Original Article

Risk factors associated with pneumonia in children under five years of age in El Salvador

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Abstract

Introduction. Pneumonia is known as one of the main causes of morbidity in the world and is the first individual cause of infant mortality worldwide. a". This disease has always been of scientific interest in animal models. **Objective.** identify the risk factors associated with community-acquired pneumonia in children under five years of age admitted to the Hospital Nacional San Rafael in 2022. **Methodology.** A case-control study with a 1:2 ratio. Cases were defined as children under five years of age hospitalized with clinical and radiological criteria of community-acquired pneumonia and controls as children under five years of age hospitalized for causes other than community-acquired pneumonia. Simple random sampling was used. Univariate analysis was performed with frequencies and proportions, and bivariate analysis was performed with the chi-square method. **Results.** The study included 63 cases and 126 controls. The median age was 14 months, and 52 % (33/63) were female. The statistical association was found for history of prematurity (OR 2.62; CI95 % 1.27-5.38; p = 0.01), stunting for age (OR 2.12 CI95 % 1.1-4.40; p = 0.02), overcrowding (OR 1.96; CI95 % 1.06-3.6; p = 0.04), exposure to tobacco smoke (OR 3.20; CI95 % 1.51-6.74; p < 0.01). **Conclusion.** Risk factors associated with community-acquired pneumonia were identified as being premature, stunting, overcrowding, and exposure to tobacco smoke.

Keywords
Pneumonia, Pediatrics, Hospitalization, Risk Factors.

Resumen

Introducción. La neumonía es conocida como una de las principales causas de morbilidad en el mundo y es la primera causa individual de mortalidad infantil a nivel global. **Objetivo.** Identificar los factores de riesgo asociados a neumonía adquirida en la comunidad en menores de cinco años de edad, ingresados en el Hospital Nacional San Rafael durante el 2022. **Metodología.** Estudio de casos y controles con una relación 1:2. Se definió como caso a menores de cinco años hospitalizados con criterios clínicos y radiológicos de neumonía adquirida en la comunidad y como controles a los niños menores de cinco años hospitalizados por causas diferentes a neumonía adquirida en la comunidad. Se usó un muestreo aleatorio simple. Se realizó un análisis univariado con frecuencias y proporciones, y un análisis bivariado con el método chi cuadrado. **Resultados.** El estudio incluyó a 63 casos y 126 controles. La mediana de edad fue de 14 meses, y el 52 % (33/63) fue del sexo femenino. Se encontró asociación estadística en los antecedentes de prematurez (OR 2,62; IC95 % 1,27-5,38; p = 0,01), retraso de crecimiento para edad (OR 2,12 IC95 % 1,1-4,40; p = 0,02), hacinamiento (OR 1,96; IC95 % 1,06-3,61; p = 0,04), exposición al humo de tabaco (OR 3,20; IC95 % 1,51-6,74; p < 0,01). **Conclusión.** Se identificaron como factores de riesgo asociados a neumonía adquirida en la comunidad ser prematuro, retraso de crecimiento para edad, hacinamiento y exposición al humo de tabaco.

Palabras clave
Neumonía, Pediatría, Hospitalización, Factores de riesgo.

Introduction

Community-acquired pneumonia (CAP) is a common infectious disease that occurs in previously healthy patients in an out-of-hospital setting.[i, ii] It is defined in clinical practice as an acute inflammatory disease affecting the lung parenchyma due to the presence of community pathogens. Viruses are the main cause of CAP in children under five years of age, with respiratory syncytial virus being the most common viral agent, while *Streptococcus pneumoniae* and *Mycoplasma pneumoniae* are the most common bacterial agents in typical and atypical CAP, respectively. [ii,iii]

