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Antimicrobial Resistance in Septicemia: Uncovering a Silent Catastrophe in Sylhet, Bangladesh

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Abstract:

Septicemia is a major global health concern, particularly in low- and middle-income countries where antimicrobial resistance (AMR) threatens effective treatment. This retrospective observational study analyzed 269 culture-positive bloodstream infection cases from Mount Adora Hospital, Sylhet, Bangladesh, between July 2023 and June 2024. *Staphylococcus aureus* (69.9%) was the predominant pathogen, followed by *E. coli* (14.5%) and *Pseudomonas spp.* (11.9%). Alarmingly high resistance rates were observed for cefixime (82.5%), ceftazidime (77.8%), azithromycin (75.9%), and fosfomycin (71.4%), indicating the limited efficacy of these commonly used antibiotics. Conversely, imipenem (10.4%), amikacin (11.3%), and doxycycline (9.0%) exhibited relatively lower resistance. These findings emphasize the urgent need for revised empirical treatment guidelines and robust antimicrobial stewardship to combat AMR in Bangladesh and similar settings.

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Introduction:

Antimicrobial resistance (AMR) has emerged as a critical global public health threat, undermining our ability to treat common infections[1,2]. The World Health Organization (WHO) estimates that bacterial antimicrobial resistance caused 1.27 million deaths in 2019, with 90% of the burden in low- and middle-income countries[2]. In South Asia, densely populated countries with overcrowded health systems and unregulated antibiotic use face especially severe challenges[1,3]. In Bangladesh, misuse of antibiotics (both in human medicine and agriculture), incomplete treatment courses, and low public awareness have driven multidrug-resistant (MDR) infections[2,3].

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In Bangladesh, misuse of antibiotics (both in human medicine and agriculture), incomplete treatment courses, and low public awareness have driven multidrug-resistant (MDR) infections[2,3]. Surveys indicate high rates of self-medication and non-prescription antibiotic use in Bangladesh, contributing to selective pressure[3]. Consequently, AMR pathogens are now commonplace in both community and hospital settings, threatening to roll back progress in modern medicine such as surgery and neonatal care[1,2].

Septicemia, or bloodstream infection (BSI), is a life-threatening condition in which pathogenic microorganisms invade and multiply within the bloodstream, often resulting in systemic inflammatory response and multi-organ failure if not promptly treated. Globally, sepsis affected 48.9 million people in 2017, predominantly in low-resource settings, and is associated with mortality rates up to 20–50%[2,4]. In South Asia, limited data indicate that Gram-negative bacteria (e.g. *Salmonella Typhi*, *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*) often predominate in BSIs[5,6], whereas *Staphylococcus aureus* and other Gram-positives also contribute substantially. For example, a decade-long surveillance at a Dhaka hospital (2005–2014) found *Salmonella Typhi* (37%) and other Gram-negatives as most frequent bloodstream pathogens[5]. A recent pediatric study in Sylhet reported similar trends in children, with *S. aureus* only 4% of isolates[7]. However, emerging reports suggest shifts in local epidemiology: a Bangladeshi ICU study (Dhaka 2016) found 94% of BSIs were Gram-negative (predominantly *Acinetobacter* and *Pseudomonas*)[8]. By contrast, studies from neighboring countries, including Nepal and Pakistan, have reported *S. aureus* as the leading BSI pathogen (up to ~40–45% of isolates)[4,6]. These variations likely reflect differences in patient populations, age groups, and healthcare environments.

The clinical impact of AMR in septicemia is grave. Resistant BSIs lead to delayed effective therapy, longer hospital stays and significantly higher mortality[9,10]. For instance, Europe-wide data show that infections with carbapenem-resistant *K. pneumoniae* have two- to three-fold higher mortality risk than susceptible strains[10]. In Bangladesh, where access to advanced care is limited, MDR sepsis may silently drive excess deaths. Published studies from Bangladesh are few and often focus on specific units or age groups. Reports exist of neonatal sepsis with high prevalence of Gram-negatives[11], and pediatric sepsis reports[7], but little is known about general inpatients. To the best of our knowledge, few published data describe the current bacteriology and resistance patterns of septicemia across all age groups in Sylhet, Bangladesh. This gap hinders evidence-based empiric therapy and public health planning.

