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Childhood mortality due to pneumonia; evidence from a tertiary paediatric referral center in Sri Lanka

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Abstract

Background Pneumonia is a major cause responsible for mortality and morbidity among children around the world. The present study aimed to determine the age distribution, and contributing risk factors for mortality among children who died from pneumonia.

Method This study was a cross-sectional study conducted at Teaching Hospital Peradeniya and Sirimavo Bandaranaike Specialized Children's Hospital (SBSCH) which is one of the two specialised children's hospitals in the country. Demographic details, clinical details, laboratory and radiological findings of the children who died due to pneumonia from 2017 to 2022 were collected from record rooms of the two hospitals. The targeted study cohort consists of children between 0 and 14 years of age who died with an established diagnosis of pneumonia. Data was analysed using SPSS version 24. Percentages were calculated to determine the demographic details. The association between different risk factors with childhood pneumonia deaths was calculated.

Results Fifty-six (56) children in the age category of 0–14 years who died due to an established diagnosis of pneumonia from 2017 to 2022 were included in this study. Fourteen (25%) of them died in the acute medical ward and the remainder in the ICU. From the total study cohort, 51.8% (29) were males and 48.2% (27) were females. The highest number of children (39.3%) was in the age category of 3–12 months. Forty-two children, 75% of the study cohort were children younger than 1 year. Among 56 total, 41 children (73.2%) were identified as underweight for age according to the WHO weight for age charts and 14 (25%) children had not completed the immunisation to the age according to the National Programme of Immunisation (NPI) of Sri Lanka. In the present study cohort, 51.8% (29) of children were diagnosed with CHD and 28.6% (16) of the study cohort had a past medical history of LRTI. Number of patients with underlying respiratory diseases and cerebral palsy were 6 (10.7%) and 5 (8.9%) respectively. There was a significant correlation between the death of children due to pneumonia and the younger age ($p=0.004$), duration of the hospital stay ($P=0.011$), cerebral palsy ($p=0.004$) and history of LRTI ($p=0.001$).

Conclusion Younger age of less than one year, cerebral palsy and a history of lower respiratory tract infections were significantly associated with children dying due to pneumonia. Nearly half of the children who died from pneumonia

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had a congenital heart disease although it is not statistically significant. A substantial number of deaths occurring in general wards needs further evaluation.

Keywords Childhood, Mortality, Pneumonia, Tertiary Care

Background

Pneumonia is a major cause responsible for mortality and morbidity among children around the world. World Health Organization (WHO) data revealed that 14% of all deaths of children less than 5 years old were due to pneumonia in 2019 [1]. According to the United Nations International Children's Emergency Fund (UNICEF) statistics, every 43 s one child dies due to pneumonia and the globally estimated incidence of childhood pneumonia is more than 1,400 per 100,000 children. The highest prevalence was identified in South Asia (2,500 cases per 100,000 children) and West and Central Africa (1,620 cases per 100,000 children) [2]. Pneumonia remains a significant cause of mortality despite worldwide interventions for prevention.

Pneumonia is a disease caused by an accumulation of secretions and inflammatory cells in the alveolar spaces of the lung caused by infection [1]. It can be classified as community-acquired pneumonia (CAP), Hospital-acquired pneumonia (HAP) and Healthcare-associated pneumonia. Community-acquired pneumonia contributes to the highest incidence of pneumonia in the paediatric cohort and mostly it is manifested as bronchopneumonia compared to lobar pneumonia [3]. The causative agents of pneumonia can be bacterial, viral and fungal in origin. Viruses remain the most common cause of pneumonia in the paediatric population worldwide. When considering the bacterial agents, *Streptococcus pneumonia* and *Haemophilus influenzae* type b pneumonia still can be seen despite preventive interventions like *H. influenza* type b and pneumococcal vaccination in many countries [4].

There are some risk factors associated with childhood pneumonia such as low birth weight, lack of exclusive breastfeeding, undernutrition, air pollution, overcrowding, sub-optimal immunisation of children and young age [4]. Young children especially neonates identified as the main age group contribute to childhood pneumonia deaths which is annually 750000-1.2 million deaths (10% of global child mortality) [5]. However, the mean age for childhood pneumonia identified as 9.94 months varies in different localities [6]. And gender is a controversial fact in childhood pneumonia. According to a study done in Teaching Hospital Peradeniya, 58% of the study cohort were girls and rest were the boys [4] whereas several other studies have found that pneumonia prevalence is higher among males [6–8].

