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ANTIBIOTIC THERAPY FAILURE AND THE RISING CHALLENGE OF ANTIMICROBIAL RESISTANCE IN PEDIATRIC PNEUMONIA PATIENTS IN KHYBER PAKHTUNKHWA PAKISTAN

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Abstract

Background: Drug-resistant bacterial strains cause various infections including pneumonia, which then go unchecked, as the prevalence of culture and sensitivity tests are not entertained before planning therapy. The current study aimed to evaluate the prescribing practices of antibiotics, therapy failure, and to assess the patient response. Therapy failure and antibiotic switching-over are a sign of drug-resistance and possibly antimicrobial resistance (AMR).

Methods: A total of n=60 pediatric pneumonia cases were collected and evaluated for prescription pattern of antibiotics, hospital longevity, overall antibiotic consumption, switching-over and patient discharge assessment, respectively.

Results: The study results showed that pneumonia is more common in children (1-5 years); n=24 (40%), followed by neonates (0-12 months); n= 19 (31.6%), respectively. Monotherapy was used upon initial admission of patients, while combination therapy and antibiotic switching-over were

noticed when patients were not responding to initial antibiotic therapy. Due to non-responsiveness, the patient's hospital stay was prolonged and antibiotic regimens were switched over indicating the possibility of drug-resistant bacterial strains. Next, upon utilization of monotherapy (single antibiotic), the average hospital stay was 6.5 days, while 3.5 days with combination therapy (two antibiotics). The total number of antibiotics were 122 with highest number prescriptions of cefoperazone (n=35, 28.6%), meropenem (n=31, 25.4%), and vancomycin and linezolid both having n=24 (19.6%) for each. The most commonly used regimens were meropenem+linezolid (n=9), meropenem+vancomycin (n=7) followed by cefoperazone+linezolid and cefoperazone+vancomycin both having n=5, respectively. Switching-over was noted mostly for monotherapy drugs cefoperazone (15 times), followed by ampicillin, ceftriaxone and meropenem (2 times), respectively. Furthermore, meropenem+linezolid reflected as the best combination with patient discharge n=10 with 16.6% and hospital longevity less than 2 days.

Conclusion: This study highlights the emerging silent pandemic of drug-resistant bacterial strains responsible for causing pneumonia in pediatric patients. This trend may be perceived as a sign of AMR, and needs careful watch and reporting. We recommend further studies on provincial and national level hospitals to prevent the upcoming health concern and its worse consequences.

Key words: Antimicrobial resistance (AMR), Antibiotic, Therapy failure, Switching-over, Pediatric pneumonia

1. BACKGROUND

Pneumonia is an infectious disease that often affects the lungs and may turn out to be serious resulting in death. With the exception of bronchiolitis, which is a well-defined condition almost entirely caused by a viral agent, pneumonia can be described as an acute infection of the lung parenchyma by one or more pathogens [1]. It is the leading cause of illness and mortality in children, however, it affects people of all ages [2]. According to estimates from the World Health Organization (WHO), pneumonia claims the lives of 2.5 million people annually, most of whom are in underdeveloped and low-income countries [3]. An estimated 120 million children under the age of 05 years, are reported to develop pneumonia each year, with 1.3 million of these infections resulting in death [4]. More than 808 000 children under the age of five died from pneumonia in 2017, making up 15% of all pediatric deaths [5]. Pneumonia-related deaths in Pakistan range from 10% to 30%. Notably, poorer access to the health care system contributes to a greater mortality rate (10–40%) among early infants in developing countries. The mortality rates were 3% for under-five-year-olds, 14% for those between five and 65 years old, and 24% for individuals beyond 65 years old [6]. An estimated 138 million cases of pneumonia were reported worldwide in 2015. Pakistan is one of five nations that collectively bear the burden of 49% of pneumonia-related deaths and 52% of all pneumonia cases. In Pakistan, pneumonia has claimed the lives of 58 000 under-five children per year. According to Pakistan's Demographic and Health Survey, which was carried out in 2012 and 2017, 82% of children in the country were seeking treatment at medical facilities for symptoms related to acute respiratory infections including pneumonia [7].

Antimicrobial resistance (AMR) is a global threat facing humanity and its trajectory is different for different countries around the globe [8]. Presently drug-resistant infections are causing 700,000 deaths. If this issue was not highlighted with serious concern, it could possibly lead us to 10 million deaths each year globally by 2050. AMR will be the leading cause for death overtaking other disease like heart disease, diabetes and cancer. In US alone, in 2019 over 2.8 million people had already acquired drug resistant infections resulting in 35000 deaths [9]. In Europe, drug resistant infections has caused deaths of 25,000 in 2020 [10]. A study in a Chinese university, had shown that in a total of 1025 prescriptions only 39 individuals underwent a microbiological analysis to determine the infection's origin. Similarly in Jakarta (Indonesia), 94% children having diarrhea were prescribed antibiotics though the physicians were suspecting it as a viral infection [11]. Furthermore, South East Asia is a major reservoir for AMR and hotspot for emerging infectious diseases which include Brunei,

