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Severe pneumonia: Treatment outcome and its determinant factors among under-five patients, Jimma, Ethiopia

Kenenisa Tegenu[1], Gelane Geleto[2], Desalew Tilahun[1], Ebissa Bayana[1] and Bayisa Bereke[1]

Abstract

Introduction: Over 2 million children die from pneumonia each year accounting for almost one in five children's deaths worldwide which is estimated to be 18% of mortality cases. Therefore, this study is aimed to assess treatment outcome and its determinant factors among under-five patients, Jimma, Ethiopia.

Methods: Study design was conducted on 522 under-five children with severe pneumonia from 1 January 2017 to 30 December 2020. Pretested chart review format was used to collect data. Data were entered into EpiData, version 3.1, and exported to Statistical Package for the Social Sciences, version 23, for analysis. Logistic regression analysis with 95% confidence interval was used to declare statistical significance at p value <0.05.

Results: Among 522 under-five children with severe pneumonia, majority (83.91%) of them were improved, whereas 1 over 6 (16.09%) of them were died. This finding showed that children who have malnutrition (adjusted odds ratio = 7.23 (3.17–14.51), $p = 0.000$), positive serostatus for HIV (adjusted odds ratio = 5.01 (1.91–12.13), $p = 0.001$), history of upper respiratory tract infections (adjusted odds ratio = 3.27 (1.55–6.91), $p = 0.002$), unvaccinated (adjusted odds ratio = 4.35 (1.60–11.79), $p = 0.004$), having complicated types of pneumonia (adjusted odds ratio = 8.48 (4.22–16.65), $p < 0.001$), and comorbidity disease (adjusted odds ratio = 5.21 (2.03–13.3), $p < 0.001$) were statistically significant with mortality.

Conclusion: This study showed that mortality secondary to severe pneumonia was high. Being malnourished, positive serostatus for HIV infection, history of upper respiratory tract infections, unvaccinated, having complicated type of pneumonia, and other comorbidity disease were identified as determinant factors of mortality. Committed, harmonized, and integrated intervention needs to be taken to reduce mortality from severe pneumonia by enhancing child's nutrition status, early detection and treatment, effectively vaccinating children, and preventing other comorbidity diseases.

Keywords

Pneumonia, child, Ethiopia, mortality, treatment, outcome

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Introduction

Globally, pneumonia is the leading cause of child mortality from infectious diseases, accounting for approximately 16% of the 5.6 million under-five deaths, killing around 900,000 children in 2016.[1,2] This revenues a loss of 2500 children's lives every day or over 100 every hour. "The forgotten child killer": Pneumonia kills two under-five kids every minute. Pneumonia kills nearly 1 million children under the age of five around the world, causing more deaths than HIV/AIDS, and diarrhea and malaria combined.[3]

According to the World Health Organization (WHO) approximations, there are 156 million cases of pneumonia each year in under-five children, with as many as 20 million cases severe enough to require hospital admission and 1.2 million deaths annually.[4,5] More than 90% of all deaths due to pneumonia in children aged less than 5 years take place in 40 countries. The incidence and severity of childhood

[1]School of Nursing, Faculty of Health Science, Institute of Health Jimma University, Jimma, Ethiopia
[2]Jimma University Medical Center, Jimma University, Jimma, Ethiopia

Corresponding author:
Kenenisa Tegenu, School of Nursing, Faculty of Health Science, Institute of Health Jimma University, Jimma, Oromia, Ethiopia.
Email: kenenisategenu56@gmail.com

pneumonia was highest in Africa and South East Asia, which accounted for 30% and 39%, respectively, of the global burden of severe cases. In these two regions, 15 countries accounted for two-thirds of all childhood pneumonia episodes and severe cases.[5,6]

