

RESEARCH ARTICLE

Smoke Exposure as a Risk Factor for Developing Pneumonia in Children under Five Years Old in Choloma, Honduras: A Case Control Study in a Public Health Center from July to October 2016

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Abstract:

Background: Pneumonia is the main cause of death during childhood in developing countries. The risk factors for developing pneumonia include age, preterm birth, low birth weight, malnutrition, poverty, comorbidities and environmental factors like smoke exposure. Air pollution increases the risk of respiratory tract infections, hospitalizations, severity of pneumonia and death during childhood. This study was designed to identify if the smoke exposure and type of smoke is a significant risk factor for developing pneumonia in children under five years in Choloma, Honduras.

Methods: Honduras during four months since July 2016 to October 2016. The study included a total of 52 children under five years (26 cases and 26 controls) to determine if they were exposed to smoke at home and if that condition was related to development of pneumonia. Cases were selected at the time of diagnosis. The controls were selected matching the age of the cases. Data was collected through an interview. Written informed consent was requested.

Results: Pneumonia was more frequent among children under two years, males, children with incomplete vaccination according to age, children with comorbidities like asthma and children from families who live in extreme poverty. Smoke exposure was more frequent among children diagnosed with pneumonia (93.3% vs 19.2%).

. The most common source of smoke was wood used as fuel for cooking. Smoke exposure was a significant risk factor for developing pneumonia, wood smoke, tobacco smoke and industrial smoke showed higher risk for developing pneumonia. Smoke from burning trash was more frequent among children diagnosed with pneumonia but this condition was not statistically significant.

Conclusion: smoke exposure is a risk factor for developing pneumonia in this population. Wood smoke and tobacco smoke are the main sources of exposure in this population.

Keywords: Pneumonia, Risk factors, Smoke exposure, Wood smoke, Tobacco smoke, Industrial smoke

Introduction

The respiratory tract infections are common during childhood. Pneumonia is one of the main causes of hospitalization and deaths during childhood, especially in developing countries; pneumonia is a major health problem because it is a preventable cause of death. (1) Pneumonia is a lung infection caused by bacteria, virus or fungi. Bacteria are the main cause of pneumonia and most of the infections are caused by *Streptococcus pneumoniae* and *Haemophilus influenzae* while in people with a compromised immune system other causes like virus, fungi or atypical bacteria are responsible. Incidence of pneumonia in children aged less than five years is greater in developing countries, where it is estimated that 151.76 million of new cases of pneumonia occur per year while in developed countries it is reported 4.08 million of new cases per year. (2) According to national statistics, during 2011 and 2012, 12.8% of the children aged less than five years showed symptoms of pneumonia (1273 cases). Pneumonia was more frequent in rural areas and the education level of the mother showed to be lower in those cases. (3)

As pneumonia remains as the main cause of death during childhood, it becomes a priority to determine the risk factors in order to set strategies for prevention such as vaccination.(4) According to studies, mortality rates are higher in children under one year, also in children with comorbidities such as asthma or children with low weight for age Z score.(5)

Risk factors for acute respiratory tract infections include variables like age, preterm birth, low birth weight, inadequate breastfeeding, malnutrition, nutrient deficiencies, socioeconomic status, maternal education, comorbidities such as asthma and environmental factors. (6,7)

Air pollution is a factor than highly increases the risk of acute respiratory tract infections, especially in children; also, it increases the proportion of deaths due to these conditions. Indoor smoke exposure during childhood could be due to combustion of solid fuels used for cooking or tobacco smoke, which are highly associated with prevalence of bronchiolitis and pneumonia in children.(8) Air pollution seems to increase severity of pneumonia; according to studies, children

with higher exposure to air pollutants were more likely to be hospitalized due to pneumonia. (9) Inhalation of tobacco smoke during childhood is a risk factor for developing not only respiratory tract infections but also higher prevalence of severe pneumonia, asthma and chronic cough. It is a common habit in developing countries to use wood as a cooking fuel, if a child is exposed to this smoke they are more likely to develop pneumonia and it highly increases the risk of treatment failure. Air pollution can contribute to develop pneumonia through direct action in the lungs causing swelling or promoting bacterial colonization by suppressing phagocytosis and cilia cells function. (10,11)

In Honduras, smoke exposure is constant, the use of wood as cooking fuel, smoke from industries, burning of trash and tobacco are common practices in this population and according to a research conducted in hospitalized children due to respiratory tract infections showed that children who have been exposed to wood smoke were more likely to develop pneumonia and higher risk of hospitalization. This practices are more common in poor areas and with the upswing of factories development in certain areas like Choloma, make this population especially vulnerable to respiratory tract infections like pneumonia.(12,13)

This study was designed to identify if the smoke exposure and type of smoke is a significant risk factor for developing pneumonia in children under five years in Choloma, Honduras.