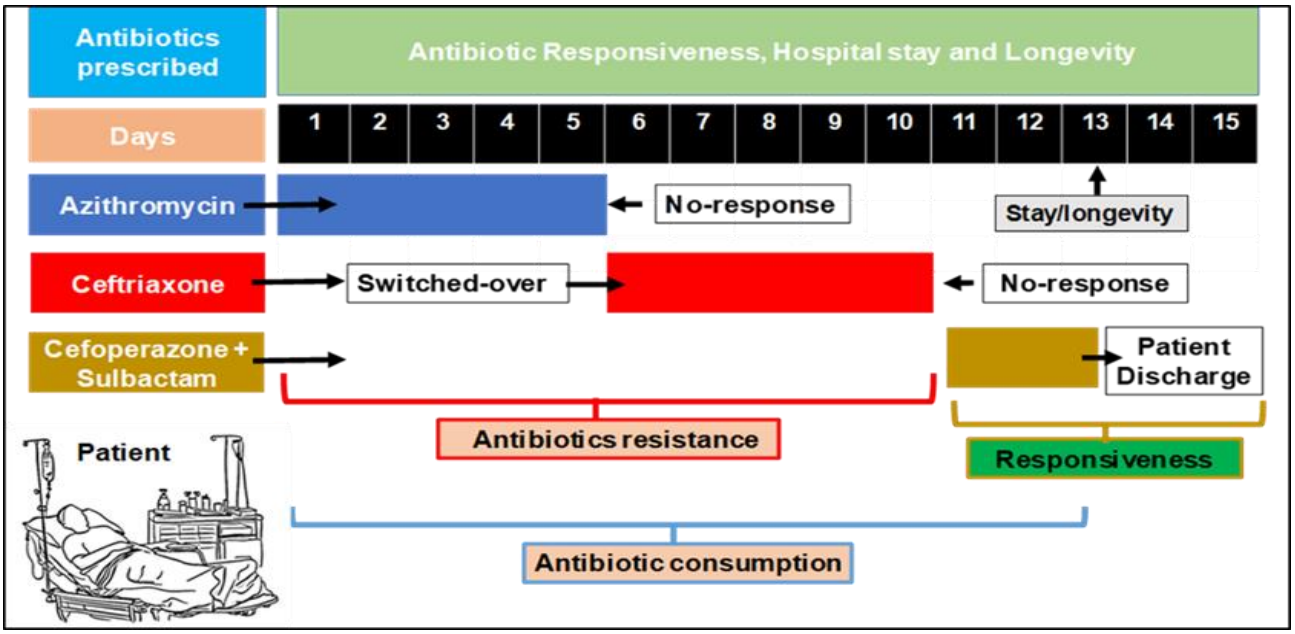
Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. In these counties demand of antimicrobial agents is much higher while public has access to substandard drugs, irrational use of antibiotics, self-medication and lack of awareness [12]. A study was carried out in Mumbai (India), when 106 private practitioners were asked to prescribe antibiotics for pulmonary tuberculosis (TB) patients, 63 different drug regimens were followed by the practitioners, out of these 63 only 6 were turned to be suitable [11]. Usually, this resistance trend is much higher in low-income countries and developing nations of the world. Specifically, *Acinetobacter baumannii* has higher rates of resistance among other bacterial strands. Secondly, *Enterococcus faecium* (87%) is now resistant to broad spectrum penicillin's while *Klebsiella pneumoniae* is also highly resistant to various antibiotics. In addition, both of these bacterial strains are placed in priority list by WHO for development of new antibacterial agents for their prevention. Geographically, the Nile River delta, the Red River delta in Vietnam, the north of Pakistan, Iran and eastern Turkey have all been highlighted as hotspots of resistance. There is a diversity in resistant genes and the most resistant genes were found in Africa while least resistant in New Zealand and Australia [13].

There are various ways for an organism to develop resistance to antimicrobial drugs. The fundamental mechanisms include; (a) production of inactivating enzyme such as *Staphylococci, gonococci, E.* coli, and some other bacteria produce β-lactamases, which can destroy certain penicillin and cephalosporin antibiotics. (b) An efflux pump mechanism is a process that inhibits drug deposition in the bacterium, such as gram-positive and gram-negative bacterial resistance to tetracycline's, chloramphenicol, and macrolides, respectively. (c) Reduced antimicrobial agent access into the organism as a result of a change in the channel/transporter necessary for its entry into the organism. (d) Alteration of the drug binding site, such as changes in penicillin-binding proteins (PBPs) in some pneumococci with lower penicillin affinity. And (d) Absence of metabolic pathway, as reported in sulphonamide-resistant bacteria, which use preformed folic acid without the regular metabolic processes for their survival [14].

A number of reasons, such as inadequate healthcare infrastructures, restricted access to high-quality treatments, and gaps in diagnostic capacities, contribute to the misuse of antibiotics in low- and middle-income countries (LMICs) [15]. Higher rates of morbidity and mortality have been linked to the inappropriate over- and misuse of antibiotics. The illegal over-the-counter sale of antibiotics by pharmacists and other sellers without a valid prescription from a licensed doctor or confirmatory test findings is one of the main causes of the misuse of antibiotics in human healthcare systems [16]. Furthermore, one of the few main causes of poverty-driven AMR in developing countries is the inability to obtain high-quality, effective antibiotics [17]. Poverty also makes it difficult for patients to comply with antibiotic treatment, which promotes the development of antibiotic resistance via limited exposure to antibiotics [18]. In addition, it is noted that those living in extreme poverty are forced to turn to unlawful physicians and drug sellers that supply inferior, counterfeit, and out-of-date medications or low-trait antimicrobial dosages [19].

