ASTHMA AND INDOOR AIR POLLUTION AMONG INDIGENOUS CHILDREN IN GUATEMALA

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ABSTRACT
Objectives: To estimate the prevalence and severity of asthma among indigenous children in Guatemala, and the association with cooking on open fires.
Methods: In 1058 homes with children 4-6 years of age, we interviewed the mothers using standardized ISAAC procedures and questionnaire.
Results: Only 3.4% reported wheezing symptoms in the last 12 months. In a logistic regression model, use of open fire for cooking was a significant risk factor for a number of asthma symptoms, with odds ratios varying from 1.81 to 3.21. For the different cooking technologies (1=improved stove with chimney, 2=mixture of gas and open fire, 3=open fire) we observed significant trends for some of the symptoms.
Conclusions: The asthma prevalence is low among indigenous children in Guatemala, compared to other populations in Latin-America. Use of open fire for cooking, may be an important risk factor for asthma symptoms and severity.

INDEX TERMS
Allergies and asthma, Cooking technologies, Fuel and combustion pollutants, Surveys, Residences.

INTRODUCTION
The objectives of this study were to estimate the prevalence and severity of asthma among Native-American children in Guatemala, and to describe the relationship between cooking technology and the prevalence and severity of asthma.

Asthma is the most common chronic disease among children worldwide, with recent increases in many countries. Despite a large body of information regarding the prevalence of asthma and allergic diseases, mostly from developed countries, the epidemiology of asthma is still in some respects similar to that of cancer epidemiology in the 1960s, when the international patterns of cancer incidences were studied (ISAAC -98). Those studies revealed striking international differences that gave rise to many new hypotheses, tested in further epidemiological studies that identified previously unknown risk factors. Whole populations may be exposed to risk factors for disease and the patterns may be apparent only when comparisons are made between, rather than within, populations. This underlines the importance of doing standardized asthma studies in countries like Guatemala.

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Recently the International Study of Asthma and Allergies in Childhood (ISAAC) has published prevalence rates from 155 centers in 56 countries revealing differences as much as 60-fold between centers in the prevalence of asthma symptoms. Large within-country variation between individual centers was also found, suggesting that environmental factors (in their broadest sense) may be critical to the development of wheezing disorder in childhood (ISAAC -98).

The evidence on exposure to biomass smoke and asthma in developing countries is limited and inconsistent (Bruce -00). Although some studies find that air pollution, including environmental tobacco smoke, may be a factor sensitizing genetically susceptible individuals (Bjorksten -99), a recent systematic review does not support this view (Strachan -98). There is more consistent evidence, however, that air pollution and environmental tobacco smoke trigger asthma in sensitized individuals (Bjorksten -99, Strachan -98). The few studies on biomass smoke in relation to asthma from developing countries have yielded mixed findings, and some of these studies were underpowered or did not adjust for confounding (Bruce -00). Given the very widespread use of biomass for cooking and the prevalence and alarming increase of asthma in many countries, biomass smoke as a risk factor deserves more scientific attention.

METHODS
In 1058 homes with children 4-6 years of age, we administered the standardized ISAAC questionnaire with selected additional questions. The ISAAC core questions have been used in a number of countries and allow for international comparison. For the translation to the native Mam language, we followed the standard ISAAC guidelines, using a Mam-speaking physician as our translator in consultation with local focus groups. The translation was verified by back translation into English, and the translated version pilot-tested. The interviewers were native speakers, and received training according to the ISAAC standard requirements. The field supervisor accompanied the interviewers unannounced in 5% of the households, and there was overlap of interviewers in approximately 10% of the household to minimize interviewer bias. The response rate was close to 100%.

Data analysis: A logistic regression model including cooking on open fire, family history of atopic disease, sex of the child, and interviewer was fitted for each of the asthma symptoms. The variables selected for the model were predetermined, based on other studies, and the fact that we found some differences between the interviewers. The chi-square test for trend was used to assess changes in symptom prevalence in relation to the different cooking technologies (1=improved stove with chimney, 2=mixture of gas and open fire, 3=open fire). Previous studies in the area found that particle levels trended in this direction, with 24-h means of PM3.5 in the kitchen-area of 330, 1200, and 2170µg/m3 by stove type (Albalak-01).

RESULTS
Table 1) shows the prevalence rates of asthma symptoms. Table 2) shows the importance of cooking on open fire as a risk factor for the different symptoms. 51.5% of the households cooked on improved stoves, 38.1% on open fires and 10.4% on both open fire and gas stove. Open fire was not significantly related to waking up at night due to symptoms, number of wheezing episodes, or dry cough at night apart from having a cold. For the different cooking technologies (1=improved stove with chimney, 2=mixture of gas and open fire, 3=open fire) there was a significant trend for wheezing symptoms ever (Chi-square for trend, p<0.05) and exercise-induced symptoms last 12 months (Chi-square for trend, p=0.01).
Table 1. Prevalence of respiratory symptoms among Mam Indian children (age 4-6) in Guatemala.