Materials and Methods

This case-control study was conducted in a public health center at Choloma, Honduras during four months since July 2016 to October 2016. The study included a total of 52 children under five years (26 cases and 26 controls) to determine if they were exposed to smoke at home and if that condition was related to development of pneumonia. Children under five years who were diagnosed with pneumonia despite were defined as cases based on World Health Organization definitions.(14) Cases were selected at the time of diagnosis. Children aged less than five years who received primary health attention in the same center during the same period and were diagnosed with illness any other than pneumonia were considered as controls. To avoid bias, controls were selected matching the age of the patients in the case group. All the pneumonia cases that received primary health attention in this center during this period were included in the study.

Written informed consent for participation in this study was obtained from the parents or caregivers of the children selected for cases and control groups, according to ethic principles. To protect patient's data, written consent and interview were kept in different files without names or codes that could be used to identify the subjects. When the parent or guardian of the child could not read, the form was read and they gave consent through the fingerprint. This study did not involve any harm for the children or caregiver. Parents or guardians were informed about the objectives of this study and when they expressed concern, they received proper explanations so they could decide whether to participate in the study or not. This study was approved by the ethic committee of Choloma Health Center.

We collected demographic data of the patients, socioeconomic status, vaccination history, comorbidities, nutritional status and smoke exposure by interviewing the parent or guardian through a questionnaire and according to

medical history file of the patient. Nutritional status was determined by body mass index based on World Health Organization Child Growth Standards.(15) A child was considered as underweight if the weight-for-age z-score was less than -2 z score and as severely underweight if the weight-for-age z-score was less than -3 z score. Children with >-2 z score were considered eutrophic. Smoke exposure was evaluated in four categories: tobacco smoke, industrial smoke, smoke from burning trash and wood smoke (used as cooking fuel). Tobacco smoke exposition was considered if any of the parents or family members who live in the same house smoke in the room with the child. Industrial smoke was considered if the house is located in a 1000 meters radius from a factory with smoke emissions. Smoke from burning trash was considered when this activity was performed in the backyard of the house. Wood smoke exposure was considered when wood was used as main fuel for cooking. Smoke exposure was considered if any of the sources of smoke were positive, then the number of sources was counted.

The collected data was entered and analyzed with Statistical Packages for Social Sciences software (SPSS-23) for Windows system. Qualitative variables were analyzed by Chi square test, statistical significance is set at $p<0.05$ and confidence interval set at 95% level. The effect sizes of smoke exposure are presented as odds ratios (OR) with 95% confidence intervals.

Results

A total of 52 children were enrolled in this study, 26 of them were diagnosed with pneumonia and 26 were controls. Of these children, 40.4% were females. The mean age was 15.46 ± 14.72 months. The socioeconomic status was low for 57.7% and 19.2% were extremely poor. According to the national guidelines for vaccination, 21.2% of these children were not fully immunized (pentavalent vaccine and pneumococcal vaccine). The majority of children were eutrophic and 34.6% were underweight (weight-for-age z-score was less than -2 z score)

Comorbidities were present for 19.2% of the children, 11.5% were chronic conditions (asthma and epilepsy) and 7.7% presented along with the current illness an acute concomitant condition (intestinal parasite infection and common cold). General data is summarized in Table 1.

Table 1. General data

Characteristic	n (%)
Gender	
Female	21 (40.4%)
Male	31 (59.6%)
Socioeconomic status	
Extremely poor	10 (19.2%)
Low	30 (57.7%)
Middle	12 (23.1%)
Vaccination	
Fully immunized	41 (78.8%)
Not fully immunized	11 (21.2%)
Nutritional status	
Eutrophic	34 (65.4%)
Underweight (less than -2 z score)	18 (34.6%)

The sources of smoke exposure were quantified, the majority of children were exposed to one or two sources of smoke (27% and 25%) while 44.2% were not exposed to smoke. The mean number of sources of smoke was 0.90 ± 0.975 sources. The most common source of smoke was wood smoke, 34.6% of the children were exposed; 23.1% of the children were exposed to tobacco smoke, 17.3% were exposed to smoke from burning trash and 15.4% were exposed to industrial smoke. The general smoke exposure is summarized in Table 2.