The rate of childhood mortality in Pakistan is 67 per 1,000 live births. With 640,000 deaths annually from pneumonia in children under five, and has the third-highest burden of pneumonia deaths worldwide [20]. Pneumonia hospitalized patients receive different types of antibiotic regimens during their stay at the hospital [21]. After starting an antibiotic regimen (whether monotherapy or combination therapy), some patients show responsiveness to the antibiotics resulting in early discharge from the hospital within a week [22]. However, some patients tend to show no response to that specific antibiotic regimen which results in antibiotic switching-over to another class of antibiotics. This switching-over increases the hospital stay and longevity of patients [23]. Drug resistant bacterial strains show resistance to the regimen which further worsen the condition of patient. This can be considered as an important factor for assessing the antibiotic resistance within pneumonia patients receiving antibiotic therapy. The goal of the present study was to evaluate the prescribing practices of antibiotics, therapy failure, and to assess the patient response. In addition, the second objective of this study was to evaluated the effectiveness of antibiotics monotherapy and

combination therapy in terms of patient's hospital longevity. Therapy failure and antibiotic switching-over are a sign of drug-resistance and possibly AMR (see study rationale).



Study rationale

2. METHODOLOGY

2.1 Study setting and design

The mixed nature (concurrent and retrospective) study was carried out in an ISO Certified (ISO 9001:2015) tertiary care hospital, which was providing tertiary care services in almost all the major medical and surgical specialties over 1300 bedded setting in Peshawar, Khyber Pakhtunkhwa, Pakistan. The study was specially conducted in pediatric wards (A and B) having majority of pneumonia admitted patients. The data was collected on the official permission of director of pharmacy services, chief pharmacist and ward incharge. The data collector was well-educated and guided ethically from university prior to data collection. The data was collected on consensus of physician, nurse on-duty, and specifically patient attendants.

2.2 Inclusion and Exclusion criteria

Patients with complete medical records, receiving at least one antibiotic, currently on bed or discharged from the hospital, and willingly participating in the study were included. In contrast, all the patients were excluded having hospital stay time less than 01 day or having insufficient or lost medical records.

2.3 Data collection

During the mentioned duration, a total 60 patients case histories, prescriptions, and biodata were collected on a prescribed proforma as given below;

			Address/Region	Hospital Longevity			
Patient ID/Admission No	**Age**	**Sex**	**District/Tehsil**	**Date of Admission**	**Date of Discharge**	**Hospital stay (Days)**	**Antibiotic consumption**

2.4 Antibiotic consumption and hospital longevity

Main focus was shifted toward the antibiotic consumption and treatment regimen. Total number of antibiotics, monotherapy or combination therapy, hospital longevity, average stay in the hospital, antibiotic at which the patient was discharged and antibiotic switching-over were evaluated on a comprehensive designed proforma.

2.5 Data analysis

The collected data was tabulated in Microsoft Excel and analyzed using Graphpad prism in the form of graphs to convey the study outcomes in an easier and understandable manner. Two online accessible applications namely; Pharma guide and Pharmapedia Pakistan were used for generic names of the drugs.

3. RESULTS

3.1 Gender and age wise distribution of patients

A total of n=60 pediatric pneumonia patient prescriptions were collected and evaluated according to the proposed study plan. The percentage of male and female patients were 58.3% (n=35) and 41.6% (n=25), respectively. Age-wise distribution showed 1 month and 12 years as minimum and maximum age of the admitted patients. The age groups were categorized in 03 groups including neonates n= 27 (45%), followed by children (age 1-05 Years) n= 24 (40%), and grade-schoolers (age 6-12 years) n= 9 (15%), respectively (Figure 1). It shows that pneumonia is very common in neonates as it accounts for the maximum n=27 (45%) patients among the total 60 patients.

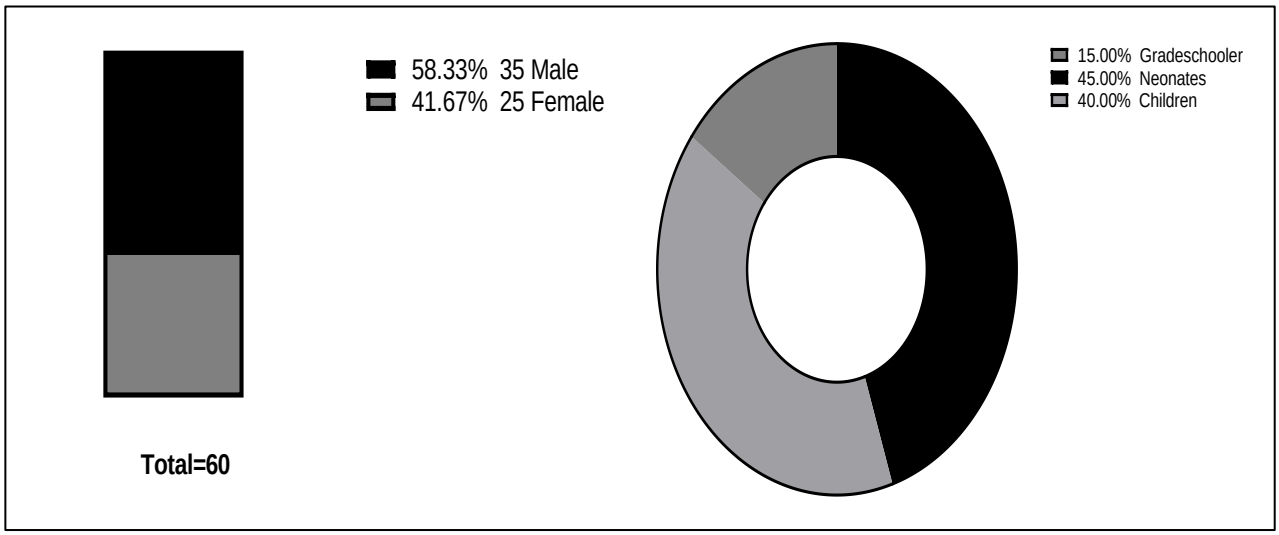


Figure 1. Gender and age wise distribution of patients

3.2 Area based distribution

The patients admitted belonged to nine different regions of KPK. Khyber accounts for n=18 (30%), followed by Peshawar n=13 (21.6%), then Swat n=9 (15%) and the rest of regions namely Bannu n=6 (10%), Charsada n=4 (6.6%) and Kohat, Karak and Dir Lower n=3 (5%) each, respectively.