Malnutrition is one of the primary risk factors for childhood infections. Pneumonia is one of those infections which is well-established among undernourished children. A study has shown that moderate and severely undernourished children's estimated mortality rate due to pneumonia is 2.0 (95% CI 1.6 to 2.6) and 4.6 (95% CI 3.7 to 5.9) respectively [9]. Therefore, childhood malnutrition can be considered a major risk factor for deaths due to pneumonia in children. In addition to that, the development of complications like diarrhea and factors like suboptimal healthcare facilities also contributed to a higher mortality rate due to pneumonia in paediatric population [10].

Morbidity and mortality due to pneumonia in patients who are diagnosed with Congenital Heart Disease (CHD) is higher than in previously well patients. Those patients are more susceptible to recurrent infectious diseases than healthy patients. A study done in a tertiary care hospital has found that 12.5% of the study cohort with pneumonia had CHD [6].

Vaccination is a proven preventive intervention carried out worldwide. In 2002, the largest number of deaths was recorded among children less than 5 years old due to pneumococcal disease (716,000) which is a vaccine-preventable disease. Africa or Southeast Asia contributed to 76% of global vaccine-preventable deaths in children younger than 5 years during 2002 [11]. *Haemophilus influenzae* B and *Streptococcus pneumoniae* vaccines are included in the national immunisation schedules in developed countries. Although *Haemophilus influenzae* type b (Hib) is included in the national immunization schedule, pneumococcal conjugate vaccines (PCV) are not currently part of the national immunization program in Sri Lanka. PCVs are available only for a fee which is not affordable to most [12, 13].

Globally, the number of childhood pneumonia decreased by 22% from 178 million in 2000 to 138 million in 2015 [14]. This improvement has been achieved through improved vaccination and other measures like reducing exposure to risk factors of pneumonia and improving hospital care [1, 14].

When considering the Sri Lankan context, childhood pneumonia has caused a significant disease burden in children. In 2005 and 2006 nearly three thousand children died due to pneumonia when the births registered in 2005 was 370,731. About 40% of these pneumonia cases are reported in children aged less than 4 years [15]. According to the weekly epidemiology report on 09th December 2016, published by the epidemiology unit 16% of under 5 years old children's deaths occurred due to pneumonia in the year 2015 [16]. Even though the health

system in Sri Lanka has made great strides, mortality due to pneumonia remains significantly high.

In addition to the mortality and morbidity among children, healthcare costs are also a considerable fact to be discussed. A study done in Teaching Hospital Peradeniya in 2016 identified that a significant percentage of patients (61%) needed hospital care for more than 5 days, about 2/3rd of the study cohort needed a second line intravenous antibiotic therapy, and 51/127 patients needed a high dependency unit care [3].

The Current economic crisis in Sri Lanka has led to an expanding cohort of children with malnutrition. According to the Sri Lanka Humanitarian Situation Report (Economic Crisis) [17], July 2022 which is the main reporting tool to monitor the United Nations International Children's Fund's (UNICEF) humanitarian response, has identified 14 370 children aged 6–59 months who visited the maternal and child health clinics were identified to have Severe Acute Malnutrition (SAM).

Since undernutrition is identified as a main risk factor for childhood pneumonia in literature, this number is predicted to be high soon since the worsening of the crisis [17]. On top of that, to manage a patient in a hospital setting government must spend more even during the economic crisis. A recent study conducted in a tertiary care hospital in Sri Lanka found that the majority of patients (61%) needed hospital care for more than 5 days while about 2/3rd of the study population needed a second-line intravenous antibiotic therapy. Nearly half of them needed high-dependency unit care making in-house management of pneumonia to be very costly [3].

Therefore, more studies concerning this area are needed to identify the effect of the economic crisis the childhood pneumonia. As the factors contributing to pneumonia mortality vary from one country to another, local data is very important to identify risk factors and develop strategies to minimize mortality.

Hence, our study aimed to determine the age distribution, contributing risk factors for mortality among children who died from pneumonia, and health care burden due to childhood pneumonia. Since there is a paucity of studies regarding childhood pneumonia mortality in Sri Lanka, this study would shed light on future studies.

