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Exposure to Second-Hand Tobacco Smoke in Portugal After the Implementation of the Smoking Ban: A Systematic Review

Exposição ao Fumo Ambiental do Tabaco em Portugal Após a Implementação da Proibição de Fumar: Uma Revisão Sistemática

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ABSTRACT

Introduction: Estimating the prevalence of second-hand tobacco smoke exposure is a public health priority while evaluating the population-attributable disease burden and impact of smoking bans. We conducted a systematic review to analyze how secondhand tobacco smoke exposure has been assessed, and how its prevalence has been estimated among the Portuguese population since the implementation of the partial smoking ban in 2008.

Methods: A literature search was conducted in the Web of Science, MEDLINE and Embase databases until November 2022, applying a pre-designed search strategy and following the PRISMA 2020 guidelines. The search was not restricted by study period, study design, sample size or language, and was complemented by a manual literature search. A modified Newcastle-Ottawa scale was used to assess the quality of the studies.

Results: Thirteen cross-sectional studies were included. The prevalence of second-hand tobacco smoke exposure among the three European studies ranged from 8.2% (adult population exposed at home in 2010) to 93.3% (adolescent/adult population exposed in bar/restaurant terraces in 2016). Three nationwide studies estimated children's exposure at home: ranging from 32.6% in 2010 - 2011 to 14.4% in 2016. According to the most recent studies, 49.8% of women living in Porto were exposed during the third trimester of pregnancy in 2010 - 2011; 32.6% and 38.4% of children were exposed at home, respectively in Lisbon and the Azores.

Conclusion: A significant proportion of the Portuguese population, especially children and pregnant women, remain exposed to secondhand tobacco smoke. A comprehensive smoke-free policy is needed, not only in outdoor public places, but also in indoor private settings.

Keywords: Environmental Exposure; Portugal; Smoke-Free Policy; Smoking/epidemiology; Tobacco Smoke Pollution/adverse effects

RESUMO

Introdução: Estimar a prevalência da exposição ao fumo ambiental de tabaco (FAT) é uma prioridade de saúde pública, permitindo avaliar a carga de doença atribuível na população e o impacto da lei de proibição de fumar. Realizou-se uma revisão sistemática para analisar como tem sido avaliada a exposição ao FAT; e como tem sido estimada a sua prevalência na população portuguesa, desde a implementação da proibição parcial de fumar em 2008.

Métodos: Foi feita uma pesquisa bibliográfica nas bases de dados Web of Science, MEDLINE e Embase até novembro de 2022, aplicando uma estratégia de pesquisa pré-concebida e seguindo as diretrizes PRISMA 2020. A pesquisa não foi restringida por período de estudo, desenho do estudo, tamanho da amostra ou idioma, e foi complementada por uma pesquisa manual da literatura. Foi utilizada a escala de Newcastle-Ottawa modificada para avaliar a qualidade dos estudos.

Resultados: Foram incluídos 13 estudos transversais. A prevalência da exposição ao FAT nos três estudos europeus variou entre 8,2% (população adulta exposta em casa em 2010) e 93,3% (população adolescente/adulta exposta em esplanadas de bares/restaurantes em 2016). Três estudos nacionais estimaram a exposição das crianças em casa: variando entre 32,6% em 2010 - 2011 e 14,4% em 2016. De acordo com os estudos mais recentes, 49,8% das mulheres residentes no Porto foram expostas ao FAT durante o terceiro trimestre de gravidez em 2010 - 2011; 32,6% e 38,4% das crianças foram expostas ao FAT em casa, respetivamente em Lisboa e nos Açores.

Conclusão: Uma percentagem significativa da população portuguesa, em particular as crianças e as mulheres grávidas, continua exposta ao fumo ambiental do tabaco. É necessária uma política abrangente de proibição de fumar, não só em locais públicos exteriores, mas também em locais interiores privados.

Palavras-chave: Exposição Ambiental; Portugal; Política Anti-Tabaco; Poluição pelo Fumo do Tabaco/efeitos adversos; Tabagismo/epidemiologia

INTRODUCTION

Exposure to second-hand tobacco smoke (SHS) is a global public health concern and there is no safe threshold of exposure.[1] Exposure to SHS (i.e., passive smoking) is defined as the involuntary inhalation of tobacco smoke produced by an active smoker. This includes both mainstream smoke (i.e., the smoke exhaled by a smoker when puffing off a cigarette) and sidestream smoke, (i.e., the combination of smoke from smoldering tobacco product between/during puffs and smoke components diffusing through cigarette paper).[1,2] In Portugal, 13 559 deaths were attributed to tobacco use in 2019, of which 1771 resulted from exposure to SHS.[3]

Since the United States Surgeon General's report on involuntary smoking in 1986,[4] research focusing on SHS exposure

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and SHS health hazards, both in nonsmoking children and adults, evolved substantially. Children are particularly vulnerable to the effects of SHS exposure due to their specific anatomical, physiological, and behavioral features.[5] Data suggests that parental smoking is a major source of SHS exposure for nonsmoking children, with the home and cars remaining the most important target settings for reducing their exposure.[1]