3.3 Antibiotic Consumption

In terms of antibiotic consumption there are two scenarios here in this study, for some patient's monotherapy was preferred upon initial admission at the hospital. Some patients failed to respond to monotherapy, hence combination therapy was utilized which was found effective in reducing the hospital longevity of patients. Overall consumption of antibiotics is illustrated in Figure 2.

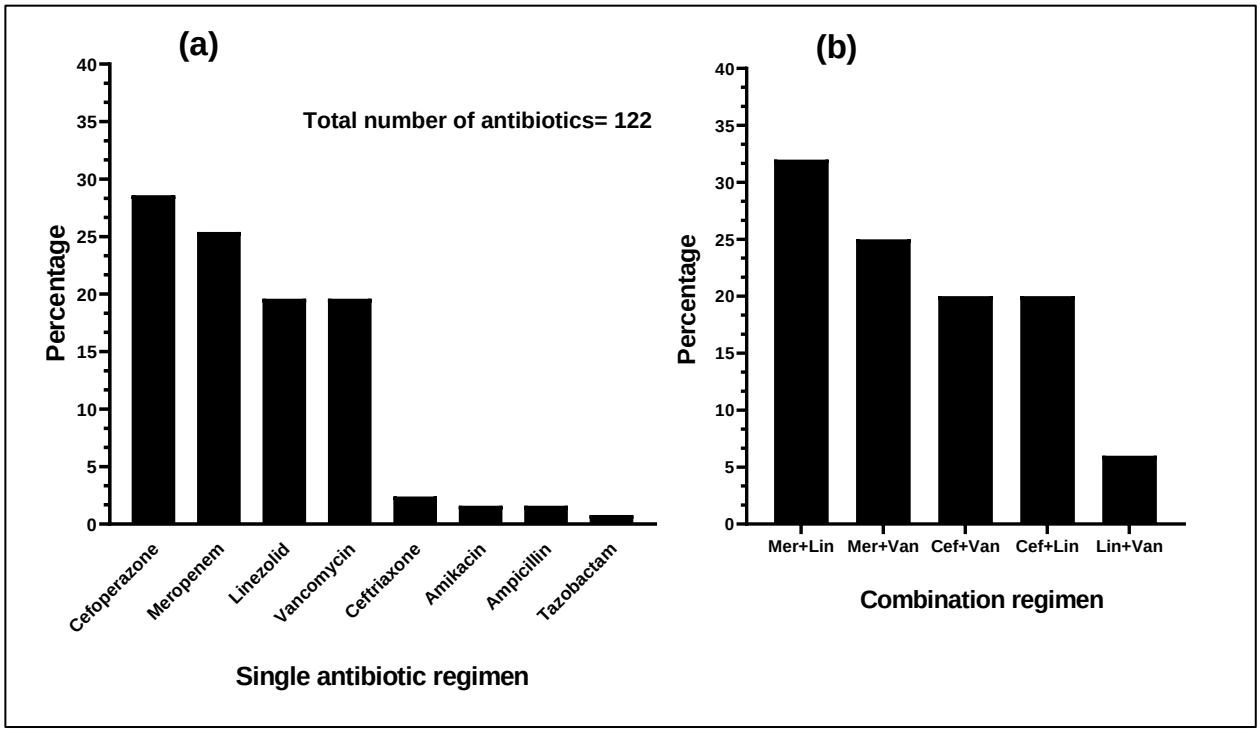


Figure 2. Overall antibiotic consumption. (a) Monotherapy (b) Combination therapy

Legends: Mer+Lin (Meropenem+Linezolid), Mer+Van (Meropenem+Vancomycin), Cef+Van (Cefoperazone+Vancomycin), Cef+Lin (Cefoperazone+Linezolid), Lin+Van (Linezolid+ Vancomycin).

Out of 35 patients whose initial therapy was started with cefoperazone (monotherapy) only 05 patients were discharged with the same drug having an average hospital longevity of 7.8 days. Furthermore, cefoperazone alone, was found ineffective for 30 patients which resulted in switching-over of cefoperazone to other antibiotic classes such as vancomycin, meropenem, and combination regimens including meropenem+linezolid, meropenem+vancomycin and cefoperazone+linezolid, and cefoperazone+vancomycin, respectively. The meropenem+linezolid combination was found as the most effective antibiotic regimen for all sort of pediatric pneumonia patients as it resulted in discharge of 10 patients with an average hospital longevity of 3 days, and without further antibiotic switching issues. Furthermore, meropenem+vancomycin combination was also found effective for reducing the hospital longevity to an average of 3 days. Followed by cefoperazone, cefoperazone+linezolid, cefoperazone+vancomycin, these combinations were also found effective for treatment of pneumonia with an average of 3.5 days' hospital stay.