Methodology

This cross-sectional study was conducted at Teaching Hospital Peradeniya and Sirimavo Bandaranaike Specialized Children's Hospital (SBSCH). Demographic details and clinical details of the children who died due to pneumonia from 2017 to July 2022, were collected from the patient records. The targeted study cohort consists of children between 0 and 14 years of age who died with an established diagnosis of pneumonia by a consultant paediatrician. Data (demographic details, clinical details including comorbidities, laboratory and radiological investigation findings along with other relevant clinical findings) was extracted into a data collection sheet from patient records. Ethical approval for the study was obtained from the Ethics Review Committee, Faculty of Medicine, University of Peradeniya, Sri Lanka (ERC No 2021/EC/82). Data were analysed using Statistical Package for Social Science (SPSS), version 24. Percentages were calculated to determine the demographic details. The association between different risk factors with childhood pneumonia deaths was calculated using univariate analysis with the Mann-Whitney U test for continuous variables and the Chi-square test for categorical variables. $p<0.01$ was considered significant.

Results

A total of 56 deaths in the age category of 0–14 with an established diagnosis of pneumonia from 2017 to 2022 were included in this study. From the total study cohort, 51.8% (29) were males and 48.2% (27) were females. The highest number of children (39.3%) was in the age category of 3–12 months. Forty-two children, 75% of the study cohort were children younger than 1 year (Fig. 1). A significant correlation was identified between the younger age and death ($p=0.004$).

When comparing the number of childhood deaths in the two hospitals, the number of deaths due to pneumonia remains stable during these six years (Fig. 2). However, total childhood deaths declined from 2019 to 2022.

According to the chi-square test for trend, there is a significant declining trend ($\chi2=12.83$, $p=0.025$) in the number of childhood deaths due to pneumonia. However, the total number of child deaths showed fluctuations from 2017 to 2022 ($\chi2=8.934$, $p=0.1117$).

The majority of patients (30, 53.6%) have been admitted to the hospital within 1–2 days of being symptomatic. Twenty-one (37.5%) have been admitted after being symptomatic for >3 days Hence, a primary delay in hospital admission could not be observed except for 21 patients (37.5%) who were admitted after being symptomatic for >3 days.

We analysed the available laboratory investigations such as total white blood cell count (WBC), C-reactive protein (CRP) levels and blood and respiratory sample culture results. Based on the white blood cell (WBC) count and C-reactive protein (CRP) levels, 21 patients exhibited a WBC count exceeding $11\times10^3/\mu L$ and 28 patients had CRP concentration greater than 6 mg/L immediately upon admission. The mean total WBC count immediately after the admission of the children in the study group was 16.95×10^3 /μL±11.54 while the mean WBC count was $16\times10^3/\mu L\pm9.84$ before the death. Additionally, the mean CRP level of the study group immediately after the admission was 44.31 mg/L±39