Estimating the prevalence of SHS exposure in the population is crucial for understanding its public health impact. Accurate estimates are essential for assessing the disease burden associated with SHS, evaluating public awareness of its risks, and measuring the effectiveness of smoking bans and cessation interventions. Questionnaires have been widely used to estimate the prevalence of SHS exposure; however, their limitations must be taken into consideration: stemming not only from exposure recall, individual perceived susceptibility to SHS, but also, and particularly how the wording of different questions affects the assessment of SHS exposure. Underreporting is a problem when gathering information on children's SHS exposure from their parents.[6,7]

Comprehensive smoke-free laws are the most effective measures to eliminate SHS-related health hazards.[8] Portugal is among the few European countries that has not yet implemented a total ban on smoking in public places. Estimating the prevalence of SHS exposure in the population is crucial for understanding its public health impact. Accurate estimates are essential for assessing the disease burden associated with SHS, evaluating public awareness of its risks, and measuring the effectiveness of smoking bans and cessation interventions.[3] This law has suffered several amendments, the latest one in January 2023, and a recent tobacco bill is currently being discussed in the parliament. However, exemptions and moratoria loopholes persist. Notably, to the best of our knowledge, no systematic review assessing the prevalence of SHS exposure among the Portuguese population and its trends over time has ever been conducted.

This systematic review aims to analyze how SHS exposure has been assessed, and how its prevalence has been estimated among the Portuguese population since the implementation of the partial smoking ban in 2008.

METHODS

A systematic review was conducted following the standard PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[9] The systematic review protocol was registered in the PROSPERO database in February 2022 (registration no. CRD42022300201).

Search strategy

A bibliographic search was performed until November 2022 in Web of Science, MEDLINE (PubMed), and EMBASE databases applying a pre-designed search strategy [Appendix, Table 1 (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/21802/15513)] drawn up by three expert reviewers in the matter. The search terms included both MeSH and free terms: "tobacco smoke pollution", "secondhand smoke", "environmental tobacco smoke", "environment smoking", "passive smoking", "tobacco products", "household smoking", "pregnancy smoking", "occupational smoking", "outdoor smoking", "smoke free law" "smoke free legislation" "smoking ban" and "Portugal". A manual review of the bibliographic references was performed to ensure the inclusion of all possible studies. Study period, study design, sample size or language restrictions were not applied.

Inclusion and exclusion criteria

This review covered studies that estimated the prevalence of SHS exposure among the Portuguese population, including both general adult and vulnerable populations (newborns-adolescents, pregnant women, and the elderly), regardless of the exposure setting and the method used to assess SHS exposure (questionnaires and/or biomarkers). The PECOS question addressed in this review was: "Among the Portuguese population, what is the prevalence of SHS exposure?". We included all the studies that met the following PECOS criteria:

- Population: Studies involving the Portuguese population.
- Exposure: Exposure to SHS from surrounding active smokers in various settings.
- Comparator: Groups within the Portuguese population not exposed to SHS.
- Outcome: Prevalence of SHS exposure (%), measured either through self-declaration or biomarkers.
- Study design: Any study design that provided data on the prevalence of SHS (%) in Portugal.

The selected studies were limited to English, Spanish and Portuguese.

Studies with the following characteristics were excluded: neither their main objective was to estimate the prevalence of SHS, nor their outcome/dependent variable was SHS exposure; studies conducted before the implementation of Law no. 37/2007; those assessing exposure to secondhand aerosol from e-cigarette; and studies that did not estimate specific

prevalence for Portugal. When different papers based on the same study were identified, we included the one with more recent data and the largest sample size.

Furthermore, we excluded conference communications, letters to the editor, opinion articles, preprints, reports, narrative reviews, simulation studies or retracted publications.

Selection of articles and evidence synthesis

After eliminating duplicated papers, three researchers screened the titles and abstract of all papers yielded by the search. Each researcher evaluated eligibility separately on the basis of the title and abstract. In the case of papers considered potentially relevant, the full text was read to ensure that they fulfilled the inclusion/exclusion criteria. Any disagreements regarding article inclusion or exclusion of any given paper were settled by consensus of the three reviewers.

From each included study, the overall prevalence of SHS exposure was extracted, differentiating by exposure settings if data were available; however, in the case that the study did not provide an overall prevalence, we extracted the one corresponding to each subpopulation defined by age group (children vs. adults) or sex (women vs. men). When different prevalence data were provided, depending on the source or frequency of exposure, the highest value was extracted. For studies that provided prevalence, both at the national and subnational level, national data were extracted.

Data-extraction was performed using an *ad hoc* data extraction sheet in Microsoft Excel to capture all the relevant information from each selected paper. The data were manually extracted by two authors, and both files were then reviewed by a third. Discrepancies were discussed and settled by consensus. From each included study, data were extracted on: (1) Study characteristics: author, publication year, period of the study, geographical scope, and study design; (2) Population characteristics: sample size, population group (pregnant women, newborns, children, adolescents and adults), age in years, and source of recruitment (hospital, health facilities, kindergartens, school or general population); (3) SHS exposure assessment data: definition of SHS exposure and method for assessment; and (4) Prevalence of SHS exposure (%) considering the geographical scope of the study (regional, national or European), population group, and exposure settings.