3.4 Drug-resistant bacterial strains and prevalence of AMR

The overall data were evaluated carefully and tabulated for therapy failure and possible AMR. Therapy failure was analyzed based on hospital stay and switching-over of antibiotics during the course of therapy. The sooner discharge is considered sensitive to antibiotic while prolongation may be used as a sign of therapy failure and possibly the prevalence of AMR in the form of drug-resistant bacterial strains causing pneumonia. In total, about n=36 (60%) patients stayed from 1-5 days and get discharged, with most patient received a combination therapy including cefoperazone+vancomycin, meropenem+linezolid, cefoperazone+linezolid, meropenem+vancomycin and linezolid-vancomycin, respectively. Switching-over were reported for monotherapy with n=6 antibiotics including cefoperazone n=15/35 (42.8%), ceftriaxone n=2/3 (66%), meropenem n=2/31 (6.4%), ampicillin n=2 (100%), vancomycin n=1, while amikacin, linezolid and tazobactam remained till the end of therapy. In addition, n=20 (33.3%) patients stayed for 6-10 days, only one patient hospital stay was between 11 to 15 days. Furthermore, Figure 3 and 4 indicates comprehensive overview of antibiotic regimen

in male and female patients, respectively. Moreover, 03 patients stayed for 6 to 24 days in the hospital and received different antibiotic regimens as indicated by Figure 5. From the results, it can be concluded that in monotherapy cefoperazone, ampicillin and ceftriaxone were less responsive as compared to meropenem, vancomycin, linezolid and amikacin, respectively (Table 1). We suspect that this was due to the drug-resistant bacterial strains, as no response was noted in patients and were switched-over to other class of antibiotics which resulted in the initiation of successful therapy.

Table 1. Antibiotic frequency and switching-over (monotherapy)

Antibiotic	Total No	Number of switching-over noticed for n=60 patients	%age
Ampicillin	2	2	100
Ceftriaxone	3	2	66
Cefoperazone	35	15	42.8
Meropenem	31	2	6.4
Vancomycin	24	1	4.1
Amikacin	2	0	0
Linezolid	24	0	0
Tazobactam	1	0	0
Total Number of antibiotics	122	22	

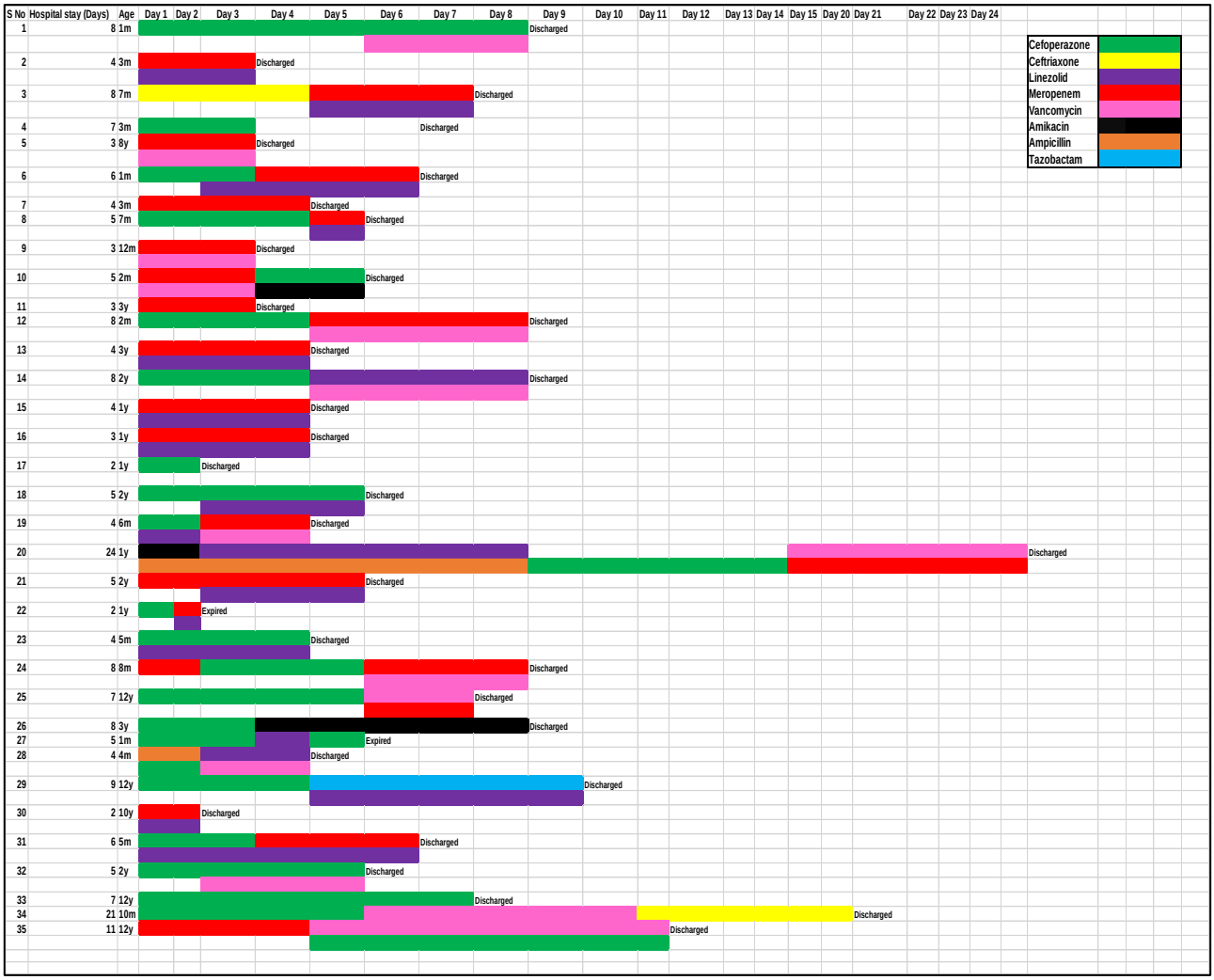


Figure 3. Male Patients (overall antibiotic consumption chart)

Note: The coloured bar lines denote antibiotic regimen, while termination/change of colour denotes that antibiotic is switched-over to other antibiotic agent/class as a result of non-responsiveness as evident from patient condition during the study.

