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Validity of self-reported indicators to assess secondhand smoke exposure in the home

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ABSTRACT

Introduction: Questionnaires are widely used to assess secondhand smoke (SHS) exposure. However, the validity of self-reported SHS exposure indicators has been rarely assessed. We aimed to assess correlations, sensitivity, specificity, and predictive values between self-reported SHS exposure indicators and airborne nicotine concentrations.

Methods: We performed a cross-sectional study with a convenience sample of 175 homes in Barcelona and Santiago de Compostela, Spain. Airborne nicotine samples were collected from participants' homes and a self-administered questionnaire was completed on SHS exposure in the home. Spearman correlations coefficients and sensitivity, specificity and predictive values were assessed between self-reported SHS exposure indicators and nicotine concentrations in the home.

Results: All self-reported SHS exposure indicators correlated moderately strongly with airborne nicotine concentrations (Spearman correlations coefficient ranging from 0.58 to 0.65). Moreover, sensitivities and negative predictive values between self-reported indicators and the presence of nicotine in the home were below 66.4% while specificities and positive predictive values were over 78.4%. The "number of people usually smoking in the home" showed the best results (r_s = 0.65, $p < 0.001$; sensitivity = 50.4%, specificity = 95.2%, PPV = 95.0, NPV = 51.3).

Conclusions: The self-reported SHS indicators assessed in this study showed moderate and strong correlations, low sensitivities, and high specificities. Among them, the best results were obtained with the "number of people usually smoking in the home".

1. Introduction

Secondhand smoke (SHS) is a health hazard with no safe exposure levels. It is considered as carcinogenic to humans by the International Agency for Research on Cancer and it has been causally linked to cancer, cardiovascular and respiratory diseases (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2004; Öberg et al., 2011). In 2011, 45.2% of adult non-smokers in Spain were exposed to SHS (Fernández et al., 2017), causing 1028 attributable deaths (López et al., 2016).

Environmental markers can be used to assess SHS exposure in a particular setting by measuring concentrations of a specific SHS compound. Most common airborne markers are nicotine, particulate matter, carbon monoxide, 3-ethenylpyridine, polycyclic aromatic hydrocarbons, and tobacco-specific nitrosamines (Apelberg et al., 2013). Nicotine is notable among other markers due to its specificity to

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tobacco smoke, sensitivity at low concentrations, and easy collection (Apelberg et al., 2013; López and Nebot, 2003). Nicotine has often been used to assess SHS in different indoor settings such as homes or working areas such as hospitality venues (Apelberg et al., 2013; Arechavala et al., 2017; Martínez-Sánchez et al., 2014), and it is also considered a reliable environmental gold standard (Avila-Tang et al., 2013).

Questionnaires are an extended and well-accepted tool to assess SHS exposure and their administration is easy and affordable (Avila-Tang et al., 2013). To assess SHS exposure, questionnaires usually include items on the frequency of exposure, collected as the number of days per week that exposure takes place, and/or intensity in terms of the number of smokers, number of hours of exposure, number of cigarettes smoked, or the perceived intensity of the exposure (Avila-Tang et al., 2013; Galán et al., 2014; Nebot et al., 2011). Although most questionnaires on SHS exposure have not been validated, some analyses have been conducted combining reported information and objective measurements. Validity in terms of correlations between airborne nicotine and self-reported intensity indicators have been analysed in various settings with heterogeneous results. For example, reporting the number of cigarettes smoked in the home per day showed strong correlations with nicotine levels (Leaderer and Hammond, 1991; Marbury et al., 1993), while reporting the perceived intensity of the exposure in hospitality venues showed weak to moderate correlations (Galán et al., 2014). However, there are scant formal validity assessments of questionnaires using performance classifications tests (sensitivity and specificity) against a true gold standard.

In 2012 and 2016, as part of an investigation of SHS exposure in homes, airborne nicotine levels were measured in a sample of homes and a questionnaire on self-reported SHS exposure was administered to household members. In the present study, we aimed to assess the validity of self-reported SHS exposure indicators in the home in terms of correlations, sensitivity, specificity, and predictive values using airborne nicotine as the gold standard.