Assessment of quality and level of evidence

Study quality was evaluated using an adaptation of the Newcastle-Ottawa scale.[10] Two researchers screened each study separately evaluating sample selection/strategy (representativeness of the sample, comparability between respondents and non-respondents), assessment of the exposure (ascertainment and characterization of the exposure), and outcome (stratification of the prevalence data on SHS exposure, statistical test and assessment of potential biases/limitations) [Appendix, Table 2 (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/21802/15513)]. Studies were scored from 0 to 8 by each researcher, with the final score being reached by agreement. In case of any difference of opinion, a third researcher was consulted. Studies with a score < 3 points were rated as poor-quality, those with a score of 3 - 4 points as moderate-quality, and those with a score of ≥ 5 points as high-quality. Regarding the quality evaluation, no studies were excluded.

RESULTS

Search results

The bibliographic search yielded a total of 296 papers; after examination of the titles and abstracts, 43 papers were deemed eligible for the full-text review; finally, 13 studies fulfilled the inclusion criteria (Fig. 1).

Characteristics of the studies

Table 1 and Fig. 2 show the main study characteristics. All the studies used a cross-sectional design; mostly were conducted between 2008 and 2013, estimating the prevalence of SHS exposure among the Portuguese population from newborns to adults aged 86 years (N = 19 823). Nine studies included children and/or adolescents. Of the 13 studies, three were performed at European level (one confined to Coimbra city),[11-13] four at the national level,[14-17] and six at the regional level (Porto, Chaves, and Lisbon cities, and the Azores region)[18-23] (Table 1 and Fig. 2).

Ten studies covered one or two settings when assessing SHS exposure (Fig. 2). The majority of the studies assessed SHS exposure by using non-standardized and proxy or self-administered questionnaires focusing on indoor SHS exposure (n = 12), and more specifically at home (n = 9). Four studies considered exposure duration (in the last six months; during the last week; before and during pregnancy;) and other four, the frequency of the exposure (daily *versus* less than daily; daily *versus* occasionally/sometimes; or frequent *versus* sometimes) (Table 1). One study measured the prevalence of SHS exposure via both questionnaires and biomarkers (urine cotinine).[11]

Table 2 shows the prevalence of exposure to SHS according to geographical scope, population group and different exposure settings. The prevalence of the exposure among studies conducted both at national (n = 10), and European level (n = 3), ranged respectively from 8.2% (adult population exposed at home in 2010) to 93.3% (adolescent and adult population exposed on bar/restaurant terraces in 2016). Among the nationwide studies, three estimated children's exposure at home: ranging from 32.6% in 2010 - 2011 to 14.4% in 2016 (Table 2). At the regional level, SHS exposure has been measured mainly in Lisbon and among vulnerable populations (children/adolescents and pregnant women) (Tables 1 and 2). According to the most recent studies, 49.8% of pregnant women living in Porto were exposed to SHS during the third trimester in 2010 - 2011; in 2017, 32.6% and 38.4% of children in Lisbon and the Azores, respectively, were still exposed at home.

Study quality

When using a modified Newcastle-Ottawa scale to standardize study quality, five studies were rated as high-quality, seven as moderate, and one as low-quality [Fig. 2 and Appendix, Table 3 (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/21802/15513)]. The low-quality score was due to lack of information on the definition of SHS exposure, poor statistical analysis, and potential limitations and biases. Most of the studies displayed information biases considering that the questions about SHS exposure were self-reported either by the children or parents.

DISCUSSION

Exposure to tobacco smoke in Portugal remains a significant concern, especially in vulnerable population groups such as children and pregnant women. The prevalence of SHS exposure derived from the 13 studies included in this systematic review might be an underestimation, since exposure was measured via proxy or self-reported questionnaires. The outdated (pre-2018) exposure data, the imprecise measurement of SHS exposure, and the heterogeneity in terms of geographical scope, target population, exposure settings, and sources of exposure preclude a precise estimate of the prevalence of SHS in Portugal. In addition, these limitations prevent an accurate assessment of the variation in SHS exposure over the last decade and a half.

The most recent data on SHS exposure in the Portuguese population aged 15 years and over-derives from a European study conducted in 2016.[13] This study places Portugal among the four countries with the highest prevalence of SHS exposure in outdoor public spaces. Thus, over 85% of Portuguese adolescents and adults were exposed on bars and restaurants terraces, beaches and public transport stops,[13] and over 50% in children's playgrounds. This exposure increases the visibility of negative role models and reinforces smoking normalization among children, adolescents, and the whole society.[24] Moreover, these data are consistent with Eurobarometer 2020 - 2021 findings, indication that Portugal is among the European countries with a highest prevalence of indoor SHS exposure in bars and restaurants above the European average.[25]

Data from the first National Health Survey with Physical Examination (INSEF) showed that the prevalence of daily exposure to SHS among the adult population in 2017 significantly varied by region and age group. The INSEF assessed SHS exposure across different settings, including home, workplaces, transports or other public spaces, and identified the highest prevalence in the Azores region (21.0%), and in the youngest age group, from 25 to 34 years (19.8%).[3] Analysis by region of the nationwide studies included in this systematic review reveals that the highest children's exposure to SHS at home was estimated in Lisbon and in the Azores, being higher than 21.1%.[14-16]