The African region has, in general, the highest burden of global child mortality—50% of worldwide deaths from pneumonia in this age group. More than 490,000 under-five children died by pneumonia in 2016 in Sub-Saharan Africa.[7] In contrast, less than 2% of these deaths take place in the European region and less than 3% in the region of the Americas.[3] Pneumonia continues to be the major cause of death in children. In Ethiopia, pneumonia is a primary particular infection killing under-five children. It is estimated that in Ethiopia, 3.37 million children encounter pneumonia annually which contributes to 18% of mortality of children and killing over 40,000 under-five children every year.[5]

Burden and severity of childhood pneumonia is high in Ethiopia children due to limited coverage and affordability of effective preventive interventions like immunization of pneumococcal conjugate vaccine, respiratory syncytial virus, and lack of worthy access to health care and unavailability of effective management strategies. The huge discrepancy between the current incompatibly big and high peal of pneumonia reflects poorly designed prevention strategies in the poorest settings like Ethiopia.[8,9] It is therefore important to look at a combination of strategies for reducing the morbidity and mortality from pneumonia. So, addressing current gaps for prevention of mortality of under-five pneumonia is critical to achieving Sustainable Development Goal (SDG 3).[10]

The widespread nature of the problem in Ethiopia has already killed thousands of children which need to look for lasting solution to end the problem. Despite the sustained effort to stop the problem, pneumonia continues to be common cause of mortality of children which calls for innovative strategies that will come about only through systematic researches. Data on the outcome of severe pneumonia and their related risk factors are important for planning child health care services but scarce in Ethiopia. Therefore, this study aimed to assess outcome of severe pneumonia and its determinant factors.

Materials and methods

A retrospective study design was conducted on 522 under-five severe pneumonia cases from 1 to 30 March 2021 at Jimma University Medical Center (JUMC), Ethiopia. The sample size was calculated by EPI info sample size calculations by taking 95% confidence level, power 80%, percent outcome in unexposed group 22%, percent outcome in exposed group 33.42%, and odds ratio 1.79,[11] which brings initial sample size 474, and by considering 10% incomplete medical records, the final sample size was 522. All eligible cases were included in the study. Discharge log book was used to identify cases admitted from 1 January 2017 to 30 December 2020. All medical records with diagnosis of severe pneumonia, age from 2 to 59 months, were included in the study. Data were collected from medical records using the pretested structured chart review format. The chart review format was adapted after reviewing relevant literatures,[11-14] and it contains two parts. Part 1 is about the socio-demographic characteristics like child age, sex, residency, and housing condition of the family. Part 2 is about preexisting medical or comorbid condition characteristics of under-five children, such as nutritional status, serostatus for HIV, immunization status, and previous history of disease. The tool was checked for content and construct validity by two medical doctors from JUMC and two pediatric Master of Science (MSc) instructors from school of nursing, Jimma University. Reliability test was done, and Cronbach's alpha coefficient was 0.87. Data were collected by two trained Bachelor of Science (BSc) degree holder nurses. The principal investigator supervised and checked the completeness and quality of data on daily basis. The incomplete medical records and medical records without full information were excluded from the study.

Statistical analysis

Data were coded and entered into EpiData, version 3.1, and exported to IBM Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to describe the socio-demographic characteristics and preexisting medical or comorbid conditions of under-five children. Then, all independent variables were first tested by bivariable logistic regression and variables with p value $\leqslant 0.25$ were further considered for multivariable logistic regression to control confounding variables. Finally, the p value <0.05 at 95% confidence interval (CI) was declared a statistically significant.

Severe pneumonia

Severe pneumonia is characterized by cough or difficult breathing plus at least one of the following: central cyanosis, hypoxemia (sustained oxygen saturation $<90\%$ in room air at sea level), temperature $\geqslant 38.5°C$ (101.3°F), capillary refill $\geqslant 2$ s, inability to breastfeed or drink, vomiting everything, convulsions, lethargy or unconsciousness, and moderate to severe respiratory distress.[15]

Complicated pneumonia

Complicated pneumonia is characterized by combination of pneumonia with local complications (e.g. parapneumonic effusion, empyema, necrotizing pneumonia, and lung abscess) and systemic complications (e.g. bacteremia, metastatic infection, multiorgan failure, acute respiratory distress syndrome, and disseminated intravascular coagulation).[16]

Table 1. Socio-demographic characteristics of under-five children admitted with severe pneumonia.

