proportion of validated questions aiming to ascertain SHS exposure was 17.9%. Most studies collected data only for one (40.3%) or two settings (33.4%), most frequently the home (83.9%) and workplace (57%). The most commonly used indicator to ascertain exposure was the presence of smokers and 68.9% of the studies included an item to assess the intensity of SHS exposure. **Conclusions:** The variability in the indicators and items used to ascertain SHS exposure is very high, whereas the use of items derived from validated studies remains low. Identifying the diverse settings where SHS exposure may occur is essential to accurately assess exposure over time. A standard set of items to identify SHS exposure in distinct settings is needed.

Introduction

Exposure to second-hand smoke (SHS) is a well-known risk factor for a range of diseases including lung cancer and coronary heart disease in adult non-smokers. SHS carries high morbidity and mortality, causing more than 600 000 deaths worldwide in 2004.[1] Consequently, accurate assessment of SHS exposure is crucial[2] to quantify the associated risks and monitor the prevalence in the population.

Although studies aiming to assess SHS exposure have accumulated over the last few decades, there is no consensus on how this exposure should be quantified. Several approaches have been employed to measure exposure, including the use of biomarkers, environmental markers and questionnaires.[3] Although in recent years there has been a move towards objective exposure assessment, questionnaires are the most commonly used tool to ascertain retrospective and current SHS exposure among the population. In addition to their simplicity and low cost, questionnaires are able to capture variability in the duration and perceived intensity of exposure. Furthermore, these instruments allow exposure to be distinguished according to settings, although they can lead to misclassification of exposure.[4]

As early as 1986, the Report of the Surgeon General 'The Health Consequences of Involuntary Smoking'[5] stressed the need to develop validated questionnaires to assess SHS exposure in distinct micro-environments. Although some studies have assessed the validity of such questionnaires,[6–11] a gold standard has not yet been established, and the variability of the indicators and questions used to ascertain SHS exposure is still very high. Consequently, comparable and sensitive indicators of SHS exposure are urgently needed. A first step in designing an optimal questionnaire is to identify the distinct measurement approaches currently in use. A review of questionnaires assessing SHS exposure in children has already been published.[12] However, no review of questionnaires assessing SHS exposure in adults has been published to date. Thus, the objective of this study was to review how SHS exposure in adults has been assessed in questionnaire-based epidemiological studies.

Methods

A literature search was carried out using the search engine PubMed (US National Library of Medicine, Bethesda, MD, USA). The terms (MeSH/keywords) used in the search were (tobacco smoke pollution

OR environmental tobacco smoke OR passive smok* OR secondhand smoke OR second hand smoke OR involuntary smoke) AND (case–control OR cohort OR prospective OR cross-sectional OR before–after). The search was limited to original articles in English, French, Italian or Spanish published from January 2000 to May 2011. Qualitative and non-original papers, papers assessing SHS without using questionnaires and those focusing on SHS exposure in children or adolescents (population aged <19 years) were excluded.

The review process consisted of the following stages:

(i) design of the search strategy;
(ii) review of abstracts and selection of those meeting the inclusion criteria;
(iii) checking of excluded abstracts by another researcher and their inclusion in the next step if recommended after the review;
(iv) acquisition of the full text of the selected abstracts and extraction of the pre-defined variables in those meeting the inclusion criteria. Reasons for excluding studies were noted; and
(v) contacting the corresponding author by e-mail when the required information was not available in the article (a second e-mail was sent after waiting 8 days for a response).

Even after contacting the authors, we excluded studies with insufficient information (no information on questions) to ascertain how SHS exposure was assessed.

The variables recorded for each study were the following: main objective of the study (SHS as the main dependent or independent variable vs. SHS as adjustment or non-principal independent variable), study design, target population, sample size, country and year of the study, type of questionnaire, validation of the SHS item, data source of the population, name of the study or project (if available) and phrasing of the items used to assess SHS exposure.