The Azores is ranked as the Portuguese region with the highest crude smoking prevalence and the highest daily consumption.[26] On the other hand, Lisbon is the region depicting the highest smoking rates among women.[26] In addition, the Azores is the region with the highest proportion of lung cancer cases and deaths attributable to smoking. The most recent study assessing SHS exposure in the Azores[22] showed that in 2017, 38.4% of nine-year-old children were exposed to SHS at home, driven by at least one smoker; this prevalence is 13.4 percentage points higher than a year earlier,[16] and it is similar to previous studies involving children from other countries.[27,28] Evidence shows that mass media awareness campaigns are effective in increasing public knowledge about the health risks associated with tobacco smoke, particularly among children and adolescents.[29,30] These campaigns enhance awareness, influence smoking behaviors, and support smoking cessation. Our results highlight the need for comprehensive tobacco control strategies, including targeted, sustained, and intensive public health campaigns, with a special focus on the Azores. Our findings show that an important percentage of Portuguese children are still exposed to SHS in their households and private vehicles. Precioso *et al*,[16] collected the most recent national data on childhood SHS exposure: in 2016, 18.4% of children aged 0 - 10 years were exposed to SHS at home or in the car driven by at least one smoking household member in 2016 (14.4% at home and 10.1% in the car).

According to the most recent Eurobarometer data on attitudes towards indoor home smoking, in 2010, 34% of

Portuguese respondents allowed smoking at home but when smokers' responses were taken into account, this number rose to 69%.[31] One of the studies conducted by Vitória *et al* assessed Portuguese participants' rules concerning indoor smoking in their homes[15]: "smoking is not allowed in any part of the house"; "smoking is allowed in some parts/rooms of the house"; "smoking is allowed in any parts/rooms of the house" and "smoking is allowed only on special occasions". Results from this study[15] revealed that the rules were more easily ignored when the family received visitors, with smoking guests being the first source of exposure for children, followed by smoking parents (32.6% *versus* 29.5%, respectively); this could be explained by parental social stigma and/or poor awareness of the harmful effects of SHS on children's health, especially among parents with a low level of education.[16,19]

Despite the evidence that children's SHS exposure at home may have increased in recent years considering the impact of the COVID-19 pandemic lockdown on tobacco smoking behaviour,[32] we identified no studies evaluating possible variations in the prevalence of SHS exposure before and after the pandemic in Portugal. Moreover, it should be noted that none of the included studies differentiated between housing type despite the evidence that children living in multi-family dwellings may be more exposed to SHS than those living in single-family dwellings.[33] Beyond household interventions, policy approaches, such as smoke-free zones in multi-family dwellings, should be implemented worldwide to help protect children.

After the home, the car was the second most common private setting where SHS exposure was measured in Portuguese children. A study conducted in 2017 by Precioso *et al* showed that 27.6% of Azorean children were exposed to SHS in the car.[22] The most recent Eurobarometer on attitudes towards smoking in the car reported that, in 2010, 57% of Portuguese respondents allowed smoking in their private vehicles.[31] In 2018, the smoke-free car legislation was implemented in some European countries such as Cyprus, Greece, the United Kingdom, France, the Republic of Ireland and Italy.[12] In this context, a study found that California's 2007 smoke-free vehicle legislation resulted in a 37% reduction in the odds of children being exposed to SHS in vehicles during 2001 - 2011.[34] This finding supports the need to adopt and implement a general ban on car smoking in Portugal.

Pregnant women are another vulnerable group that should be a preferential target for interventions aimed at preventing SHS exposure, both for their and the fetus' well-being. A study by Madureira *et al,*[23] the first to assess SHS exposure in pregnant women in Portugal, observed a decrease in the prevalence of exposure during the third trimester compared to the first trimester (49.8% *versus* 51.2%), especially among women with high literacy levels. Pregnant women who are more educated may have greater willingness to avoid sources of exposure to tobacco smoke as a result of adequate health education on SHS-related health hazards.[23]

Our findings show that estimates of SHS exposure are based on non-standardized questionnaires completed and administered by the adult participant, and in the case of minors, by a proxy, or by the minors themselves after parental consent for participation. Although some studies measured exposure with validated questionnaires, most of them used broad definitions that do not allow for accurate quantification of the level, intensity and duration of SHS exposure. Furthermore, the questions did not include all possible settings where the population might be exposed; in fact, only two studies measured children's exposure both at home and outside home, but without specifying the outdoor settings.[11,19] Importantly, the use of questionnaires may have resulted in the inaccurate measurement of SHS exposure due to subjectivity (linked to differences in perception), ignorance of SHS exposures or recall, and social desirability biases.[6,7]

Over time, cotinine has become one of the most widely used biomarker of SHS exposure, particularly in the United States of America.[6,35] In Portugal, only the study conducted by Lupsa *et al*[11] measured SHS exposure using urine cotinine in conjunction with questionnaires; however, the same cotinine cut-point was used to differentiate between exposed and unexposed mothers and their children of different ages, without taking into account possible differences in their level of exposure, and in their cotinine metabolism/clearance.[36] Four of the 13 studies indicated that the non-measurement of cotinine exposure was due to budgetary constraints.[14-16,22] More studies measuring exposure to SHS with biomarkers are needed to accurately estimate the prevalence of SHS exposure, and thus update the impact of SHS exposure on different health outcomes.

