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Sources of household air pollution: The association with lung function and respiratory symptoms in middle-aged adult

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ABSTRACT

Introduction: The objective of the present study was to investigate the relationship between sources of household air pollution, respiratory symptoms and lung function.
Methods: 3039 adults aged from 40 to 65 participated in the 2011–2013 ELISABET cross-sectional survey in northern France. Lung function was measured using spirometry. During a structured interview, respiratory symptoms, household fuels, exposure to moulds, and use of ventilation were recorded on a questionnaire.
Results: The self-reported presence of mould in at least two rooms (not including the bathroom and the kitchen) was associated with a 2.5% lower predicted forced expiratory volume in 1 s (95% confidence interval, −4.7 to −0.29; p-trend < 0.05) and a higher risk of wheezing (p-trend < 0.001). Visible condensation was associated with wheezing ($p < .05$) and chronic cough ($p < .05$). There were no significant associations with the type of household fuel or inadequate ventilation/aeration. Similar results were found when the analyses were restricted to participants without known respiratory disease.
Conclusion: Our results suggest that the presence of mould (known to be associated with more severe asthma symptoms) could also have an impact on respiratory symptoms and lung function in the general population and in populations without known respiratory disease.

1. Introduction

1.1. Context

Outdoor air pollution has a major health impact on the general population (Pascal et al., 2013). It is notably associated with the incidence and exacerbations of cardiovascular and respiratory diseases (Mannucci et al., 2015), such as asthma and chronic obstructive pulmonary disease (COPD) (Berend, 2016). A number of studies have shown that exposure to air pollution has an impact on lung function (Adam et al., 2015; de Jong et al., 2016; Rice et al., 2015).

Indoor air pollution is an especially important issue because many people spend two-thirds of their time at home (Brasche and Bischof, 2005), and much of the rest of their time in other buildings. Moreover, rooms that lack ventilation may have higher concentration of pollutants (including PM10 (Dorizas et al., 2015; Zhou et al., 2014)) than outdoor environments (Kattan et al., 2007; Schneider et al., 2001). The measure of household air pollution is difficult because (i) it requires individual measures, and (ii) the sources of pollution are heterogeneous. In the literature, two approaches for evaluating household air pollution have been described. The first consists in performing quantitative measurements of particle matter, nitrogen dioxide, carbon monoxide, volatile organic compounds, spores, and so on. (Bentayeb et al., 2015). Quantitative studies often have small sample size, and the measurement are only valid for a given point in time. The second approach consists in estimating the sources of pollution in a non-quantitative manner using questionnaires. These results can be more readily exploited for prevention because modifiable sources of pollution can be identified. These studies have often a larger size sample. In developing countries, the household air pollution resulting from cooking and heating is a known risk factor for COPD (Kurmi et al., 2010). In developed countries, smoke from biomass is less of a problem. However, household air pollution

Abbreviation: COPD, chronic obstructive pulmonary disease; ECRHS, European community respiratory health survey; FEV1, volume in one second; FVC, forced vital capacity

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results from several other sources, such as mould, dampness (Fisk et al., 2007), outdoor air pollution (Sarnat et al., 2000), environmental tobacco smoke (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2004; Repace and Lowrey, 1980), building materials, household cleaning products, and so on. Furthermore, sources of household air pollution (such as mould and dampness) have been linked to the exacerbation of asthma (Mendell et al., 2011). Lastly, ventilation with outdoor air is intended to remove pollutants emitted from indoor sources. Inadequate ventilation may be associated with a greater frequency of lower respiratory tract problems and asthma symptoms (Sundell et al., 2011), and with more pronounced effects of some air pollutants on respiratory health (Bentayeb et al., 2015). Some previous studies have reported a non-significant association between exposure to mould and poorer respiratory function (Ebbehøj et al., 2005; Gunnbjörnsdottir et al., 2003; Hernberg et al., 2014; Norbäck et al., 2011).

1.2. Objective

The objective of the present study of middle-aged adults in northern France was to investigate the relationship between sources of household air pollution (mould, window condensation, inadequate ventilation/airing, and household fuels) on one hand and lung function and respiratory symptoms (wheezing and chronic cough) on the other.