Material and methods:

This retrospective observational study was conducted in Mount Adora Hospital, Akhalia, Sylhet, from July, 2023 to June, 2024. The hospital is a private facility with a microbiology laboratory accredited with ISO 9001:2015. A purposive sampling method was applied, whereby patients admitted to Mount Adora Hospital with confirmed positive blood cultures during the study period were included. During specimen collection, samples were obtained and transported in strict adherence to standard guidelines for specimen handling and transport, with aseptic precautions maintained throughout the procedures. Antimicrobial susceptibility testing was performed using the disc diffusion method, and the interpretation of susceptibility results followed the Clinical and Laboratory Standards Institute (CLSI) guidelines.

The inclusion criteria consisted of patients of any age and sex who had positive blood culture results showing significant colony growth and complete clinical and microbiological data available in hospital records. Any patient with prior antibiotic exposure within 14 days preceding admission were excluded from this study.

Demographic information, including age and sex, was retrieved from hospital records. Key study variables included patient demographics, identification of culture-positive pathogens, and their antibiotic susceptibility profiles. Data were entered and analyzed using SPSS version 27, and descriptive statistics were used to summarize the findings. Data were obtained as part of routine clinical services, using noninvasive collection methods from medical records. Confidentiality of the data was protected by omitting their identifiers. Permission to conduct this research was obtained from the Mount Adora Hospital authority prior to data collection.

Results:

Among the 269 culture-positive cases, most patients were aged 19–60 years (45.7%) and over 60 years (45.4%), with a male predominance (56.1%) and a mean age of 53.88 ± 23.65 years. The most commonly isolated organism was Staphylococcus aureus (69.9%), followed by Escherichia coli and Pseudomonas spp. (Table 1).

Overall, high levels of antimicrobial resistance were observed against several commonly used antibiotics. The highest resistance rates were seen with Cefixime (82.5%), Ceftazidime (77.8%), Azithromycin (75.9%), and Fosfomycin (71.4%), indicating widespread resistance to third-generation cephalosporins and macrolides. Moderate resistance was noted against Cefaclor (40.1%), Amoxicillin (36.8%), and Linezolid (28.3%). In contrast, relatively lower resistance was observed against

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Doxycycline (9.0%), Imipenem (10.4%), and Amikacin (11.3%) (Table 2, Column chart 1).

Table I: Distribution of organisms isolated

Organism Isolated	Frequency (%)
Staphylococcus aureus	188 (69.9%)
Escherichia coli	39 (14.5%)
***Pseudomonas* sp.**	32 (11.9%)
***Klebsiella* sp.**	9 (3.3%)
***Streptococcus* sp.**	1 (0.4%)
Total	**269**

Table 2: Antimicrobial sensitivity status

Antibiotic Group	Antibiotic	Resistant (%)	Sensitive (%)	Intermediate (%)
Penicillin	Amoxicillin	36.8	59.0	4.2
	Piperacillin-Tazobactam	28.9	65.9	5.2
Cephalosporin	Cefaclor	40.1	53.3	6.6
	Cefuroxime	33.2	65.4	1.5
	Ceftazidime	77.8	20.3	1.9
	Ceftriaxone	72.0	19.5	8.5
	Cefixime	82.5	14.2	3.3
Aminoglycoside	Amikacin	11.3	82.5	6.1
	Gentamicin	28.3	68.4	3.3
Tetracycline	Doxycycline	9.0	88.7	2.4
	Tigecycline	0.0	85.7	14.3
Macrolide	Azithromycin	75.9	18.9	5.2
Oxazolidinone	Linezolid	28.3	71.1	0.6
Fluoroquinolone	Ciprofloxacin	32.5	63.2	4.2
	Levofloxacin	25.0	69.3	5.7
Carbapenem	Imipenem	10.4	86.8	2.8
	Meropenem	22.4	72.9	4.8
Polymyxin	Colistin	31.6	67.5	0.9
Others	Vancomycin	21.8	76.3	1.9
	Fosfomycin	71.4	28.6	0.0