Our findings underscore the need of a multifaceted approach to tobacco control and SHS exposure. A comprehensive strategy should include increasing tobacco excise taxes and allocating the revenue to strengthen tobacco control programs, public education, and cessation resources. A key component of this strategy involves regulating retail outlets and vending machines to limit tobacco access and prevent youth initiation. Enforcement of bans on tobacco advertising and promotion, along with prohibiting the sale, purchase, and consumption of tobacco products by individuals under 21 years of age is crucial for countering the normalization of smoking and reducing its consumption.[37] Effective smoke-free policies must extend to both public places (such as school campuses, childcare centers, parks, beaches, and government

buildings) and private settings (such as homes and vehicles). By creating smoke-free environments at home, parents not only improve their own well-being but also contribute to a healthier, smoke-free setting that discourages their children from starting to smoke.[14,16,37] These measures are crucial for reducing smoking initiation, minimizing SHS exposure, supporting smoking cessation, and reinforcing the social unacceptability of smoking.[37] Public education campaigns should clearly communicate the health risks of smoking, including graphic warnings on cigarette packages, the benefits of quitting, and the importance of maintaining smoke-free environments.

Healthcare professionals play an important role in reducing tobacco use and SHS exposure by providing essential support and advocating for smoke-free policies and cessation efforts.[38] All frontline workers, including general practitioners / family physicians, nurses, hospital clinicians, pharmacists, and dentists, should be trained to provide smoking cessation advice and support across various care settings. Furthermore, a national tobacco cessation campaign could be developed, incorporating telephone support services, online resources, social media outreach, and partnerships with community organizations and businesses to establish a comprehensive support network involving multiple stakeholders beyond healthcare professionals.[38]

To enhance the effectiveness of the strategies aimed at reducing tobacco consumption and SHS exposure, a coordinated national framework with a designated lead agency, standardized guidelines, and robust surveillance systems is essential. Establishing a national database and conducting ongoing research on tobacco use will help refine strategies and ensure their relevance. Regular evaluation of interventions and continuous training for healthcare professionals will ensure that strategies are evidence-based and have a significant impact.[38]

This review has both weaknesses and strengths. Firstly, we only used MEDLINE (PubMed), Web of Science, and EMBASE databases. However, we are reasonably confident not having missed any relevant studies, since we complemented the search with a manual reference review of the included studies. To the best of our knowledge, just one study was excluded due to language (written in French)[39]; however, it did not seem to meet the inclusion criteria based on the abstract data. As a major strength, this is, to the best of our knowledge, the first systematic review on the prevalence of SHS exposure among the Portuguese population. Our inclusion criteria were strict, and our results made it possible to examine the differences in the assessment of the prevalence of SHS exposure in Portugal, across almost one decade, considering the definitions of SHS exposure, exposure settings and target population, for a total of 19 823 children, adolescents, and adults exposed to this carcinogen. Finally, 12 out of 13 studies were judged to be of high or moderate quality when applying the modified Newcastle-Ottawa scale, which is a reliable tool for assessing the methodological quality of studies included in a systematic review.[40]

The results of this systematic review support the need for further research obtaining updated and accurate data on the prevalence of SHS among the Portuguese population.

Future research should address specific gaps, including evaluating the impact of COVID-19 on SHS exposure and conducting longitudinal and quasi-experimental studies to better understand how SHS exposure changes over time, and how specific tobacco control policies affect this exposure. In addition, more regular and standardized monitoring of SHS exposure, using consistent methods, is needed to accurately assess its prevalence, burden, and the effectiveness of existing tobacco control measures. Strengthening current tobacco control laws and policies in Portugal will be critical to addressing these issues and improving public health outcomes.

CONCLUSION

A significant proportion of the Portuguese population, especially vulnerable populations such as children and pregnant women, remains exposed to SHS. This may result from the limited protection of the partial smoking ban and its failure to change social norms. These findings also suggest poor awareness of SHS-related health hazards among the Portuguese population.

Notably, the highest level of children's SHS exposure occurs in public places not yet included in the current smoking ban. Portugal lacks a public health strategy to monitor SHS exposure in different settings and population subgroups. To address this shortcoming, it is essential to implement a multifaceted approach to tobacco control. This approach should include increasing excise taxes, regulating retail outlets, and raising the minimum age for tobacco consumption. Effective smoke-free policies must extend to both public and private settings, including a ban on smoking in vehicles where children are transported, as already implemented in some countries. These measures are critical for promoting smoke-free environments, reducing overall tobacco consumption, and consequently, minimizing SHS exposure. In addition, developing a national tobacco cessation campaign that integrates telephone support services, online resources, social media outreach, and partnerships with community organizations and businesses will provide a robust support network.

AUTHOR CONTRIBUTIONS

NM, MPR: Conception and design of the work; acquisition, analysis, and interpretation of data; drafting and critical review of the manuscript; final approval of the version to be published.