2. Methods

2.1. Design and study sample

This is a cross-sectional study based on a convenience sample of Spanish homes. 75 households were recruited in Santiago de Compostela in 2012 and 100 in Barcelona in 2016 through contacts of the researchers. A total of 175 homes took part in the study and there was representation of houses with smokers and houses without smokers.

2.2. Airborne nicotine measurement

We collected vapor-phase nicotine using a passive sampling monitor containing a 37-mm diameter filter treated with sodium bisulphate. Monitors were installed in the living rooms of the participants' homes and remained there for 7 days. Afterwards, they were sent to the laboratory of the Public Health Agency of Barcelona, where nicotine was extracted from the filters and quantified by gas chromatography coupled with mass spectrometry. Nicotine concentrations were obtained taking into consideration the air flow rate and the exposure time (Hammond and Leaderer, 1987). The limit of detection (LOD) of the assay is 0.02 μg/m^3. In this study, airborne nicotine concentration (μg/m^3) was considered the gold standard for SHS exposure.

2.3. Questionnaire and study variables

A questionnaire aiming to assess self-reported SHS exposure at homes was administered to an adult resident in the household (≥ 18 years). The questionnaire gathered information on usual tobacco use in the home, the characteristics of SHS exposure in the home, and sociodemographic questions. The questionnaire also included a set of questions on tobacco use during the week that the airborne nicotine monitor was installed.

Self-reported SHS exposure was defined by the "number of smokers living in the home" and the "number of people usually smoking in the home". Both variables were later categorized as "homes with or without smokers" (at least 1 or none) and "people usually smoking in the home" (at least 1 or none). In addition, smoking rules in the home (allowed or not allowed) were also assessed.

The questionnaire also gathered information on the week that the nicotine monitors were installed. An open-format question was included on the "number of hours someone smoked inside the home in the last working day" and the "number of hours someone smoked inside the home in the last nonworking day". We categorized these variables to define SHS exposure renaming them as "hours that someone smoked inside in the last working day" and "in the last nonworking day" with the categories none (0 h) or some (different than 0 h). In addition, participants reported the "areas where someone smoked during the last week", and the categories were inside (in indoor rooms), only outside (e.g., on balconies, terraces) or nowhere in the home. This variable was also dichotomized as smoking inside vs outside and nowhere. When participants reported smoking inside, the "number of cigarettes smoked inside during the last week" were also reported in an open-format question.

Finally, sex (male or female), age, and the highest educational attainment (primary and secondary vs university) of the survey respondent were collected.

2.4. Data analysis

The characteristics of the sample were described stratifying by homes with or without smokers. Median and interquartile ranges (IQR) of nicotine concentrations were calculated stratifying by "homes with smokers and without smokers" and all self-reported variables. Differences within categories between "homes with or without smokers" were assessed by the Mann-Whitney *U*-test, and differences between categories of each indicator were assessed separately among "homes with smokers" and "homes without smokers" by the Mann Whitney *U*-test or Kruskal-Wallis test, as appropriate.

Spearman correlation coefficients (95% confidence level) were calculated between nicotine concentrations and the continuous variables "number of smokers living in the home", "number of people usually smoking in the home", "number of hours someone smoked inside in the last working day", "number of hours someone smoked inside in the last nonworking day", and "number of cigarettes smoked inside during the last week".

Nicotine concentration was used as the gold standard to assess the validity of the self-reported SHS exposure indicators. For analysis purposes, this variable was dichotomized considering the LOD (0.02 μg/m^3) as the cut-off point, since it classifies by the presence or absence of airborne nicotine. Sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV) and their corresponding confidence intervals (CI95%) were calculated for the self-reported dichotomously categorized variables "homes with or without smokers", "people usually smoking in the home", "smoking rules", "areas where someone smoked", and "number of hours someone smoked inside the home in the last working day" and "in the last nonworking day".

All statistical analyses were carried out using the STATA 13.1 software.

2.5. Ethical considerations

Participants were invited to take part in the study. An information sheet was given to them explaining the study in detail and stating that participation was voluntary, that confidentiality was guaranteed, and that participants could quit the study at any time without penalty. Those who decided to enroll signed an informed consent form at the