The variables recorded for each item on SHS exposure were: setting where exposure was reported (home, work, leisure time, transportation, other places and unspecified), type of indication of SHS exposure (smell, presence of smokers, self-perception of being exposed, other and any type of combination of these) and intensity of exposure (duration, number of cigarettes smoked or number of smokers in the presence of the exposed person, other and any type of combination of these).

Results

The initial search identified 977 articles. We excluded 496 publications after reviewing the abstracts, and a further 112 articles after reviewing the full text. Hence, 369 articles were reviewed. Of these, 186 (50.4%) did not include items on SHS exposure but we were able to include 79 of these papers after contacting the authors by e-mail. A further 73 papers with partial information were included. Finally, 335 papers were included in the review (figure 1). The complete list of references and studies' characteristics is available in Supplementary Appendix A1.

Table 1 shows the main characteristics of the 335 studies. In 75.8% of the studies, the main objective was to assess SHS exposure descriptively or to evaluate its health consequences. Half of the studies focused on the general population and most (51.3%) had a cross-sectional design. Three out of four studies were conducted in Europe or America and 46.6% were administered face-to-face. The proportion of validated items aiming to ascertain SHS exposure was low (17.9%). Most questionnaires collected data only for one setting (40.3%) or two settings (33.4%). The most frequent settings studied were homes (83.9%) and workplaces (57%).

Tables 2 and 3 show the distribution characteristics of the papers' items. We identified 665 items (Supplementary Appendix A2) that mainly assessed home (42.3%) and workplace (28.7%) exposure (table 2). The most common way of assessing exposure was ascertaining the presence of smokers (e.g. sharing of physical space with smokers, such as being in front of a smoker or in the presence of smokers in the same room or office). Nevertheless, most studies (68.9%) also included items with the objective of assessing the risks associated with the exposure. These items tried to assess the intensity of exposure, depending on the setting studied, the most frequent being leisure time (89.8%). The most frequent way of assessing SHS exposure was ascertaining the presence of smokers, independently of the study design. Information on the intensity of exposure was less frequently included in cross-sectional or longitudinal studies than in other designs (table 3). Questions extracted from all studies are available as Supplementary Appendices 1 and 2, and more information is available from the authors upon request.

Table 1 Characteristics of 335 studies assessing SHS exposure by questionnaires (PubMed search, 2000–11)

	n (%)
Main objective	
SHS	254 (75.8)
No SHS	81 (24.2)
Target population	
General	178 (53.1)
Patients	81 (24.2)
Workers	44 (13.1)
Pregnant women	32 (9.6)
Study design	
Cross-sectional	172 (51.3)
Case–control	83 (24.8)
Longitudinal	72 (21.5)
Before–after	8 (2.4)
Sample size[a]	
<500	80 (24.5)
500–1000	42 (12.8)
>1000	205 (62.7)
Geographical area[a]	
America	136 (40.7)
Europe	116 (34.7)
Asia	68 (20.4)
Oceania	8 (2.4)
Africa	2 (0.6)
Various	4 (1.2)
Questionnaire administration[a]	
Face-to-face	144 (46.6)
Self-administered	78 (25.3)
Telephone	54 (17.5)
Mailed	25 (8.1)
Combined	8 (2.5)
Self-reported exposure validation	
No	275 (82.1)
Cotinine	39 (11.6)
Environmental nicotine	3 (0.9)
Other	12 (3.6)
Combined	6 (1.8)
Number of settings studied	
One	135 (40.3)
Two	112 (33.4)
Three	50 (14.9)
More than three	38 (11.4)
Setting of exposure studied[b]	
Home	281 (83.9)
Work	191 (57.0)
Leisure time	49 (14.6)
Transportation	28 (8.4)
Other	65 (19.4)
Any place/not specified	51 (15.2)

a: Not available for all studies
b: Multiple response
SHS: Second-hand smoke

Discussion

This review shows wide variability in the indicators used to obtain information on self-reported exposure to SHS in adults. All the