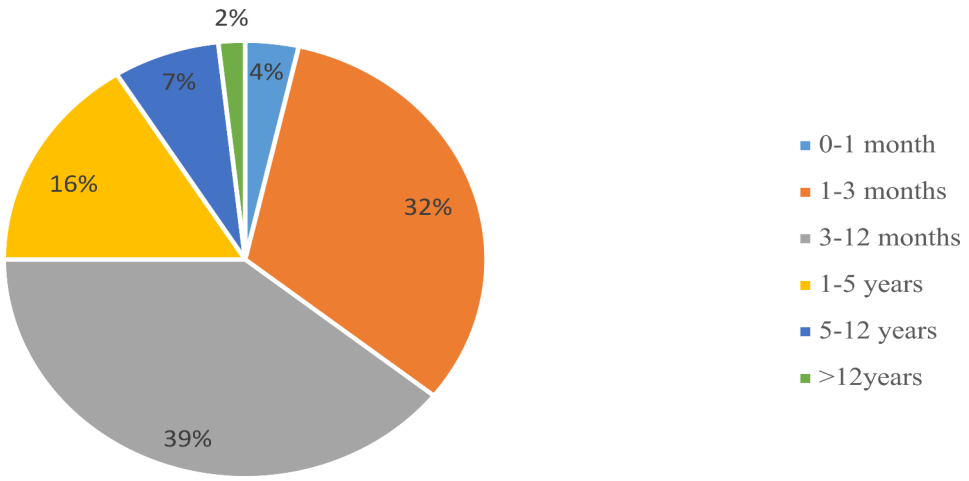

Fig. 1 Age Distribution of children who died due to pneumonia

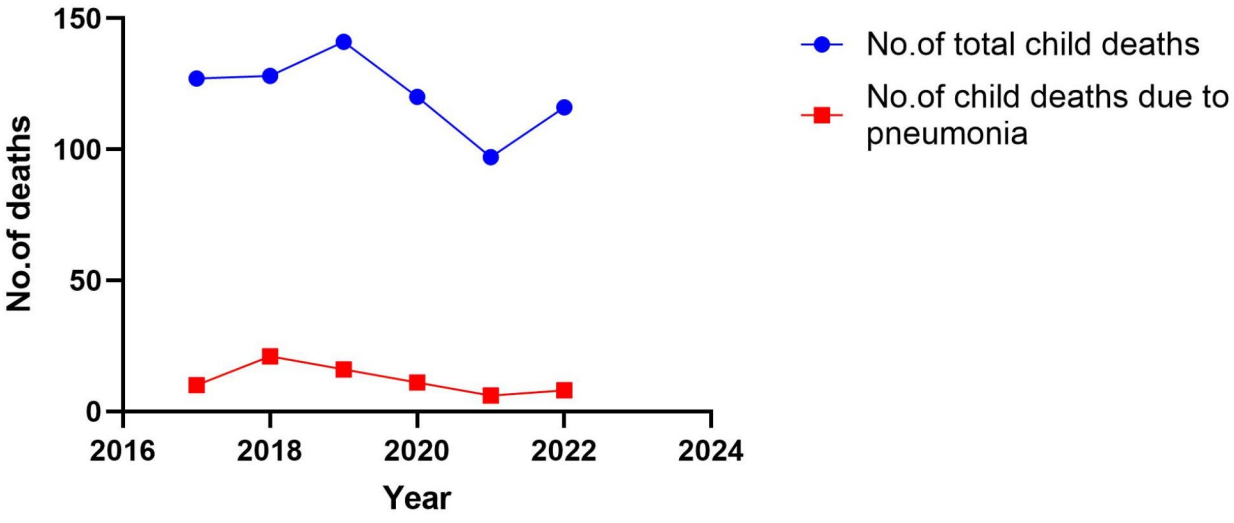

Fig. 2 No of total child deaths and number of deaths due to pneumonia from 2017–2022

and 34.14 mg/L±32.15 before the death. Approximately 25% (14) of the total study cohort was blood culture positive suggestive of having septicaemia. The highest number of cultures were positive with *Klebsiella pneumonaie* (12.82%) followed by coagulase-negative *staphylococcus spp* (7.69%). The isolated organisms from the blood culture are shown in Fig. 3.

There were 34% (19) positive respiratory sample cultures while 7 of them were found to be positive for blood cultures as well. According to the respiratory sample (endotracheal samples, BAL, tracheostomy samples, oropharyngeal secretions etc.) culture results, 31.82% *Acinetobacter spp*, 9.09% *Pseudomonas spp*, 4.55% *Candida non albicans spp*: 4.55% *Flavobacterium*, 2.27% Coagulase-negative *Staphylococcus spp*, 6.82% coliforms, 13.64%, *Klebsiella pneumonia* and 2.27% *Burkholderia spp* were isolated. Interestingly, there was one bronchoalveolar lavage (BAL) culture positive for Influenza A. In most of the cases in the present study, radiological findings such as chest X-ray was used to diagnose and monitor the treatment outcomes of the patients. Bilateral inflammatory shadows, patchy shadows, opacification, and pleural effusions were the commonest X-ray findings in this group of children who died from pneumonia.

When considering the duration of hospitalization before the death, half of the study cohort (28) were admitted to the hospital for less than 1 week before the death. When considering the total study cohort of 56 children, 25% (14) of them died in the ward and the others, 75% (42) died in the Intensive Care Units (ICU).

Nearly 84% (47) of the study cohort had undergone septic shock before dying and were on inotropes to