Characteristic features of this acute illness in children include fever, cough, increased respiratory rate, changes in lung auscultation, and inflammatory infiltrates on chest radiography. CAP can progress to complications involving other organs, and approximately 40 % require hospitalization, and five percent are admitted to the intensive care unit.[i–vi] This acute disease often occurs at the extremes of life, and in the pediatric age group, and is influenced by the anatomy of the airways and the response of the still developing immune system;[iii-vi] in addition to other biological conditions, this disease is increasingly associated with environmental and socio-cultural conditions as risk factors.[vii-ix]

CAP is currently the leading preventable cause of under-five deaths worldwide, affecting all regions, with the highest rates of morbidity and mortality in low-income countries.[x] In 2019, CAP caused 14 % of under-five deaths worldwide and 22% of all deaths in children aged one to five years, mainly in regions of South Asia and sub-Saharan Africa.[xi] In the Americas, the incidence of CAP due to *Streptococcus pneumoniae* is more than 350 cases per 100 000 children and accounts for 80 % of pneumococcal deaths in children under five years of age. [xii]

Historically, CAP has been linked to the first reason for consultation in health facilities in El Salvador.[xiii] According to national epidemiological data for the last five years, pneumonia was among the three most frequent reasons for hospitalization in children under five years of age and among the five main reasons for consultation in all age groups who consulted in Ministry of Health facilities. [xiii] In 2022, it was the leading cause of death in patients aged one to four years and the third cause of death in patients under one year of age. [xiv]

Studies from different parts of the world have increasingly linked biological and sociodemographic factors and environmental degradation to increased susceptibility of children to pneumonia. Various risk factors have been studied, such as a history of prematurity or low birth weight, malnutrition, non-exclusive breastfeeding, incomplete immunization, parental education level, poor housing conditions, lack of household hygiene, unhealthy household habits, low household income, air quality, exposure to environmental pollutants, among others, have been associated with the occurrence of CAP in the pediatric age group.[vii-ix,xv-xx] The consequences of CAP risk factors include increased susceptibility to developing recurrent pneumonia, severe and prolonged illness, and increased likelihood of hospitalization and death; the behavior of these outcomes may vary according to individual circumstances and the presence of multiple risk factors.[xxi-xxiii]

The objective of this study was to determine whether there is an association between patient, sociodemographic, and environmental factors in children under five years of age and the occurrence of CAP. Little literature has been published on this topic in El Salvador. Knowing the association of risk factors with CAP allows health authorities to strengthen preventive health strategies, surveillance, and control in a comprehensive manner and work to reduce the current worrying morbidity and mortality rates of the disease.

Methodology

An observational, analytical, case-control study was conducted with a case-control ratio of 1:2. The study was conducted at the San Rafael National Hospital, a second level of care, geographically located in the department of La Libertad, El Salvador. The definition of cases was that all patients under five years of age from the department of La Libertad were hospitalized in the pediatric service between January and December 2022, with a clinical and radiological diagnosis of CAP made by an institutional pediatrician. The definition for the controls was: all patients under five years of age from the department of La Libertad and hospitalized in the Pediatric Service from January to December 2022 with diagnoses other than CAP or any other acute respiratory or pulmonary disease.

Inclusion criteria were patients older than one month and younger than five years of age, previously healthy, admitted to the Pediatric Service, and residing in the department of La Libertad for both cases and controls, from whom the necessary data for the study were collected. Exclusion criteria included patients with evidence of incomplete information in the file or referred from other hospital centers, both for cases and controls. In addition, the study did not include patients with another concomitant disease at the time of admission or hospitalization, patients with known chronic and immunosuppressive diseases, children with congenital malformations with chromosomal alterations, or from institutions that function as children's homes.

The sample size was calculated using the StatCalc calculator of the Epi Info 7.0 program, with the following elements: a confidence level of 95 %, a power of 80 %,

an expected odds ratio (OR) of 2.5 %, a ratio of two controls for each case, and a proportion of controls with an estimated exposure of 50 % and a proportion of cases with an exposure of 71.4 %. A simple randomized sampling was performed using the random number generator module of the OpenEpi software; the source is the list of discharges of the Pediatric Hospital Service during one year, 2022, registered in the Morbidity and Mortality System through the Ministry of Health Web. The data collection technique was the documentation of the information of each patient contained in the clinical files requested from the Department of Statistics and Medical Documents of the hospital. It was performed using a digital instrument elaborated in the program Microsoft Excel 2019. The information collected from the files was saved and stored in a digital database using the same program.