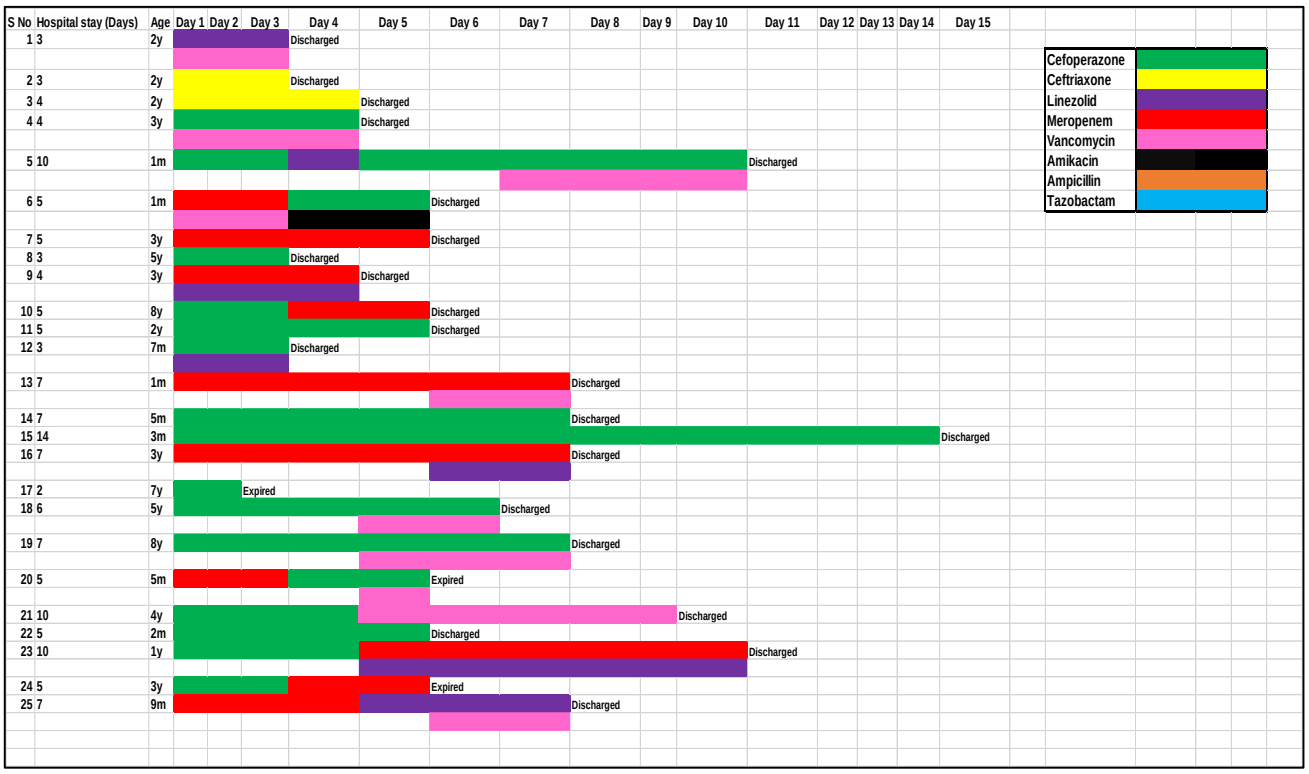


Figure 4. Female Patients (overall antibiotic consumption chart)

Note: The coloured bar lines denote antibiotic regimen, while termination/change of colour denotes that antibiotic is switched-over to other antibiotic agent/class as a result of non-responsiveness as evident from patient condition during the study.