S. No.	Variable		Frequency	%
1.	Age (months)	2–12	254	48.7
		13–36	214	41.0
		37–59	54	10.3
2.	Sex	Male	236	45.2
		Female	286	54.8
3.	Residency	Urban	188	36.0
		Rural	334	64.0
4.	Number of windows in house	Up to three	308	58.6
		Greater than four	214	41.4
5.	Kitchen	Separated from house	188	36.0
		Not separated from house	334	64.0
6.	Smoker in house	Yes	188	36.0
		No	334	64.0

Malnutrition

The weight-for-height ratio of less than minus 2 standard deviations below the median WHO growth standards or weight-for-height ratio of below 80% of the median or presence of nutritional edema.[17]

Ethical approval

Ethical approval for this study was obtained from Research Ethics Committee of School of Nursing, Jimma University [Nurs/90/2021]. Then the letter was submitted to JUMC administration to get permission prior actual data collection. Written informed consent was taken from Ethics Committee of JUMC prior to study initiation. The information gathered from medical records was confidential, secured, and used for research purposes only.

Results

Socio-demographic characteristics

Among the 522 cases analyzed, around half (48.7%) of them were found between 2 and 12 months of age and 64% of them were female (see Table 1).

Preexisting medical conditions, comorbidity, and treatment outcome

Out of total sample, more than one-third, 204 (39.1%), of the cases had malnutrition and 171 (32.8%) of them were not vaccinated. Among 522 children admitted with severe pneumonia, 136 (26.1%) of them had complicated severe pneumonia and 260 (48.2%) children had other comorbidity disease. From total under-five children admitted by severe pneumonia, 84 (16.1%) of them were died and 438 (83.9%) were improved (see Table 2).

Determinant factors associated with treatment outcome of severe pneumonia

All study variables were tested by binary logistic regression analysis and variable those had less than 0.25 *p*-values were candidate for the multivariate logistic regression to control confounding variable and to determine potential predictors of outcome of severe pneumonia.

On multivariable logistic regression, six variables were found to have significant association with mortality of severe pneumonia. This finding showed that children who had malnutrition (adjusted odds ratio (AOR) = 7.23 (3.17–14.51), $p = 0.000$), children who were positive serostatus for HIV (AOR = 5.01 (1.91–12.13), $p = 0.001$), children who had previous history of upper respiratory tract infection (URTI; AOR = 3.27 (1.55–6.91), $p = 0.002$), children who were not vaccinated (AOR = 4.35 (1.60–11.79), $p = 0.004$), children who had complicated types of pneumonia (AOR = 8.48 (4.22–16.65), $p < 0.000$), and children who had comorbid disease with severe pneumonia (AOR = 5.21 (2.03–13.3), $p < 0.001$) were significantly associated with mortality from severe pneumonia among under-five children (see Tables 3 and 4).

Discussion

This study showed that among 522 under-five severe pneumonia, 4 out of 25 (16.09%) were died. This finding is nearly similar with the estimation of the under-five pneumonia death (18%) of the Ethiopia.[2] However, mortality rate in this study is higher than studies conducted in the Philippines, 4.7%;[13] India, 10.5%;[18] and China, 12%.[19] This may be due to the study setting, quality of health care system, and deference of socio-demographic factors. This study showed that children who had malnutrition were seven times more likely to die by severe pneumonia than children who had no malnutrition. This finding is consistent with the study conducted in

Table 2. Preexisting medical conditions and treatment outcome of under-five children admitted with severe pneumonia.