A descriptive analysis of the patient's clinical history was performed. The variables analyzed for their association with CAP were divided into biological, sociodemographic, and socioenvironmental variables. The biological variables were: cesarean delivery, prematurity, low birth weight, nonadherence to exclusive breastfeeding, lack of infant monitoring, growth retardation for age, incomplete immunization, attendance at children's institutions, and malnutrition at admission.

The sociodemographic variables were: male sex, urban origin, adolescent mother, low maternal education, prenatal checkups less than four, no child control, living in children's institutions, mother working outside the home, overcrowding, mud house, tin house, dirt floor, non-drinking water in the home, excreta disposal in a pit, and incomplete basic services. The socio-environmental variables were disposal of buried garbage, disposal of burned garbage, exposure to wood smoke in the home, exposure to tobacco smoke in the home, pet ownership, poultry ownership, and altitude less than 900 meters above sea level.

The Kolmogorov-Smirnov normality test was performed for age, and descriptive presentation was made using frequencies and proportions of variables in tables. The association between the variables studied and the OR calculated by cross-tabulations measured the risk of CAP. The Chi-square method was used to determine the statistical significance of the results, with a decision threshold of p-value less than 0.05 and a 95 % confidence interval. Statistical analysis was performed using SPSS version 26. The information reviewed was treated as strictly confidential, no patient identity data were collected, and the study was approved by the Ethics Committee of the San Rafael National Hospital in Act No. 7-2023 and approved modification in Act No. 13-2023 .

Results

Clinical characterization of patients with CAP

The study included 189 patients, 63 cases, and 126 controls. The proportion of cases was 59 % (37/63) between one and four years, with a median age of 14 months, and 52 % (33/63) in females.

The presence of cough was reported in 81 % (51/63), fever on admission in 83 % (52/63), and tachypnea on admission in 68 % (43/63). Right-sided pulmonary infiltrates were present in 64 % (35/63), leukocytosis in 60 % (38/63) and anemia on admission in 46 % (29/63). CAP was classified as non-specific etiologic origin in 57 % (36/63), bacterial origin in 24 % (15/64) and viral origin in 19 % (12/63).

Cases with any complication due to pneumonia were 17 % (11/63). Ninety-four percent (59/63) were discharged alive and recovered, 6 % (4/63) were transferred to another hospital of higher complexity, and no case died (Table 1).

Bivariate Analysis

Among the biological factors, patients born prematurely (OR 2.62; 95 % CI 1.27-5.38; p = 0.01) had twice the risk of developing CAP. Similarly, patients with growth retardation for age (OR 2.12; 95 % CI 1.1-4.40; p = 0.02) had a twofold increased risk of neumonia compared to those without this condition. No significant associations were found when analyzing cesarean delivery, low birth weight, lack of exclusive breastfeeding, incomplete immunization status, or malnutrition at the time of hospital admission (Table 2).

Regarding sociodemographic factors, patients living in overcrowded households (OR 1.96; 95 % CI 1.06-3.61; p = 0.04) had almost double the risk of developing CAP compared to those not exposed to overcrowded living conditions. No statistically significant associations were observed for age less than one year, male sex, urban residence, adolescent motherhood, low maternal education, lack of routine pediatric check-ups, attendance at childcare facilities, maternal employment outside the home, mud or tin housing, dirt floors, lack of access to potable water, use of pit latrines, or incomplete basic household services (Table 3).