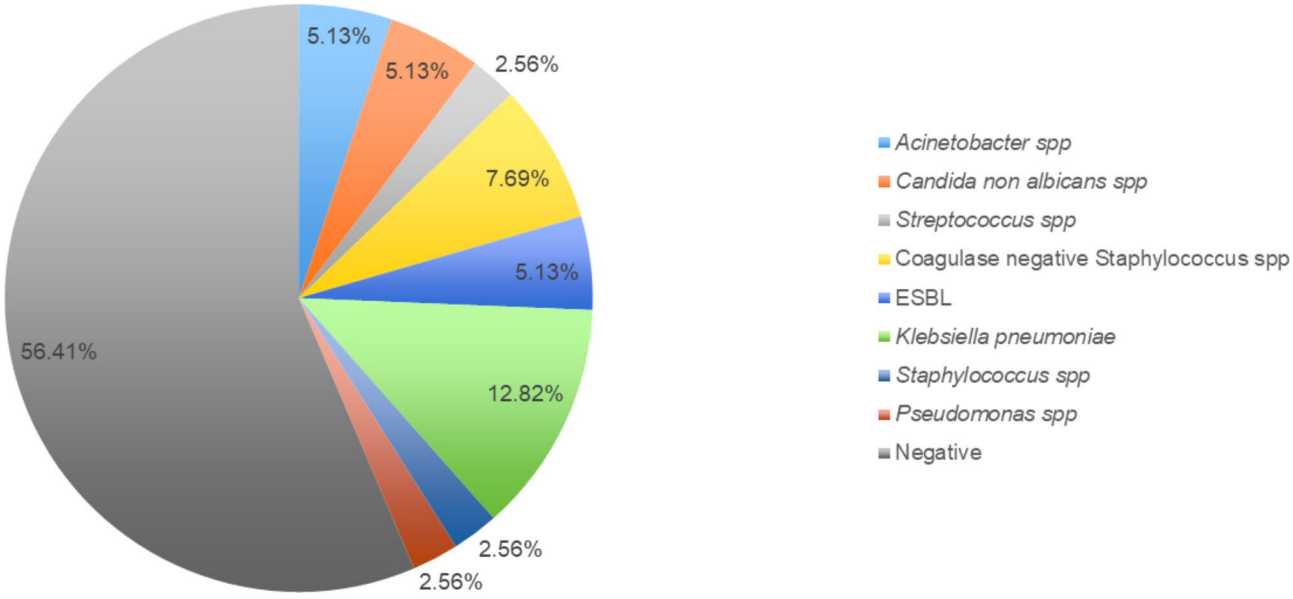

Fig. 3 Blood culture results of the patients who died due to pneumonia

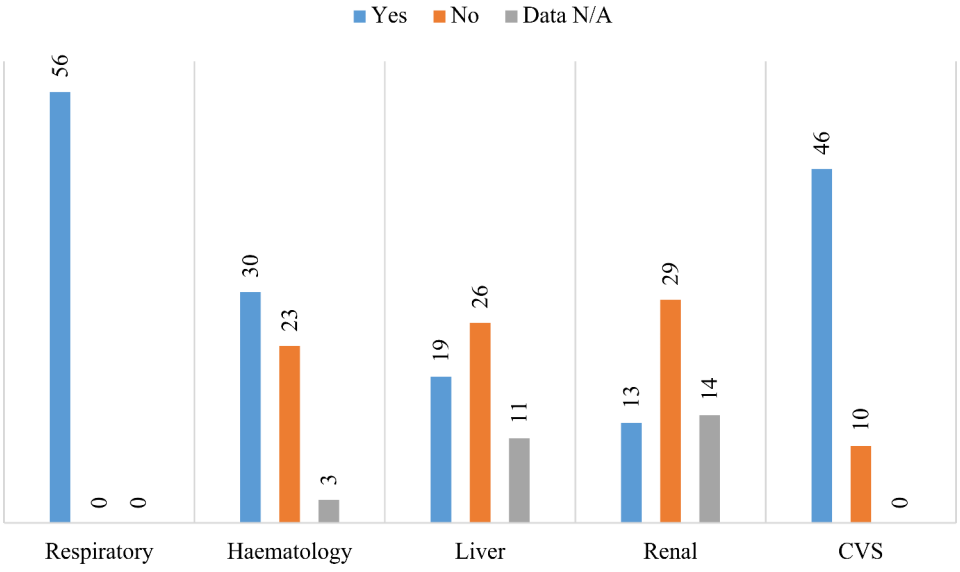

Fig. 4 Organ Involvement during the death of the children due to pneumonia

maintain their blood pressure. The majority of them had respiratory and cardiovascular system compromise (Fig. 4). Thirty children out of 56 had more than three organ involvement. When considering the respiratory complications, 39% (21) of children had defined pulmonary complications like acute respiratory distress syndrome, pleural effusions and pneumothorax.