S. No.	Variable		Frequency	%
1.	Duration illness prior to admission	Up to 3 days	214	41.0
		4 to 7 days	210	40.2
		More than 8 days	98	18.8
2.	Nutritional status	Malnutrition	204	39.1
		Non-malnutrition	318	60.9
3.	Serostatus for HIV	Reactive	49	9.4
		Non-reactive	473	90.6
4.	Previous history of URTI	Yes	182	34.9
		No	340	65.1
5.	Previous history of measles	Yes	28	5.4
		No	494	94.6
6.	Immunization status	Fully vaccinated	162	31.0
		Vaccinated for age	128	24.5
		Partially vaccinated	61	11.7
		Not vaccinated	171	32.8
7.	Types of pneumonia	Non-complicated	386	73.9
		Complicated	136	26.1
8.	Comorbidity	Yes	260	49.8
		No	262	50.2
9.	Outcome	Improved	438	83.9
		Died	84	16.1

URTI: upper respiratory tract infection.

Table 3. Binary logistic regression analysis of determinant factors associated with treatment outcome of severe pneumonia.

Variable		Outcome of severe pneumonia		COR	*p* value
		Improved	Died		
Kitchen	Separated from house	174	14	1	
	Not separated from house	264	70	3.29 (1.80–6.03)	0.00
Smoker in house	Yes	110	40	2.71 (1.67–4.37)	0.00
	No	328	44	1	
Duration illness prior to admission	Up to 3 days	172	42	1	
	4 to 7 days	192	18	0.38 (0.21–0.69)	0.01
	More than 8 days	74	24	1.32 (0.75–2.35)	0.33
Nutritional status	Malnutrition	132	72	13.9 (7.30–26.49)	0.00
	Non-malnutrition	306	12	1	
Serostatus for HIV	Reactive	26	23	5.97 (3.20–11.13)	0.00
	Non-reactive	412	61	1	
Previous history of upper respiratory tract infection	Yes	123	69	6.04 (3.62–10.08)	0.00
	No	315	25	1	
Previous history of measles	Yes	12	16	8.30 (3.78–18.42)	0.00
	No	426	68	1	
Immunization status	Fully vaccinated	154	8	1	
	Vaccinated for age	118	10	1.63 (0.62–4.26)	0.31
	Partially vaccinated	51	10	3.77 (1.41–10.07)	0.008
	Not vaccinated	115	56	9.37 (4.30–20.43)	0.00
Types of pneumonia	Non-complicated	359	27	1	
	Complicated	79	57	7.59 (5.71–16.11)	0.00
Comorbidity	Yes	186	74	10.02 (5.04–19.9)	0.00
	No	252	10	1	

COR: crude odds ratio.

Table 4. Determinant factors associated with treatment outcome of severe pneumonia.

Variable		Outcome of severe pneumonia		COR	AOR	*p* value
		Improved	Died			
Nutritional status	Malnutrition	132	72	13.9	7.23 (3.17–14.51)	0.000
	Non-malnutrition	306	12		1	
Serostatus for HIV	Reactive	26	23	5.79	5.01 (1.91–12.13)	0.001
	Non-reactive	412	61		1	
Previous history of URTI	Yes	123	59	6.04	3.27 (1.55–6.91)	0.002
	No	315	25		1	
Immunization status	Fully vaccinated	154	8		1	
	Vaccinated for age	118	10	1.63	2.11 (0.59–7.48)	0.245
	Partially vaccinated	51	10	3.77	3.03 (0.88–10.40)	0.078
	Not vaccinated	115	56	9.37	4.35 (1.60–11.79)	0.004
Types of pneumonia	Non-complicated	359	27		1	
	Complicated	79	57	7.59	8.48 (4.22–16.65)	0.000
Comorbidity	Yes	186	74	10.0	5.21 (2.03–13.3)	0.001
	No	252	10		1	

COR: cured odds ratio; AOR: adjusted odds ratio; URTI: upper respiratory tract infection.