<table>
<thead>
<tr>
<th>% overall (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever wheezed</td>
</tr>
<tr>
<td>Wheezed in the last 12 months</td>
</tr>
</tbody>
</table>

In the last 12 months:

<table>
<thead>
<tr>
<th>% overall (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech limited by asthmatic symptoms</td>
</tr>
<tr>
<td>Exercise induced wheezing</td>
</tr>
<tr>
<td>Woke up at night &gt; 4 times</td>
</tr>
</tbody>
</table>

Table 2. In a logistic regression model including family history of wheeze, sex and interviewer, open fire for cooking was a risk factor for the following symptoms:

<table>
<thead>
<tr>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever wheezed</td>
<td>1.81</td>
<td>1.04-3.12</td>
</tr>
<tr>
<td>Wheezed in the last 12 months</td>
<td>2.35</td>
<td>1.08-5.13</td>
</tr>
<tr>
<td>Speech limited by asthmatic symptoms</td>
<td>3.21</td>
<td>1.14-9.01</td>
</tr>
<tr>
<td>Exercise induced wheezing</td>
<td>2.22</td>
<td>1.06-4.64</td>
</tr>
<tr>
<td>Asthma diagnosis</td>
<td>2.02</td>
<td>0.91-4.4</td>
</tr>
</tbody>
</table>

Open fire was not significantly related to waking up at night due to symptoms, number of wheezing episodes, or dry cough at night apart from having a cold. For the different cooking technologies (1=improved stove with chimney, 2=mixture of gas and open fire, 3=open fire) there was a significant trend for wheezing symptoms ever (Chi-square for trend, p<0.05) and exercise-induced symptoms last 12 months (Chi-square for trend, p=0.01).

Family history of wheezing was highly significant in the logistic model for all asthma symptoms, with odds ratios ranging from 9-55. Sex was not significantly related to any of the symptom categories.

DISCUSSION

A recent publication of asthma symptoms among 6-7 year olds from 17 centers in nine Latin-American countries showed a large variation in the prevalence of current wheeze (wheezing in the last 12 months), ranging from 8.6-32.1% (Mallol -00). To our knowledge, no centers worked with a purely Native-American population. It’s remarkable that in our study only 3.4% of the 4-6 years old had wheezing symptoms in the last 12 months, less than half the prevalence of the center with the lowest prevalence (Cuernavaca, Mexico) in the main Latin-America survey.

Based on high prevalence also in poor populations, the main study concludes that factors considered protective against asthma in other regions of the world, like parasitic infestations and a high level of respiratory infections do not have the same effect in Latin-America. The Mam Indians of Guatemala are among the most exposed populations to parasites and respiratory infections, and our findings go against the conclusions from the Latin-American group and support the findings from other parts of the world (ISAAC -98) that a life-style associated with high prevalence of infections and infestations is related to lower asthma prevalence. We can just speculate about the reasons for the low prevalence found in our study; they could be due to genetic/racial factors, to a number of life style factors, or geography. Our study population lives at a moderately high altitude (approx. 2000 meters), which fits well with the Cuernavaca population, which had the lowest prevalence and the
highest altitude (1500-2000 m.) in the main Latin-America ISAAC survey. The very high prevalence rates found in Spanish speaking Latin-American communities, also compared to findings from other developing countries around the world (ISAAC -98), makes it is tempting to speculate that the Spanish term for wheezing, may yield more false positive cases than other language translations. Our study population was somewhat younger (4-6 years) compared to the main study (6-7) years. The fact that younger children usually have more wheezing make the low prevalence found in our study even more striking.

**Biomass-smoke exposure:** Improved wood stoves with a chimney were distributed at minimal costs by a governmental organization to a number of homes that signed up. A few households invested their own funds in small gas stoves that are used together with the traditional open fires, producing an intermediate range of smoke pollution (Albalak -01). The mode of distribution of the improved wood stoves is thought to have reduced the socio-economic differences between the exposure groups, to make this a good setting for comparisons.

We found a consistent trend, with higher prevalence of general symptoms and symptoms indicating severity of the disease among children from homes cooking on open fires, with adjusted odds ratios indicating a doubling or more of the risk of symptoms. Few other studies have reported similar findings. A study from Nepal of people aged 11-17 years (Melsom -01) found an adjusted odds ratio of 2.3 (1.2-4.8) for asthma among those cooking on open fires compared to wood stoves with a flue, gas, or kerosene stoves. A case-control study of schoolchildren in Nairobi found increased exposure to wood smoke in asthmatics (Mohammed, 1995). Two other studies from Turkey and Jordan found similar results, but did not adjust for confounding (Gharaibeh -96, Guneser -94). Several studies have reported no association; some of these studies had small numbers of asthmatic children (Ellegard -96, Noorhassim -94).

A number of studies, including the main ISAAC papers (ISAAC -98, Mallol -00) have reported lower asthma prevalence in areas with higher outdoor air pollution. This is a paradox, when we look at our findings and the relatively strong evidence that outdoor air pollution triggers asthma attacks in asthmatic individuals (Ostro -85, Lebowitz -94, Strachan -98, Bjorksten -99). There are differences in pollutant types and mixtures between biomass indoor air pollution and urban outdoor air pollution, but the similarities between the mixtures may be more important than the differences. Outdoor air pollution as well as indoor air pollution may very well be independent risk factors for asthma, but other, even stronger risk factors related to modernization may overcome the effects of air pollution in many industrialized societies. A homogenous population with large differences in household exposure levels, like ours is ideal for evaluation of exposure, independent of modernization factors. For outdoor air pollution, whole populations rather than households share the same exposure, and differences within the population are harder to elucidate. Thus, household exposure differences in a setting like our may provide the most ideal setting we can find, to evaluate the role of air pollution as an independent risk factor.

Our study gives a “snapshot” of asthma symptoms related to current exposure, but does not tell anything about potential sensitization, immune effects, or long term symptoms. Different mechanisms may be involved in the body’s short-term “alarm response” to extreme pollution, compared to long-term, partly immune-mediated asthmatic disease. A study where children are randomized to groups with and without improved cooking technology, and asthma symptoms and immune status followed over time, is needed to get conclusions on the short-term and long-term causal effects of air pollution on asthmatic disease.
CONCLUSIONS
The asthma prevalence is low among indigenous children in Guatemala, compared to other populations in Latin-America. Our study indicates that the use of open fire for cooking may be an important risk factor for asthma symptoms and severity, which needs to be studied further.

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