Patients admitted with acute respiratory tract infection symptoms were identified with several risk factors for developing pneumonia. Among 56 total, 41 children (73.2%) were identified as underweight for age according to the WHO weight for age charts [18]. Eleven children were in normal weight for the age category and the rest of the patient's data was unavailable in the records. We considered Congenital Heart Disease (CHD), Respiratory diseases (asthma and recurrent wheezing), Cerebral palsy and past medical history of lower respiratory tract infection (LRTI) as other risk factors for the development of childhood pneumonia. Among the study cohort, 51.8% of children were diagnosed with CHD, and sixteen patients (28.6%) of the study cohort had a past medical history of LRTI. Respiratory diseases and Cerebral palsy diagnosed patients were 6 (10.7%) and 5 (8.9%) respectively (Fig. 5).

When considering the mortality percentage, there were 12 children without any significant underlying risk factor for severe disease. However, neurological disabilities were

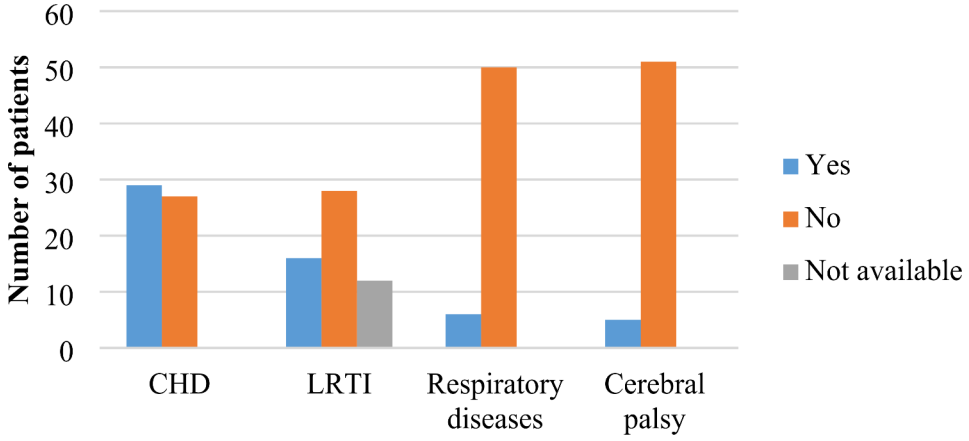

Fig. 5 Presence of comorbid conditions in children who died due to pneumonia

present in 10 children including 6 patients with cerebral palsy, 2 patients with spinal muscular atrophy (SMA) and 2 patients with an epileptic syndrome. In addition to that, there were 2 patients with failed Kasai surgery and two patients with short bowel syndrome.

Genetic and chromosomal syndromes were identified in 10 children including Down syndrome. Out of the total, 6 had a diagnosis of Trisomy 21.

Out of the total 56 patients, data on immunisation status was available for 43 individuals. Out of them, 14 (32%) had not completed the immunisation to the age according to the national programme of immunisation of Sri Lanka. When considering the duration of hospitalization before the death of the patients, half of the study cohort (28 patients) were admitted to the hospital less than 1 week before the death while the other half of the study cohort were treated in the hospital more than 1 week before the death. Among the total study cohort of 56 patients, 25% (14) of patients died in the ward and the majority of the patients 75% (42) were treated in the Intensive Care Units (ICU) before their death.

We have analysed the correlation between the death of the children due to pneumonia and the other independent variables. According to the results, there was a significant correlation with the younger age ($p=0.004$), duration of the hospital stay ($p=0.011$), cerebral palsy ($p=0.004$) and past history of LRTI (0.001).

Discussion

The present study was conducted in two tertiary paediatric referral centers in Sri Lanka. The population is unique in that the health indices are quite impressive for a country in the lower middle-income category. We have included 56 patients who died due to an established diagnosis of pneumonia in the present study. We aimed to determine the demographic characteristics and the contributing factors of the children who died from pneumonia.

In our total study cohort of 56 patients who died due to pneumonia, 51.8% (29 patients) were males and 48.2% (27 patients) were females. However, several other studies have found that pneumonia prevalence is higher among males which is not compatible with the present study [6–8].

Neonates have been identified as the main age group that is more vulnerable to childhood pneumonia deaths which is annually 750000-1.2 million deaths (10% of global child mortality) [6]. In our study cohort, the highest number of patients (22) were in the age range of 3–12 months which is not in line with the above fact.