SR, CCP: Analysis, and interpretation of data; critical review the manuscript; final approval of the version to be published.

JRB, LVL, ARR: Critical review of the manuscript; final approval of the version to be published.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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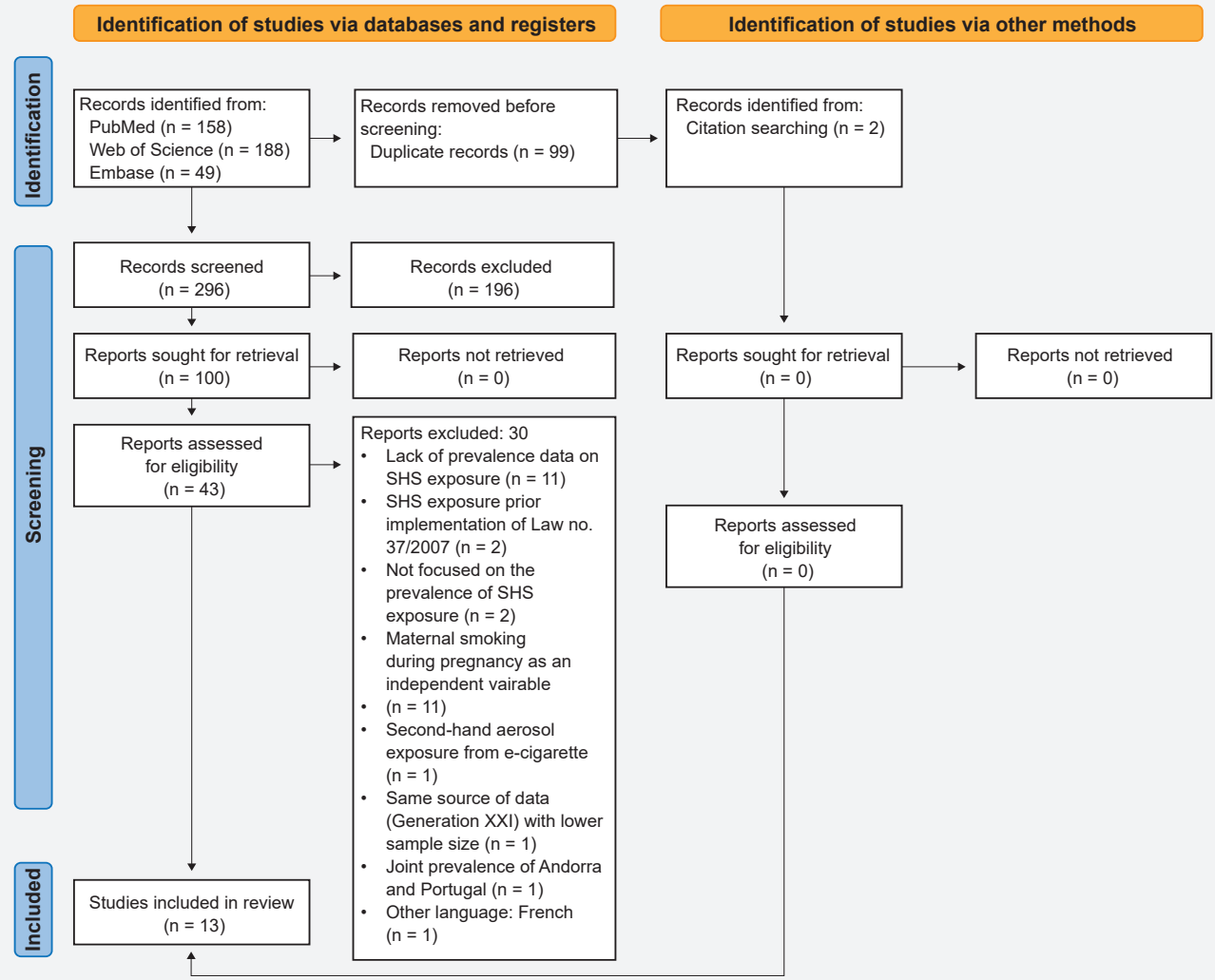

Figure 1 – Flowchart of studies selected for systematic review in accordance with the PRISMA 2020 guidelines

Table 1 – Main characteristics of the studies included in the systematic review (n = 13)