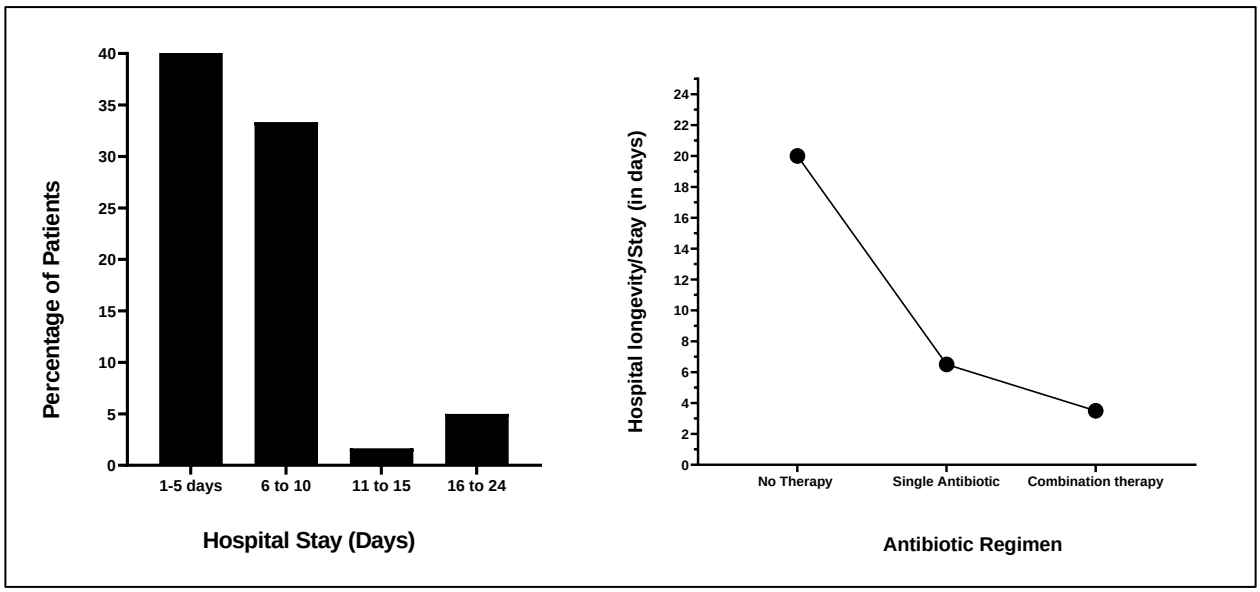


Fig. 5 Hospital longevity vs antibiotic regimen (monotherapy/combination therapy)

4. DISCUSSION

The current study was carried out in pediatric ward (A and B) Hayatabad Medical Complex (HMC) Peshawar, KP, Pakistan. In this study, total of n=60 pediatric pneumonia patient prescriptions were

collected and evaluated. The percentage of male patients was 58.3% (n=35) while the percentage of female patients was 41.6% (n=25). The age groups were categorized in 04 groups including children (age 1-5 years) n=24 (40%), followed by neonates (age 0-12 months) n= 19 (31.6%), respectively. It shows that pneumonia is very common at age of 1-05 years' as it accounts for the maximum n=24 patients among the 60 patients.

In terms of antibiotic consumption there are two scenarios here in this study, for some patient's monotherapy was preferred upon initial admission at the hospital. Some patients failed to respond to monotherapy, hence combination therapy was utilized which was found effective in reducing the hospital longevity of patients. Out of 35 patients whose initial therapy was started with cefoperazone (monotherapy) only 05 patients were discharged with the same drug having an average hospital longevity of 7.8 days. Cefoperazone alone, was found ineffective for 30 patients which resulted in switching over of cefoperazone to other antibiotic classes such as vancomycin, meropenem, and combination regimens including meropenem+linezolid, meropenem+vancomycin and cefoperazone+linezolid, cefoperazone+vancomycin, respectively. According to Sano et al., improper early antibiotic therapy is substantially linked to ARP isolation at diagnosis. Unsuitable antibiotic medication has been linked in the past to poor patient outcomes and a rise in antibiotic resistance, according to research. Furthermore, when the detected bacteria are susceptible to narrow-spectrum antibiotics, usage of broad-spectrum antibiotics may increase mortality. Thus, it is critical to identify people at risk of AR at the time of diagnosis [24].

Meropenem+linezolid combination was found as the most effective antibiotic regimen for all sort of pediatric pneumonia patients as it resulted in discharge of 10 patients with an average hospital longevity of 3 days, and without further antibiotic switching issues. Furthermore, meropenem+ vancomycin combination was also found effective for reducing the hospital longevity to an average of 3 days. Followed by cefoperazone, cefoperazone+linezolid, cefoperazone+vancomycin, these combinations were also found effective for treatment of pneumonia with an average of 3.5 days' hospital longevity. Combination therapy offers an insight into the potential risk posed by multidrug-resistant (MDR) bacteria [25]. A study found that *K. pneumoniae* isolates have a high rate of carbapenem resistance. Cefiderocol and the combination of meropenem and colistin seem to be promising treatments for infections brought on by *K. pneumoniae* [26]. The antibiotic resistance was analyzed based on hospital stay and switching-over the classes of antibiotics during the course of therapy. The sooner discharge is considered sensitive to antibiotic and vice versa. We have n=36 patients stayed from 1-5 days and get discharge most of them were on combination therapy including cefoperazone+vancomycin, meropenem+linezolid, cefoperazone+linezolid, meropenem+ vancomycin and Linezolid Vancomycin, respectively. Switching-over were noted for 06 antibiotics including cefoperazone n=15/35 (42.8%), ceftriaxone n=2/3 (66%), meropenem n=2/31 (6.4%), ampicillin n=2 (100%), vancomycin n=1, while amikacin, linezolid and tazobactam remained till the end of therapy. According to Foucrier et al., prolonged antibiotic therapy and mechanical ventilation, which may be linked to greater challenges in achieving clinical cure, the patients in the combination antibiotic therapy group had similar outcomes to those in the monotherapy group [27]. Furthermore, a meta-analysis showed that patients receiving beta-lactam monotherapy or combination therapy for *P. aeruginosa* infections did not shift in terms of mortality, clinical cure rate, or microbiological cure rate [28].