Table 2. General smoke exposure

Characteristic	n (%)
Number of sources of smoke	
0	23 (44.2%)
1	14 (27.0%)
2	13 (25.0%)
3	1 (1.9%)
4	1 (1.9%)
Wood smoke exposure	
Yes	18 (34.6%)
No	34 (65.4%)
Industrial smoke exposure	
Yes	8 (15.4%)
No	44 (84.6%)
Tobacco smoke exposure	
Yes	12 (23.1%)
No	40 (76.9%)
Exposure to smoke from burning trash	
Yes	9 (17.3%)
No	43 (82.7%)
Exposed to smoke (at least one source)	29 (55.8%)
Not exposed to smoke	23 (44.2%)

When comparing general characteristic from cases and controls, males were more common in both groups, the socioeconomic status was lower in the cases, the children diagnosed with pneumonia were not fully immunized more often than the controls, in both groups was more common that the child was classified as eutrophic and pneumonia cases had comorbidities more often than the controls; this characteristics are summarized in Table 3.

Table 3. General characteristics from cases and controls.

Charateristic	Pneumonia cases n (%)	Controls n (%)
Gender		
Female	11 (42.3%)	10 (38.5%)
Male	15 (57.7%)	16 (61.5%)
Socioeconomic status		
Extremely poor	8 (30.8%)	2 (7.7%)
Low	14 (53.8%)	16 (61.5%)
Middle	4 (15.4%)	8 (30.8%)
Vaccination		
Fully immunized	17 (65.4%)	24 (92.3%)
Not fully immunized	9 (34.6%)	2 (7.7%)

Nutritional status		
Eutrophic	18 (69.2%)	16 (61.5%)
Underweight (less than 2 z score)	8 (30.8%)	10 (38.5%)
Comorbidities		
None	19 (73.1%)	23 (88.5%)
Chronic or acute conditions	7 (26.9%)	3 (11.5%)

Smoke exposure was more common in children diagnosed with pneumonia (93.3% vs 19.2%). The most common source of smoke was wood used as fuel for cooking. All the studied sources of smoke showed higher risk for developing pneumonia. Exposure to wood smoke had the highest risk for developing pneumonia. There is statistically significant difference for wood smoke, industrial smoke and tobacco smoke. The comparison of smoke exposure between cases and controls is summarized in Table 4.

Table 4. Comparison of smoke exposure in cases and controls

Characteristic	Cases n (%)	Controls n (%)	Odds ratio (95% CI)	p value
Wood smoke				
Exposed	17 (65.4%)	1 (3.8%)	47.222 (5.468-407.796)	.000*
Not exposed	9 (34.6%)	25 (96.2%)		
Industrial smoke				
Exposed	7 (26.9%)	1 (3.8%)	9.211 (1.043-81.361)	.021*
Not exposed	19 (73.1%)	25 (96.2%)		
Tobacco smoke				
Exposed	11 (42.3%)	1 (3.8%)	18.333 (2,147-156.583)	.001*
Not exposed	15 (57.7%)	25 (96.2%)		
Smoke from burning trash				
Exposed	6 (23.1%)	3 (11.5%)	2.300 (0.508-10.411)	.271
Not exposed	20 (76.9%)	23 (88.5%)		
Any source of smoke				
Exposed	24 (92.3%)	6 (23.1%)	40.000 (7.258-220.448)	.000*
Not exposed	2 (7.7%)	20 (76.9%)		

*statistically significant difference

Discussion

Demographic characteristics of children diagnosed with pneumonia were similar as the results of a research in children with lower acute respiratory infection in hospitalized cases, showing higher frequency of pneumonia in children aged less than two years (72% while in our study 71.2% of the pneumonia cases were in children under two years); also pneumonia cases were more common in males. (16)

Pneumonia cases were more common among children that belong to families who live in extreme poverty, this finding is consistent with prior results and national statistics. (3,13)