Study characteristics				Population characteristics		
Author, year of publication	**Period of the study**	**Geographical scope**	**Study design**	**n**	**Population group**	**Age (years)**
Areias *et al*, 2009[18]	2008	Lisbon	Cross-sectional	96	Adults	18 - 44
Constant *et al*, 2011[19]	2010 - 11	Lisbon	Cross-sectional	313	Children and adolescents	5 - 13
Pereira *et al*, 2013[14]	2010	Portugal	Cross-sectional	6003	Children, adolescents and adults	< 15 - ≥ 65
Paradela *et al*, 2013[20]	2009 - 10	Chaves	Cross-sectional	287	Adults	19 - 86
Lupsa *et al*, 2015[11]	2010	Europe (includes Portugal)	Cross-sectional	120	Children and adults (mothers)	6 - 11
Vitória *et al*, 2015[15]	2010 - 11	Portugal	Cross-sectional	3187	Children and adolescents	8 - 13
Vitória *et al*, 2017[21]	2016 - 17	Lisbon	Cross-sectional	949	Children and adolescents	8 - 13
Mlinaric *et al*, 2019[12]	2016	Europe (Coimbra)	Cross-sectional	N/A*	Adolescents	14 - 17
Precioso *et al*, 2019[22]	2017	Azores	Cross-sectional	292	Children	9
Precioso *et al*, 2019[16]	2016	Portugal	Cross-sectional	2396	Newborns and Children	0 - 9
Alves *et al*, 2020[17]	2010 - 11	Portugal	Cross-sectional	3368	Adults (men)	25 - 79
Madureira *et al*, 2020[23]	2011 - 12	Porto	Cross-sectional	619	Pregnant women	18 - 46
Henderson *et al*, 2021[13]	2016	Europe (includes Portugal)	Cross-sectional	N/A*	Adolescents and adults	≥ 15

N/A*: not applicable

	SHS exposure assessment data	
Source of recruitment	**Definition exposure to SHS**	**Method for assessment**
Hospitals	SHS exposure in closed public spaces and workplace two months after the implementation of the new legislative ban on smoking	One-on-one interviews using standardized pre-validated and anonymous questionnaires
Schools	Exposure at home and outside home to household smokers (mother/father or other members)	Proxy and self-administered questionnaire
General population	Exposure to at least one current smoker at home	Computer-assisted telephone interviews (CATI). The primary caregiver was responsible for answering the questions when the participant was under 15 years
Primary care facilities	Exposure from smokers during last week (daily or sometimes) at home/workplace/public spaces (bars, discos and restaurants) considering the duration of the exposure (hours per day/week)	Self-administered questionnaire by trained nurses
Schools	Exposure at home (daily or less than daily) and elsewhere than at home (frequent or sometimes)	Face-to-face interviews by trained staff. Proxy and self-administered (mothers) structured questionnaire
Schools	Exposure to SHS at home by family members or guests (daily/ occasionally). Inclusion of questions regarding rules concerning smoking inside the house	Self-administered and child-responsive validated questionnaire (it does not mention if parental permission for participation was gathered)
Schools	Exposure at home (no-yes) based on paternal/maternal smoking	Self-administered and child-responsive questionnaire (after parental permission for participation)
Schools	Exposure in a car within the past seven days	Self-administered and adolescent-responsive questionnaire
Schools	Exposure at home (daily or sometimes) by at least one smoking household member (parental/siblings/visitors/others); exposure in the car by household members.	Self-administered and child-responsive validated questionnaire (CHETS) (after parental permission for participation)
Health centers, kindergartens and elementary schools	Exposure at home by at least one smoking household member (parental/siblings/others); exposure in the car by household members	Proxy and self-administered validated questionnaire (CHETS)
General population	Exposure in closed spaces by smokers	Self-administered questionnaire
Hospital	Exposure to SHS before and during pregnancy at home, leisure places or at work	Face-to-face interview
General population	Exposure in the last six months by people smoking regular cigarettes in outdoor areas (terraces of restaurants/bars, public transport stops, outdoor areas of hospitals and schools, parks, children's playgrounds, stadia and beaches)	Computer-assisted personal interviews (CAPI) by trained staff