In literature, it can be seen that combination drugs can be used to treat these drug-resistant strains, and in certain situations, there is even evidence to support the idea that they are more effective than monotherapies. It was discovered that none of the combination therapies significantly underperformed the monotherapies, and many of them were able to meet or even surpass them. However, there was a lack of statistical significance, the majority of the clinical investigations were small, and very few of them were prospective randomized clinical trials [29]. The findings of the current study are consistent with already available literature. For instance, according to Shah et al., pneumonia patients may be showing signs of AMR due to their decreased responsiveness to

combination therapy (ampicillin/cloxacillin) and longer hospital stays [30]. Sharma et al., revealed that the higher hospital stay has been caused by AMR [19]. Pediatric respiratory infections, specifically community-acquired pneumonia (CAP), are a significant illness that frequently occurs during outpatient and hospital visits. The season, the epidemiological features of the neighborhood, and an individual's susceptibility all affect the causes of CAP [31]. A significant issue with hospital-acquired infections is biofilm-related multi-drug resistance, which raises patient morbidity and death rates as well as financial expenditures from high medical expenses and extended hospital stays [32]. Poudel et al. also included as a result of a total of 29 studies in their review study. Sixty-nine percent (20/29) of this study's results were carried out in high-income economies, with the remaining studies being undertaken in upper- and middle-class countries. 44.8% (13/29) of the studies were carried out in tertiary care settings, while the majority of studies (89.6%, 26/29) were undertaken from a healthcare or hospital viewpoint. According to the available data, the attributable cost of resistant infection varies from -US$2,371.4 to +US$29,289.1 (adjusted for 2020 price) per patient episode; the odds ratios for readmission and mortality are 1.492 (95% CI: 1.231–1.807) and 1.844 (95% CI: 1.187–2.865) respectively, and the mean excess length of stay (LoS) is 7.4 days (95% CI: 3.4–11.4) [33].

Antimicrobial-resistant bacteria are becoming more prevalent globally, posing a silent pandemic threat to public health and requiring immediate action. There are few treatment choices for infections brought on by bacteria resistant to antibiotics, which increases hospital stays, morbidity, and costs significantly [34]. Since pneumonia has high medical and financial expenses and increases morbidity and death in individuals of all ages worldwide, it is one of the most important public health problems. In addition, antimicrobial resistance has increased over time, and the emergence of multi-drug resistance in gram-negative bacteria makes therapy more difficult, increase hospital stay and negatively affects patient outcomes [35]. Antibiotics were thought to be essential for treating bacterial illnesses. Antimicrobial resistance, on the other hand, has led to antibiotics becoming less effective against bacterial infections, increasing morbidity and death and carrying a significant financial cost: Treatment for infections brought on by just six multidrug-resistant bacteria costs $4.6 billion a year [36]. The overuse and misuse of antibiotics in human medicine is a significant contributor to antimicrobial resistance. Antibiotic over-prescription is still quite common; depending on the situation, up to 50% of all human prescriptions for antibiotics might turn out to be unnecessary, and multiple studies indicate that at least 50% of antibiotic treatments are ineffective [37]. Hospitals are particularly concerned about antibiotic resistance because it can result in longer hospital stays and a higher risk of infection. Antibiotic-resistant bacterial infections are more challenging to treat, which extends recovery times and raises medical expenses. More intensive care, such as longer hospital stays, more procedures, and stronger medications, may be necessary for patients with illnesses resistant to antibiotics. To reduce the emergence and spread of antibiotic resistance in healthcare settings, hospitals must adopt efficient infection control procedures and encourage the responsible use of antibiotics [38]. Since bacteria do not respond to that particular class of antibiotics, inappropriate initial antimicrobial therapy is independently linked to higher mortality and longer hospital stays [39].

A study included 82 cases of *Klebsiella pneumoniae* in total. Five strains (12.5%) were categorized as susceptible, three (7.5%) as resistant, seven (17.5%) as MDR, and twenty-five (62.5%) as XDR out of the 2018 group. Regarding amoxicillin/clavulanic acid (90%), ciprofloxacin (100%), piperacillin/tazobactam (92.5%), and cefoperazone/salbactam (95%), the 2018 group showed the highest rates of antimicrobial resistance. In contrast, no strain was identified in the 2022 group as susceptible; nine strains (21.4%) were identified as resistant; three strains (7%), as MDR; and thirty strains (93%) as XDR. Resistance to amoxicillin significantly increased, going from 10% in 2018 to 0% in 2022. Overall, the rate of resistant *Klebsiella pneumoniae* rose from 7.5% (3/40) in 2018 to 21.4% (9/42) in 2022. Furthermore, among ICU patients on mechanical ventilation, the rate of XDR

Klebsiella pneumoniae increased dramatically from 62.5% (25/40) in 2018 to 71% (30/42) in 2022 [40]. As per results discussed above, the current study found that monotherapy approach in pneumonia patient is not responsiveness due to the emergence of AMR bacterial strains which makes it difficult to treat pediatric pneumonia with first line antibiotics which were once used as a prominent approach. In addition, combination therapies were found effective, however through natural selection process bacteria are going to become resistance as part of the evolutionary process. In order to tackle this issue more in-depth studies are required to unleash the root causes, arrange preventive measures and look for alternative antibiotics from natural sources, and utilize modern technology to eradicate this silent pandemic.

5. CONCLUSION

To sum up, this study illuminates the urgent problem of AMR in pediatric pneumonia in Pakistani population. The study highlights the effectiveness of combination therapy, with the meropenem+linezolid regimen being predominantly effective in reducing hospital stays in pediatric pneumonia patients. Moreover, this study highlights the significance of responsive treatment approaches and makes significant improvements to our understanding of pediatric pneumonia and AMR. In order to successfully address this issue, further research is needed to determine the underlying reasons of AMR in pediatric pneumonia. In order to minimize the emergence of resistance, it is necessary that preventive measures be put into place as well as alternate sources of antibiotics be explored. Taking use of innovative medical research and technology will be essential for combating this silent pandemic.

Availability of data

The data analyzed or presented in the present study will be made available upon reasonable request from the corresponding author.

Competing Interest

The authors declare that they have no known competing financial or personal interests that could have appeared to influence the work reported in this paper.

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