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Biomass fuel use and the risk of asthma in Nigerian children

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Summary
Background: Biomass fuel smoke exposure contributes to respiratory infections in childhood, but its association with asthma has not been established. We studied the relationship of biomass fuel use with asthma symptoms and lung function in Nigerian children.
Methods: A cross-sectional study was performed in 299 village children aged 5–11 years in North Central Nigeria. Data were collected regarding the cooking fuels used and duration of daily smoke exposure in the cooking area. Asthma symptoms were assessed with a modified International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire, and lung function was assessed with spirometry.
Results: The prevalence of a lifetime history of wheeze was 9.4% (95% CI: 6.3%–13.2%). Fourteen children (4.7%) had airway obstruction (FEV_1/FEV_6 <85%). Female subjects had lower FEV_1 and FEV_6 (110 % and 120% percent predicted, respectively) than males (121% and 130%, respectively, P <0.001 for both differences). Advancing age was associated with a relative decline in the predicted value of FEV_1 of 7.8 % per year ($r = -0.61$; $P < 0.001$). Children in families that used firewood daily did not have a significantly increased likelihood of asthma-related symptoms (OR = 2.36, 95% CI: 0.66–8.44). Similarly, airway obstruction did not differ significantly between children in households that did and did not use firewood daily (mean FEV_1/FEV6 of 0.95 and 0.97, respectively; $P = 0.41$).
Conclusion: Reported smoke exposure was not associated with an increased risk of asthma symptoms or airway obstruction. However, lifetime smoke exposure may explain the reduction in spirometric values in female subjects and with advancing age.

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Introduction

It is estimated that 2 million people die prematurely each year from smoke produced by open fires and improvised stoves, leading to 4% of the global health burden [1,2]. In today's world roughly half, and close to 90% of those living in rural households, still rely on biomass fuels (BMF) [2]. This translates into 500 million households or 2.4 billion people worldwide using unprocessed BMF for cooking and heating [1]. Biomass fuels consist of coal, wood, crop residues, or any plant or animal material burned in household stoves or open fires, often with inadequate ventilation [2–4]. Inefficient BMF combustion creates substantial smoke, carbon monoxide, hydrocarbons, free radicals, oxygenated organics and particulate matter [5,6].

Exposure to biomass smoke doubles the risk of pneumonia and other acute lower respiratory infections, and contributes to over 800,000 deaths in children under five [7,8]. In rural Africa, exposure to biomass smoke in young children is frequent, because they are carried on their mothers' backs or remain close to their mothers during cooking. Older girls commonly help in cooking, increasing their exposure risk.

Asthma is potentially associated with exposure to biomass smoke. Airway obstruction is caused by bronchospasm, airway inflammation, and mucus plugging. Symptoms of wheezing, cough, and dyspnea may be provoked by inhalation of smoke, leading to inflammation and bronchospasm. Exposure to biomass smoke has been associated with respiratory diseases like chronic obstructive pulmonary disease, asthma, tuberculosis, and lung cancer in adults. During episodes of high pollution, asthma and respiratory related hospital admissions increase [9,10]. However, individual studies report conflicting results regarding the association of biomass smoke exposure and asthma [7]. The findings of a meta-analysis of four studies of asthma in children and biomass smoke exposure were inconclusive [7].

Although the evidence for particulate air pollution in the pathogenesis of asthma is suggestive, the link between asthma and biomass smoke exposure has not been confirmed. The relationship of biomass smoke exposure with pulmonary function has not been previously reported in children in Nigeria, the most populous country in Africa. In order to clarify the relationship of biomass smoke exposure and asthma in African children, we conducted a community-based cross-sectional study to determine the association between biomass smoke exposure in children and the risk of asthma symptoms and airway obstruction in a rural Nigerian village.

Methods

Eligible children, aged 5–11 years, were recruited from households in Kisayhip village near the city of Jos, in North Central Nigeria. Kisayhip is on rocky plateau with an altitude of approximately 1000 m. Data were collected during the dry season in February 2012. A trained community health worker, who resided in the village and was fluent in English and the local languages of Rukuba and Hausa, accompanied the study investigator. All households were visited in an area of the village prior to moving to the next cluster of homes, beginning at one end of the village and progressing to the other. As no list of households was available, we did not use a formal method of random selection. Households were revisited up to four times to include all eligible children that were missing on previous visits. A household was defined as all persons who eat from the same pot. Acutely ill children, children with obvious physical or mental disabilities, and children unable to perform acceptable spirometry were excluded. The study was approved by the village chief and by the Jos University Teaching Hospital Institutional Health Research Ethical Committee. Written informed consent was obtained from the parent or guardian of each child enrolled.

Data were collected about cooking fuels, the cooking environment and the number of family members who smoked cigarettes. A modified version of the questionnaire developed by the International Study of Asthma and Allergies in Childhood (ISAAC) was used to identify asthma symptoms [11]. Wheezing was defined as reported wheezing in the past 12 months and wheeze ever, which were coded positive if the subject answered "yes" to wheezing or whistling in the chest. Cough was defined as the presence of a dry cough not associated with a cold or chest infection. Lung auscultation was performed, and the presence of rhonchi or wheezing was classified as adventitious breath sounds. The variable "symptoms and signs of asthma" was considered positive if wheeze, cough, or adventitious breath sounds were present, based on the aforementioned definitions. Weight was measured to the nearest half kilogram with a platform scale. Height was measured to the nearest quarter inch by having children stand against a wall and using a tape measure.

Pulmonary spirometry was performed with a compact spirometer with a pediatric mouthpiece (Vitalograph COPD-6, Ennis, Ireland). Spirometric measurements included the forced expiratory volume in 6 s (FEV_6), forced expiratory volume in 1 s (FEV_1), and FEV_1/FEV_6, the ratio of volumes expressed as a percentage to quantify the degree of airway obstruction. Spirometry was performed by a respiratory therapist (JDT) in a standing position with the child's arms at the sides. Nose clips were used to prevent nasal exhalation. The interviewer was trained in proper use of the spirometer and instructed children on proper technique, which was demonstrated to the child. Efforts were repeated up to ten times, or until a good effort and technique were observed. Spirometric values for three acceptable efforts were recorded, and the effort with the greatest values was used for analysis. Based on the American Thoracic Society guidelines for the interpretation of spirometry, obstruction was defined as FEV_1/FEV_6 ratio less than 85 percent of predicted [12]. Predicted spirometric reference values for gender, age, and height were based on African Americans in the National Health and Nutrition Examination Survey (NHANES III) [13].

Statistical methods

Epi Info 3.5.3 (CDC, Atlanta, Georgia) and SPSS 17 (IBM, Armonk, New York) were used for data analysis. Spirometric values were compared between those using different fuel