Table 1. Clinical background of the patients included in the study

Variable	CAP n= 63 (%)	No CAP n=126 (%)
Age		
< 1 year	37 (41.3)	57 (42.2)
1 to 4 years	26 (58.7)	69 (54.8)
Gender		
Male	30 (47.6)	66 (52.4)
Female	33 (52.4)	48 (47.6)
Nutritional status		
Malnutrition	18 (28.6)	25(19.8)
Normal	43 (68.3)	96 (76.2)
Overweight	2 (3.1)	5 (4.0)
Complete vaccination for age		
Yes	41 (65)	98 (78)
No	22 (35)	28 (22)
History of repeated respiratory infection		
Yes	8 (12.6)	5 (04.0)
No	55 (87.4)	121(96.0)
Presence of cough		
Yes	51 (80.9)	0 (0.00)
No	12 (19.1)	126 (100)
Presence of fever during hospital admission		
Yes	52 (83.0)	19 (15.0)
No	20 (35.0)	107 (85.0)
Tachypnea		
Yes	43 (68.0)	6 (04.8)
No	24 (38.0)	120 (95.2)
Tachycardia		
Yes	35 (55.6)	18 (14.3)
No	28 (44.4)	108 (85.7)
Anemia		
Yes	29 (46.0)	33 (26.8)
No	34 (54.0)	90 (73.2)
Leukocytosis		
Yes	38 (60.3)	56 (51.9)
No	25 (39.7)	52 (48.1)
Localization of pulmonary infiltrate on chest radiography		
Right	35 (55.6)	-
Left	5 (7.9)	-
Both lobes	21 (33.3)	-
Complicación		
Yes	11 (17.4)	16 (12.6)
No	52 (82.6)	110 (87.4)
Days of hospital stay		
> 5 days	18 (28.6)	57 (45.2)
< 5 days	45 (71.4)	69 (54.8)
Classification of pneumonia		
Bacterial	15 (23.8)	-
Viral	12 (19.0)	-
Unclassified	36 (57.1)	-
Hospital discharge		
Alive and fully recovered	59 (93.7)	119 (94.4)
Alive with after-effects	0 (0.0)	2 (1.6)
Referred to another hospital	4 (06.3)	5 (4.0)
Deceased	0 (0.0)	0 (0.0)

With regard to socioenvironmental variables, a statistically significant association was observed with exposure to household tobacco smoke (OR 3.20; 95 % CI 1.51-6.74; p = 0.00), with exposed patients having a 3-fold higher risk of developing CAP compared to non-exposed patients. No significant associations were found for practices such as burying or burning garbage, exposure to wood smoke, ownership of pets or poultry, or living at an altitude below 900 m above sea level (Table 4).

Discussion

Most children with pneumonia were older than one year, with a slight predominance of females. Vijayan in India and Fonseca in Brazil found a similar distribution, with most cases occurring in children aged one to four years.[vii, xv] In contrast, Ara in Bangladesh reported a predominance of children younger than one year.[xvi] In this study, no association was found between age and CAP. Regarding sex, the present study aimed to associate male sex as a risk factor, but the result was not significant. Other researchers have also shown that sex is not a relevant factor in the occurrence of CAP in children under five, as shown by Cano in Spain, Cuevas in Peru, and Tuğcu in Japan, although female children showed a slightly higher prevalence.[ix,xix] Vijayan in India observed a relatively balanced sex distribution of CAP prevalence.[xv]

Table 2. Biological Factors Associated with CAP

Variable	Cases n = 63 (%)	Controls n = 126 (%)	OR	IC 95%	p value
Cesarean delivery	20 (31.7)	53 (42.7)	1.63	0.86 - 3.09	0.17
Prematurity	20 (31.7)	19 (15.1)	2.62	1.27 - 5.38	0.01
Low birth weight	15 (23.8)	37 (32.7)	0.65	0.32 - 1.30	0.30
Lack of exclusive EBF*	9 (45.0)	13 (35.5)	1.70	0.57 - 5.11	0.51
Growth retardation	18 (28.6)	20 (15.7)	2.12	1.1 - 4.40	0.02
Incomplete vaccination	22 (34.9)	28 (22.6)	1.88	0.96 - 3.65	0.91
Malnutrition at admission	18 (28.6)	25 (19.8)	1.34	0.87 −2.05	0.25