According to the statistics, the number of deaths due to pneumonia remains stable for the period of 6 years from 2017 to 2022. However, there is a decline in total childhood deaths from 2019 to 2021. This declining trend may be attributed to enhanced programmes of immunisation and improved empirical treatment.

When considering the present study cohort, 41 patients (73.2%) were identified to be underweight for age according to the WHO weight for age charts. A study has shown that moderate and severely undernourished children's estimated mortality due to pneumonia is 2.0 (95% CI 1.6 to 2.6) and 4.6 (95% CI 3.7 to 5.9) respectively [9]. This fact has been supported by the present study as well.

We have identified that the vaccination rate in the chosen group is relatively low (32%) compared to national immunisation coverage which is 99% for 3 DPT containing vaccines. PCV vaccine is available in the private sector although it is not included in the national programme of immunisation of Sri Lanka [13]. However, we do not have data on how many people are getting the PCV vaccine, as our analysis focused on the immunisation status of the study population based on the national vaccination schedule. This points out the importance of paying more attention to this potential risk factor for childhood mortality due to pneumonia.

Morbidity and mortality due to pneumonia in children who are diagnosed with Congenital Heart Disease (CHD) is higher than in previously healthy children since they are more susceptible to recurrent infections [6]. Recurrent lower respiratory tract infection increases the mortality rate due to pneumonia in paediatric patients which is an established fact [10]. We found that there were 51.8% of children diagnosed with CHD, and 28.6% with a past medical history of LRTI.

The majority of patients (53.6%) were admitted to the hospital within 1–2 days of being symptomatic which supports the fact that parents have shown responsibility and attention towards children by taking children to a hospital without much delay.

Healthcare costs remain high in managing children with pneumonia due to long hospital stays and needing top-notch care to reduce mortality and morbidity. A study done in Teaching Hospital Peradeniya has identified that a significant percentage of patients (61%) needed hospital care for more than 5 days, about 2/3rd of the study cohort needed a second line intravenous antibiotic therapy and 51/127 patients needed a high dependency unit care [3]. In our study cohort, about half of the cohort (28 out of 56 patients) were treated in the hospital more than 1 week before the death and 75% (42) of the total cohort were treated in ICU before the death.

Among the total study cohort of 56 patients, 25% (14) of patients died in the ward. This may be due to a delay in recognition of patients needing ICU care or due to limited ICU facilities and a lack of guidelines for ICU care.

Although the present study has revealed the age distribution and contributing risk factors for mortality among children who died from pneumonia, there are some limitations. Further investigation of the laboratory test results and radiological findings along with improved diagnostics would be useful in determining the definitive causes of mortality due to pneumonia in the selected study cohort. Moreover, comprehensive data regarding the status of immunisation within the study cohort would be essential for assessing the effect of immunization on the incidence of pneumonia-related mortality in children.

Conclusion

Contributing factors for mortality due to childhood pneumonia in the present study cohort were young age, cerebral palsy, incomplete status of immunisation and a history of lower respiratory tract infection. Nearly half of the children who died from pneumonia had a congenital heart disease although it is not statistically significant. Pneumonia in children increases health care costs which is evidenced by more than 1-week longer hospital stays and ICU facilities of most of the study participants before death. A substantial number of deaths occurring in general wards needs further evaluation.

Abbreviations

CAP	Community Acquired Pneumonia
CHD	Congenital Heart Disease
CRP	C-reactive protein
HAP	Hospital Acquired Pneumonia
ICU	Intensive Care Unit
LRTI	Lower Respiratory Tract Infection
SBSCH	Sirimavo Bandaranaike Specialized Children's Hospital
SMA	Spinal Muscular Atrophy
UNICEF	United Nations International Children's Emergency Fund
WBC	White Blood Cell
WHO	World Health Organization

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Author contributions

ST conceptualized and designed the study with assistance from WK, SP. GV and SP developed the study design, methodology and statistical analysis plan under the guidance of ST and WK. GV and SP drafted the manuscript and revised by ST and WK; All authors contributed to the manuscript and approved the final version.

Funding

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Data availability

Data is available upon request (with the corresponding author).

Declarations

Ethical considerations

Ethical clearance was granted by the ethics review committee of the Faculty of Medicine, University of Peradeniya (ERC No 2021/EC/82).

Consent to participate

No human subjects participated in the study. Already available data in the patient records were used with the permission of the Directors of the respective hospitals.

Consent for publication

Consent is given for publication.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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