An incomplete immunization was more frequent in pneumonia cases than in controls (34.6% vs. 7.7%), this finding is consistent with results of previous studies about risk factors for developing pneumonia while complete vaccination

according to age is a protecting factor and therefore it is necessary for the national health system to continue with immunization campaigns, education for the parents and other strategies to ensure a complete vaccination in order to prevent pneumonia and related deaths.(17)

Children classified as underweight represent 34.6% of the pneumonia cases, this frequency is higher than showed by Prado et al. (2011) in hospitalized children due to viral lower respiratory tract infections in 23%. (16) However, this finding is consistent with well known risk factors for developing pneumonia when child weight for age is less than 2 z score. (2,18)

Smoke exposure is frequent among the population in Honduras and it is a risk factor for developing pneumonia in children under five years. The most common source of smoke is wood used as fuel for cooking, this is practiced by 65.4% of the families of children diagnosed with pneumonia and it increases the chances of developing this illness by 47.222 times, this is higher than the results showed by Rivera and Medina (2012) who reported increase of three times the chance of developing pneumonia when the child is exposed to wood smoke, however, this study included other respiratory infections, not only pneumonia. (13) According to Kammen et al. (1998), when wood is used as fuel for cooking, children are exposed to higher levels of particulate pollution, increasing the risk for developing respiratory illness and this condition was more frequent in low income areas.(19)

Exposure to tobacco smoke was found in 23.1% of all children, similar result was showed by Rivera and Medina (2012) who described this condition in 25.9% of the children.(13) Association between tobacco smoke exposure and pneumonia has been described in previous studies. Tobacco smoke exposure not only is a risk factor for developing pneumonia, it is also a risk factor for mortality in children.(20) Tobacco smoke exposure increased eighteen times the risk for developing pneumonia in our study and this exposure was present in 42.3% of the patients diagnosed with pneumonia. Children exposed to tobacco smoke had a greater chance of developing pneumonia according to other studies with statistically significant differences ($p < 0.001$). (21)

Industrial smoke showed increase of nine times for developing pneumonia, while lower results were shown in other studies that indicate 1.72 times higher risk for developing pneumonia. (17) Despite the difference found, the area of our study is an industrial area and this could explain the dissimilarity; according to other researches, respiratory illness are more frequent in children who live in industrialized areas than those who live in rural areas, however a causal relationship has not been established yet and further research is needed. (19)

It is a common practice among this population to burn trash, 17.3% of the children in this study were exposed to this source of smoke. This exposure was higher among children diagnosed with pneumonia, (23.1% vs. 11.5%), however this was not statistically significant. Similar results were provided by Rivera and Medina (2012), 28% of the children diagnosed with respiratory tract infection were exposed to smoke from burning trash. (13) Despite results in our study do not seem to correlate smoke from burning trash and pneumonia, other researches showed higher rates of respiratory symptoms among people who live near incinerators increasing nine times the risk of developing cough or wheezing; also, the pollutants emitted, like dioxins, organic compounds and heavy metals are highly associated with cancer development and mortality during childhood, therefore, there is no evidence to consider smoke from burning trash as harmless. As this remains as a common practice among this population, research is needed to inquire the effects and hazards due to this smoke exposure.(22) There are no regulations to pollutants in this area and as this community continues as the

main city of factories in the country, it is necessary to evaluate the effects in public health, especially during childhood and its influence on pneumonia development and severity. This study opens the gate for further research in this population, because the risk of pneumonia development was high in this population, especially in children under two years. It is important to advise the parents of the potential harms in children's health due to smoke exposure, so they could prevent it or avoid it, like cigarette smoking, which showed to be an important factor in pneumonia development.

Smoke exposure increased the risk of developing pneumonia in this study; children diagnosed with pneumonia were exposed to smoke with higher frequency than the controls (92.3% vs. 23.1%). This finding is consistent with prior researches that indicate smoke exposure as a risk factor for developing pneumonia and secondhand smoking has been widely associated with higher frequency of pneumonia. (2,23) Pneumonia is a preventable disease and deaths due to pneumonia are also preventable, therefore, vaccination is required and smoke exposure must to be avoided during childhood.

Conclusions

Smoke exposure during childhood increases the risk of developing pneumonia, especially in children under two years and those who live in extreme poverty. Wood smoke and tobacco smoke are the main sources of exposure in this population. Industrial smoke was related with pneumonia development and its further research is needed to establish its relation with the severity of pneumonia.

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