*EBF: Exclusive breastfeeding

Table 3. Sociodemographic Factors Associated with CAP

Variable	Cases n = 63 (%)	Controls n = 126 (%)	OR	IC 95%	p value
Age under 1 year	37 (41.3)	57 (42.2)	1.72	0.90 - 3.16	0.10
Male sex	30 (47.6)	64 (50.8)	0.88	0.48 - 1.61	0.80
Urban origin	40 (63.5)	80 (63.5)	1.00	0.53 - 1.87	1.00
Adolescent mother	15 (23.8)	26 (20.6)	1.20	0.58 - 2.48	0.76
Low maternal education	23 (63.9)	44 (56.4)	1.37	0.61 - 3.08	0.58
Prenatal check-ups < 4	6 (16.7)	12 (15.2)	1.12	0.38 - 3.25	1.00
No pediatric check-ups	8 (12.7)	11 (8.8)	1.50	0.57 -3.96	0.55
Attendance at childcare centers	6 (9.5)	21 (16.8)	0.52	0.20- 1.38	0.27
Mother working outside home	20 (31.7)	30 (24.0)	1.47	0.75 - 2.88	0.34
Overcrowding	36 (57.1)	51 (40.5)	1.96	1.06 - 3.61	0.04
Adobe housing	14 (22.2)	20 (15.9)	1.51	0.71 - 3.25	0.38
Tin housing	6 (9.5)	9 (7.1)	1.37	0.47 - 4.03	0.78
Dirt floor	5 (7.9)	15 (11.9)	0.64	0.22 - 1.84	0.56
Non-potable water at home	13 (20.6)	21 (16.7)	1.30	0.60 - 2.80	0.64
Excreta disposal by pit	23 (36.5)	39 (31.0)	1.28	0.68 - 2.43	0.55
Incomplete basic services	34 (54.0)	53 (42.1)	1.62	0.88 - 297	0.16

Table 4. Socio-environmental Factors Associated with CAP

Variable	Cases n = 63 (%)	Controls n = 126 (%)	OR	IC 95%	p value
Garbage disposal: buried	7 (11.1)	7 (5.6)	2.13	0.71 - 6.35	0.28
Garbage disposal: burned	9 (14.3)	26 (20.6)	0.64	0.28 - 1.47	0.39
Exposure to wood smoke	23 (36.5)	37 (29.4)	1.38	0.73 - 2.62	0.40
Exposure to tobacco smoke	20 (31.7)	16 (13.0)	3.20	1.51 - 6.74	0.00
Ownership of pets	38 (60.3)	64 (50.8)	1.47	0.80 - 2.72	0.28
Ownership of poultry	11 (17.5)	32 (25.4)	0.62	0.29 - 1.33	0.3
Altitude below 900 masl*	42 (66.7)	69 (54.8)	1.65	0.88 - 3.10	0.16

*masl: meters above sea level

At the same time, Girma in Ethiopia reported a 15 % higher proportion in females, and Paredes in a Cuban hospital reported a greater severity of CAP in male children.[vi,xx]

Among biological factors, prematurity has been identified as a risk factor for CAP in children under five years of age. Other investigators have also identified premature birth as an associated risk factor.[vi,xxii-xxv] In Europe, Clark found that prematurity increased the risk of developing CAP fourfold in a prospective study of over 600 children with CAP in 13 hospitals in the United Kingdom.[xxv] Fadl and Baseer in Egypt also found a significant association between prematurity and CAP,[xxvi,xxvii,] and Kasundriya in India found a sevenfold increased risk of severe CAP in premature infants.[xxi] In addition, in a ten-year prospective cohort study in Israel, Feinstein identified prematurity as a factor associated with CAP in children under five years of age requiring admission to the intensive care unit.[xxii] Cheng in China found that both preterm birth and low birth weight were significantly associated with a higher risk of developing severe CAP.[v]