the Philippines,[13] Brazil,[20] and Tanzania,[21] which indicates that malnutrition is significantly associated with the mortality of severe pneumonia. This may be due to the fact that malnutrition weakens a child's overall immune system, as an adequate amount of protein and energy is needed for proper immune system functioning. In addition, undernourished children have weakened respiratory muscles, which inhibit them from adequately clearing secretions in their respiratory tract.[22]

This result showed that children with positive serostatus for HIV were five times more risk to die by severe pneumonia than children who were negative serostatus for the HIV. This finding is similar to a study conducted in Tanzania which shows HIV infection is one of the predictors of the severe pneumonia treatment failure.[21] This is because HIV infection weakens the immune system which leads the children to serious or life-threatening and increases the mortality of severe pneumonia.

This study finding revealed that children who have previous history of URTI were three times more likely to die by severe pneumonia than children who have no previous history of URTI. Similarly, the study conducted in the Philippines[13] showed that the previous history of URTI is significantly associated with death of under-five severe pneumonia. Available evidence showed that an increased risk of pneumonia or acute lower respiratory tract infections in children who have had a prior episode of pneumonia or wheezing, and viral infections, particularly with respiratory syncytial virus or influenza virus, also predisposes to invasive pneumococcal disease for a period of 4 weeks.[23,24]

According to this result, children who were not vaccinated were fourfold more risk of dying due to severe pneumonia than children who were fully vaccinated. This is similar to a study conducted in India which showed that use of conjugate vaccines against pneumonia, particularly *Streptococcus pneumonia* and *Haemophilus influenzae*, appears to be justified for the prevention of pneumonia morbidity and mortality in children younger than 5 years.[18] Immunization also helps to reduce childhood pneumonia in two ways. First, vaccinations help prevent children from developing infections that directly cause pneumonia, such as *Haemophilus influenzae* type b (Hib). Second, immunizations may prevent infections that can indicate pneumonia as a complication like measles and pertussis.[25]

The findings of the study indicated that children who have complicated types of pneumonia are threefold more likely to die by severe pneumonia than children who have non-complicated types of pneumonia. Similarly, study conducted in Bangladesh revealed that complicated types of pneumonia increased risk of pneumonia mortality.[26] This might be due to complicated types of pneumonia being able to worsen preexisting chronic conditions, particularly those of the heart and lungs which increase the mortality.

This study revealed that children who have comorbidity disease with severe pneumonia were also four times more risky to die by severe pneumonia than children who have no comorbidity disease with severe pneumonia. This is consistent with a study conducted in China[19] and Bangladesh,[26] which showed that septic shock, multiorgan dysfunction, acute renal failure, liver dysfunction, decreased hemoglobin, and albumin levels are associated with mortality of severe pneumonia. This could be due to other comorbidity disease increased risk for having a serious or life-threatening and increase the mortality of severe pneumonia. Although this finding revealed important detection, it is not free of limitation. One limitation of this study is being a retrospective

study design which does not include environmental and health professional factors. Therefore, prospective longitudinal study is recommended to include all determinant factors that result in death of under-five patients diagnosed with severe pneumonia.

Conclusion

This study showed that mortality secondary to severe pneumonia was high. Being malnourished, positive serostatus for HIV infection, previous history of URTI, not vaccinated, having complicated type of pneumonia, and other comorbidity disease were identified as determinant factors of mortality. Committed, harmonized, and integrated intervention needs to be taken to reduce mortality from severe pneumonia by enhancing child's nutrition status, early detection and treatment, effectively vaccinating children, and preventing other comorbidity diseases.

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Author contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Informed consent

Written informed consent was taken from Ethics Committee of Jimma University Medical Center prior to study initiation. The information gathered from medical records was confidential, secured, and used for research purposes only.

ORCID iDs

Kenenisa Tegenu https://orcid.org/0000-0001-7173-3242

Ebissa Bayana https://orcid.org/0000-0001-5611-6799

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