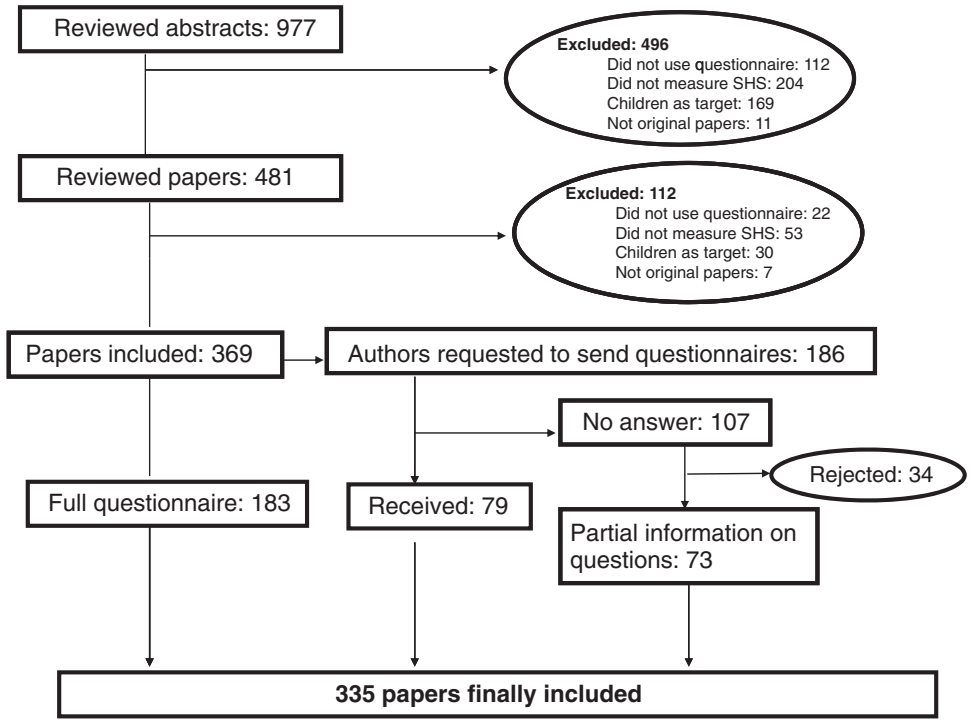

Figure 1 Selection process flow chart of the papers included in the study (PubMed search, 2000–11)

Table 2 Characteristics of SHS exposure questions ($n = 665$) by setting of exposure (PubMed search, 2000–11)

	Home *n* (%)	Workplace *n* (%)	Leisure time *n* (%)	Transportation *n* (%)	Any place *n* (%)	Others *n* (%)	Total *n* (%)
Ascertainment of exposure to SHS							
Presence of smokers	209 (74.4)	101 (52.9)	27 (55.1)	14 (50.0)	22 (43.1)	37 (56.9)	410 (61.7)
Tobacco smell	6 (2.1)	12 (6.3)	3 (6.1)	1 (3.6)	0 (0.0)	4 (6.2)	26 (3.9)
Perception of being 'exposed'	39 (13.9)	41 (21.5)	14 (28.6)	8 (28.6)	20 (39.3)	15 (23.1)	137 (20.6)
Others	20 (7.1)	28 (14.7)	4 (8.2)	4 (14.3)	9 (17.6)	7 (10.8)	72 (10.8)
Any type of combination	7 (2.5)	9 (4.6)	1 (2.0)	1 (3.5)	0 (0.0)	2 (3.0)	20 (3.0)
Intensity of exposure							
Time	98 (34.9)	93 (48.7)	37 (75.5)	16 (57.1)	31 (60.8)	33 (50.8)	308 (46.3)
Number of cigarettes	24 (8.5)	4 (2.1)	1 (2.0)	2 (7.1)	1 (2.0)	4 (6.2)	36 (5.4)
Number of smokers	15 (5.3)	3 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	18 (2.7)
Others	9 (3.2)	7 (3.7)	2 (4.1)	0 (0.0)	0 (0.0)	0 (0.0)	18 (2.7)
Any type of combination	38 (13.6)	23 (12.0)	4 (8.2)	3 (10.8)	3 (5.8)	7 (10.7)	78 (11.8)
Not assessed	97 (34.5)	61 (31.9)	5 (10.2)	7 (25.0)	16 (31.4)	21 (32.3)	207 (31.1)
Total	281 (42.3)	191 (28.7)	49 (7.4)	28 (4.1)	51 (7.7)	65 (9.8)	665