Growth retardation for age was another finding associated with the diagnosis of CAP in this study. Similarly, Vijayan in India found that growth retardation in children under five years of age doubled the risk of CAP compared to those with appropriate height for age.[xv] Goya, also in India, identified low weight-for-height as an independent risk factor for pneumonia.[xxviii] Sheikh in Bangladesh showed that poor nutritional status, reported as stunting and wasting, was predominantly associated with acute respiratory infections in children.[xxiii] Srivastava in India and Fonseca in Brazil found significant independent risk factors for malnutrition leading to growth retardation associated with CAP in children under five years of age.[vii,xxix] Malnutrition as an isolated condition was not associated with CAP in this study. However, Ngocho in Tanzania included malnutrition as a risk factor for childhood pneumonia, and Dembele found it to be the most common factor associated with pneumonia deaths among children under five in the Philippines.[xvi,xxx]

In terms of sociodemographic conditions, household overcrowding was found to be a predisposing factor for CAP. Fonseca in Brazil, Abebaw in Ethiopia, and Ara in Bangladesh also found an association between living in overcrowded conditions or large families (more than five members) and hospitalization for CAP in children under five years of age.[vii, xvii, xxxi] Srivastava in India reported an even stronger association between overcrowding and CAP than this study. [xxix]

Among the socio-environmental factors, exposure to cigarette smoke at home was identified as a risk factor. It was considered an important finding as it is a modifiable factor. Savitha found that parental smoking habits at home were associated with respiratory infections in rural India.[xxiv] In contrast, Álvarez in Cuba found that passive smoking in children was associated with the acquisition of severe pneumonia.[xxxii] Tazinya in Cameroon found that passive smoking was a significant risk factor for respiratory infections in children under five in a national hospital and also identified wood smoke exposure as a significant risk factor, in contrast to the results of this study, where wood smoke exposure was not statistically significant.[xxxiii] Nirmolia in India, Zhuge in China, Ngocho in Tanzania, and Soelaeman in Asian countries found that indoor air pollution from using solid fuels or natural gas for cooking was associated with childhood pneumonia.[xvi,xxxiv-xxxvi] Other important factors associated with CAP in children under five years of age that have been identified in studies from different countries include incomplete immunization, lack of exclusive breastfeeding, malnutrition, poor adherence to well-child care, low maternal education, and outdoor air pollution.[vii-x, xv-xvii] However, these factors were not found to be conclusively associated with CAP in this study. Limita-

tions of this study included incomplete or disorganized information in clinical records, mostly in digital format, which prompted the inclusion of physical records.

In some cases, physicians and nurses' poor legibility of handwritten clinical notes presented difficulties. Certain variables evaluated in other studies were not recorded in the medical files, which might have expanded and enriched the context of this study. The validity of the results may have been affected by Berkson's bias due to the selection of hospital-based controls.

It is recommended that the implementation of promotion and education activities at the primary health care level be strengthened to reduce preterm births by addressing preventable risk factors such as maternal age, habits acquired during pregnancy, and adherence to antenatal care.[xxxvi-xxxviii] It is also necessary to implement interventions at all levels of health care, focusing on nutrition, psychosocial care, and well-child care to prevent stunting, particularly in the first two years of life.[vii,xv,xxiii, xxix] In addition, promoting healthy environments free from indoor pollution, ensuring proper ventilation in homes, and promoting safe community environments should be emphasized from primary care onwards. [xxxi,xix]

Conclusion

Prematurity and growth retardation for age were identified as biological risk factors for CAP. Household overcrowding was identified as a sociodemographic risk factor. Exposure to tobacco smoke in the home was identified as a socio-environmental risk factor. These factors are consistent with findings from studies conducted in other regions and continents.

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