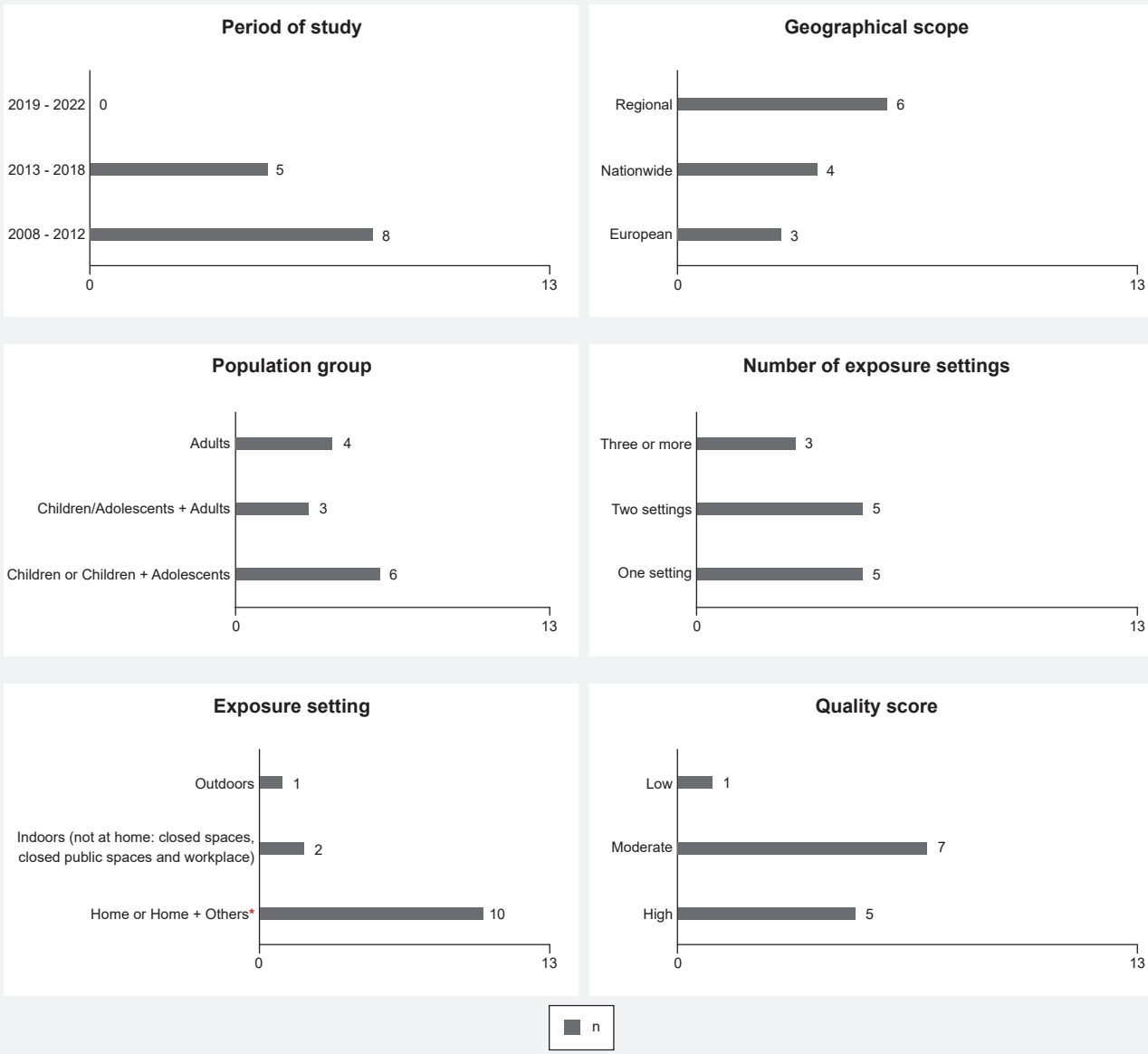

Figure 2 – Main characteristics of the studies included in the systematic review (n = 13) considering the period of the study, geographical scope, population group, SHS exposure settings, and the quality score based on the modified Newcastle-Ottawa scale

* Others: outside home, elsewhere than at home, car, workplace, public places/leisure places

Table 2 – Prevalence of exposure to secondhand tobacco smoke in the studies included in the systematic review according to the geographical scope, population group and settings of exposure

Author, year of publication	Population group	Setting of exposure	Prevalence of self-reported SHS exposure (%)
European studies			
Lupsa *et al*, 2015	Adults	Home	8.2
Lupsa *et al*, 2015	Adults	Elsewhere than at home	46.6
Lupsa *et al*, 2015	Children	Home	15.0
Lupsa *et al*, 2015	Children	Elsewhere than at home	58.3
Mlinaric *et al*, 2019	Adolescents	Car	23.2
Henderson *et al*, 2021	Adolescents-adults	Children's playgrounds	53.0
Henderson *et al*, 2021	Adolescents-adults	Outdoor areas in schools	72.8
Henderson *et al*, 2021	Adolescents-adults	Stadia	81.5
Henderson *et al*, 2021	Adolescents-adults	Parks	83.3
Henderson *et al*, 2021	Adolescents-adults	Outdoor areas in hospitals	71.9
Henderson *et al*, 2021	Adolescents-adults	Public transport stops	87.3
Henderson *et al*, 2021	Adolescents-adults	Restaurant/bar terraces	93.3
Henderson *et al*, 2021	Adolescents-adults	Beaches	88.7
Nationwide studies			
Pereira *et al*, 2013	Children-adolescents-adults	Home	26.6
Vitória *et al*, 2015	Children-adolescents	Home	32.6
Precioso *et al*, 2019	Children	Home	14.4
Precioso *et al*, 2019	Children	Car	10
Precioso *et al*, 2019	Children	Home + Car	5.4
Alves *et al*, 2020	Adults (men)	Closed spaces	53.8
Alves *et al*, 2020	Adults (women)	Closed spaces	38.4
Regional studies			
Areias *et al*, 2009	Adults	Closed public places	3.1
Areias *et al*, 2009	Adults	Workplace	2.5
Constant *et al*, 2011	Children-adolescents	Home	34
Constant *et al*, 2011	Children-adolescents	Outside home	12
Paradela *et al*, 2013	Adults	Home	16.4
Paradela *et al*, 2013	Adults	Workplace	14.1
Paradela *et al*, 2013	Adults	Public spaces	32.7
Paradela *et al*, 2013	Adults	Home + Workplace + Public spaces	46.2
Vitória *et al*, 2017	Children-adolescents	Home	32.6
Precioso *et al*, 2019	Children	Home	38.4
Precioso *et al*, 2019	Children	Car	27.6
Precioso *et al*, 2019	Children	Home + Car	17.8
Madureira *et al*, 2020	Adults (pregnant women)	Before pregnancy	57.4
Madureira *et al*, 2020	Adults (pregnant women)	First trimester of pregnancy	51.2
Madureira *et al*, 2020	Adults (pregnant women)	Third trimester of pregnancy	49.8