SHS: Second-hand smoke

Table 3 Characteristics of SHS exposure questions ($n = 665$) by study design (PubMed search, 2000–11)

	Cross-sectional *n* (%)	Case–control *n* (%)	Longitudinal *n* (%)	Before–after *n* (%)	Total *n* (%)
Ascertainment of exposure to SHS					
Presence of smokers	228 (63.0)	94 (65.3)	81 (59.6)	7 (30.5)	410 (61.7)
Tobacco smell	13 (3.6)	4 (2.8)	4 (2.9)	5 (21.7)	26 (3.9)
Perception of being 'exposed'	88 (24.3)	15 (10.4)	25 (18.4)	9 (39.1)	137 (20.6)
Others	26 (7.2)	23 (16.0)	21 (15.4)	2 (8.7)	72 (10.8)
Any type of combination	7 (1.9)	8 (5.5)	5 (3.7)	0 (0.0)	20 (3.0)
Intensity of exposure					
Time	152 (42.0)	70 (48.6)	77 (56.6)	9 (39.1)	308 (46.3)
Number of cigarettes	27 (7.5)	4 (2.8)	5 (3.7)	0 (0.0)	36 (5.4)
Number of smokers	8 (2.2)	7 (4.9)	1 (0.7)	2 (8.7)	18 (2.7)
Others	10 (2.8)	4 (2.8)	4 (2.9)	0 (0.0)	18 (2.7)
Any type of combination	33 (9.0)	27 (18.9)	8 (6.0)	10 (43.4)	78 (11.8)
Not assessed	132 (36.5)	32 (22.2)	41 (30.1)	2 (8.7)	207 (31.1)
Total	362 (54.4)	144 (21.6)	136 (20.5)	23 (3.5)	665

SHS: Second-hand smoke

different approaches used to assess SHS were limited in its accuracy due to failure to consider all the components involved such as: setting, perceived intensity or duration. Furthermore, it also precludes comparisons among studies, which shows the importance of standardizing the way this information is collected. There are some initiatives to standarize data collection, such as Global Youth Tobacco Survey, which apply the same questionnaire across the world are very useful.

Only a small proportion of the studies (17.9%) used validated items to assess SHS exposure. In those studies that included some kind of validation, it was mainly done by means of biomarkers such as serum nicotine or salivary cotinine. These biomarkers give us information about the individual exposure. However, this 'aggregate' measure of exposure at the individual level does not allow us to distinguish between the sources of exposure, that is, the setting where SHS exposure takes place. For example, a non-smoker bartender working in a smoke-free pub may be exposed at home if he/she lives with a smoker, thus showing a determined concentration of serum nicotine. In order to validate questions that ascertain individual exposure, environmental markers are less used, due to the difficulty of extrapolating these results to an individual level. However, they can be useful in some specific cases, for example, when only one setting of exposure is analysed. So, in our opinion, a gold standard approach based only in biological or environmental markers of SHS is not recommended and personal questions related to perceived exposure are necessary.

Most studies focus only on the settings where exposure takes place most frequently over time (home and workplace), ignoring other settings that may be less important in terms of duration of exposure (leisure and transport), but not necessarily in terms of intensity. On the other hand, comprehensive legislation aimed at protecting the non-smoking population from SHS has been implemented in several countries.[13] This legislation could change exposure profiles, reducing exposure at work and in some leisure settings (hospitality venues) but increasing it in other places such as outdoors settings (trains or bus stops). Identifying the diverse settings where SHS exposure may occur, is essential for appropriate assessment of exposure over time.[4]