2. Methods

2.1. Study population

The study included adults aged from 40 to 65 participating in the 2011–2013 Enquête Littoral Souffle Air Biologie Environnement (ELISABET) cross-sectional survey in northern France. The methodology of the ELISABET Study has been described in detail elsewhere (Clement et al., 2017; Giovannelli et al., 2016; Hulo et al., 2016; Quach et al., 2015). Briefly, the study sample is representative of the general population in the Lille and Dunkirk urban areas. The participation rate was 32.9% (3276 out of 9945 potentially eligible participants). Data were collected at home or (very occasionally) during a consultation in a healthcare establishment by 12 nurse investigators. In all cases, a trained, registered nurse administered a detailed questionnaire and performed spirometry testing. The study protocol was approved by the local independent ethics committee (CPP Nord Ouest IV, reference 2010-A00065-34; ClinicalTrials.gov identifier: NCT02490553), in compliance with the French legislation on biomedical research. All participants provided their written, informed consent to participation in the study.

2.2. Outcome assessments

Spirometric lung function was assessed in terms of the forced expiratory volume in one second (FEV1), the forced vital capacity (FVC), and the FEV1/FVC ratio. Spirometry was performed according to the 2005 American Thoracic Society and European Respiratory Society guidelines (Miller et al., 2005). Values were expressed as a percentage of the predicted value (100 x observed value/predicted value) for the participant's age, height and gender, using previously developed equations (Quanjer et al., 2012). The spirometers (Micro 6000, Medisoft, Sorinnes, Belgium) were calibrated weekly. No bronchodilators were administered. For each participant, the spirometry test was repeated (up to seven times) until three acceptable, reproducible flow-volume loops were obtained, according to the same guidelines (Miller et al., 2005). The highest acceptable values of FEV1 and FVC were selected for statistical analysis. All spirometry data were validated by an experienced, specialist physician (JLE). Participants lacking acceptable spirometry results were excluded from the analysis. Women under 145 cm in height and men under 155 cm in height were also excluded because the calculation of predicted values as a function of height would have been irrelevant (Miller et al., 2005).

Respiratory symptoms (such as wheezing and chronic cough) were reported on the standardized Medical Research Council questionnaire (Medical Research Council's Committee on Environmental and Occupational Health, 1986). Participants were considered to have wheezing if they had experienced wheezing or whistling in their chest at any time in the previous 12 months. Chronic cough was defined as cough on most days for at least three months each year in the winter.

2.3. Assessment of exposure

Exposure was measured using a questionnaire. Participants were asked whether or not they had mould in their dining room, living room, kitchen, own bedroom, other bedroom, bathroom or other rooms. The mould score was defined as the stated number of rooms with mould (i.e. the number of "yes" answers, ranging from 0 to 7). In previous studies (Norbäck et al., 2013; Pekkanen et al., 2007), the association with asthma has been found to be stronger for mould exposure in the living area (i.e. the living room and the bedroom) than for exposure in the kitchen or bathroom. Therefore, we analyzed the data for the living area and the non-living area (kitchen or bathroom) separately. The mould score in the living area (ranging from 0 to 5) was defined as the number of "yes" answers to the questions concerning the dining room, living room, own bedroom, other bedroom and other rooms (excluding toilets and utility rooms, in this case). The mould score in the non-living area (ranging from 0 to 3) was defined as the number of "yes" answers to the question concerning the kitchen, the bathroom and other rooms (toilets and utility rooms only, in this case). Cellars and attics were not considered.

The presence of household fuel was defined as presence in the household of a gas stove, a boiler not connected to an outside exhaust or an auxiliary source of heating with household fuel (such as an open fireplace or oil- or coal-burning stove) used on more than 14 days a year. In order to evaluate the impact of exposure time, we performed a sensitivity analysis of exposure to an auxiliary source of heating used throughout the winter. The presence of condensation was defined as an answer of "often" or "always" to the question "Is there occasional condensation on the windows in your dwelling". Ventilation was defined in the present study as a system (whether mechanical or non-mechanical) enabling the movement of outdoor air around an indoor space. Ventilation was considered to be adequate if the accommodation had mechanical ventilation or natural ventilation that was not obstructed in the winter. Aeration was defined in the present study as opening a room's windows. Aeration was considered to be adequate if the room was aired more than once a day in summer and in winter. Exposure to passive smoking was defined as the presence of a current smoker living and smoking in the household or the presence of smokers in the household at least once a month. Information on passive smoking was collected for non-smokers only.

2.4. Covariables

The following variables were recorded: age, gender, educational status (the number of years of full-time education, including primary school), smoking status, height, body mass index (BMI), level of income, number of people living in the household, population density in the locality, and the investigator. Tobacco exposure was estimated from the self-reported smoking status as either a "current smoker" (i.e. at least one cigarette per day for the previous 12 months), a "former smoker" or a "never smoker". Population density data for each locality were sourced from the French National Institute for Statistics and Economic Studies' database (INSEE, 2013, 2011). The "level of income" variable was missing for 801 participants, and so a "missing data" modality was created in this instance.