The great advantage of questionnaires is that they allow for a detailed ascertainment of exposure and this should be specially valued. But the first step, in order to identify and describe in depth the settings where exposure takes place, should be to distinguish between exposed or non-exposed population to SHS. After this, the identification of all the settings is essential in order to accurately assess exposure over time. Once the settings are identified, it is necessary to obtain information regarding the intensity and duration of the exposure in each setting. Time of exposure is the proxy mostly used in order to assess exposure intensity, especially in studies with questions validated with biomarkers. However, time itself does not cover all the dimensions of the intensity, since SHS concentration is also an important issue. When the evocated period of time included is long or not specified, recall bias could appear. It is vital to state clearly the time period in which the exposure of interests takes place and, especially if a biomarker or an environmental marker has been used to validate exposure ascertainment questions. In this case, questions related to time of exposure should be set in the same time frame as environmental or biological markers. Number of smokers or tobacco smell intensity are less frequently used as proxys of intensity. Their use may be of interest, but it would be recommended to obtain additional information, such as proximity to smokers, ventilation sources, etc.

A limitation of our study is that the search was limited to papers indexed in PubMed and published between 2000 and mid-2011 and thus articles published in journals not covered by this database were excluded. However, PubMed includes most of the journals in epidemiology, public health, respiratory diseases and environmental sciences where studies on SHS are usually published. The revision only includes manuscripts published from 2000 because this responded to our aim of analyses, how exposure to SHS is currently assessed. Moreover, almost no research on SHS had been published before the landmark articles showing an association between exposure to SHS and lung cancer in non-smoking women published in the 1980s.[14,15] Interestingly, one out of four identified papers cited studies conducted before the 1990s, which may point to a delay in the publication of some reports. To widen the scope of our search, we included papers written in English, Spanish, French or Italian, which could be fully understood by the researchers. Another strength of our review lies in the exhaustive search for relevant studies independently of the study design or the setting(s) of exposure.

Some indicators might be over-represented because the same questionnaire is sometimes used in multiple publications. This is the case, for example, of the Nurses Health Study, the US National Health and Nutrition Examination Survey (NHANES), the European Community Respiratory Health Survey (ERCHS) and the Californian Teachers Study. Furthermore, whereas in some studies the use of questionnaires from other studies is clearly indicated (in the methods or acknowledgement sections) other studies might have used them without mentioning the source of the questionnaire in the manuscript.

This review offers an outline of how SHS exposure is currently assessed around the world in questionnaire-based epidemiological studies and, despite its limitations, constitutes a first step towards a standardization of SHS exposure assessment. The study indicates that future analyses should take into account the setting of exposure and the population studied. Further studies, focussing on papers that included validated questionnaires, would allow us to obtain a questionnaire or a set of questionnaires to assess the prevalence of SHS exposure in the population in a valid and reliable way.[4,16,17] These questionnaires should include items that are able to ascertain whether the interviewees are exposed or not in a dichotomous way and also to measure the intensity of the exposure. This could be done using the number of smokers around and the duration of the exposure. Importantly, these questionnaires would allow for comparison of SHS levels across different studies and populations.

An analysis of the published questions is the first step before attempting to reach a consensus on the optimal way to assess SHS exposure using questionnaires. Such analyses have been rarely performed, whereas the 'new study – new questionnaire' approach seems to be very frequent. Any consensus should include a generic measure of exposure, the main settings where exposure to SHS must be studied, as well as a detailed description on how SHS exposure and its intensity should be assessed.

In conclusion, exposure assessment based solely on biological or environmental indicators is unable to estimate prevalence of exposure to SHS because it does not include relevant information about personal characteristics. Also, the variability in the indicators and items used to ascertain SHS exposure is very high, whereas the use of items derived from validated studies remains low. Thus, identifying the diverse settings where SHS exposure may occur is essential to accurately assess exposure over time. A standard set of items to identify SHS exposure in distinct settings is needed.

Supplementary Data

Supplementary Data are available at *Eurpub* online.

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Conflicts of interest: None declared.

Key points

- To our knowledge, this is the first review of how exposure to SHS is currently assessed by questionnaires in epidemiological studies. It could be useful for professionals working in tobacco control in order to identify the most frequent items used to ascertain SHS exposure in each setting.
- Further studies, focused on papers including validated questionnaires, would allow the construction of an instrument to estimate the prevalence of SHS exposure in the population in a valid and reliable way.

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