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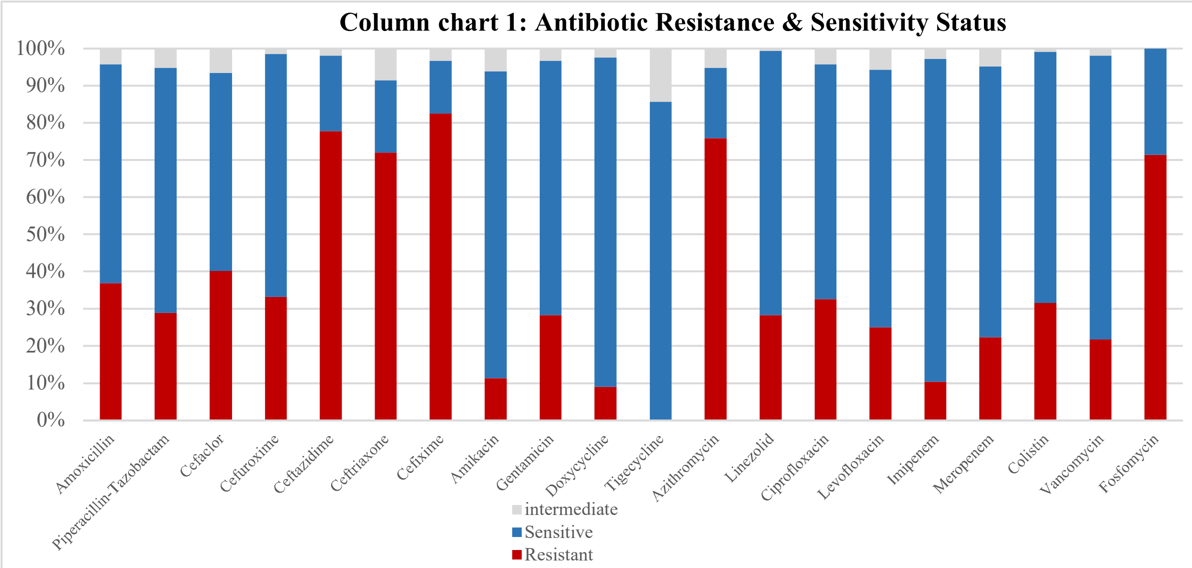

Discussion

This observational study from Mount Adora Hospital highlights the predominance of *Staphylococcus aureus* (69.9%) as the leading bloodstream pathogen, followed by *Escherichia coli* (14.5%) and *Pseudomonas spp.* (11.9%). This predominance of *S. aureus* contrasts sharply with many other settings. Notably, antibiotics of the cephalosporin class showed significant resistance, i.e: cefixime (82.5% of isolates resistant) and ceftazidime (77.8%). Macrolide resistance was also high, i.e: azithromycin 75.9%. In contrast, imipenem, doxycycline and amikacin retained strong activity: only 10.4%, 9.0%, and 11.3% of isolates were resistant to these agents, respectively. Linezolid was relatively effective (28.3% resistance among tested Gram-positives). These results underscore a worrisome resistance profile: most first-line agents have poor activity, while only a few reserve drugs remain active.

The dominance of *S. aureus* in our cohort is strikingly higher than reported in most Bangladeshi series. A study done in the ICU setting in a hospital from Dhaka found Gram-positive bacteria in only 6.4% of BSIs (primarily coagulase-negative staphylococci)[8], and a pediatric study from Sylhet recorded *S. aureus* in merely 3.9% of sepsis cases[7]. A neonatal study from Dhaka identified *S. aureus* in 17.6% of infections[11]. In contrast, another study from Sylhet reported *S. aureus* as the single most frequent isolate, with culture positivity ~19%[12]. Our findings (69.9% *S. aureus*) align more with the latter study (and differ dramatically from pediatric/neonatal results), suggesting possible age or hospital-unit effects. The significant predominance of *S.aureus* isolates from our study raises a matter of concern. The pattern differs from other studies, where *Salmonella Typhi*, *E. coli*, and *Klebsiella* have been common[5]. Here, sample contamination might play a role, though strict blood culture protocols were used and isolates were identified by automated systems. The disparity may reflect geographic variation or changes over time. It also underscores that septicemia etiology can vary greatly between regions. Compared to the high Gram-negative predominance (72%) seen in Dhaka from 2005–2014[5], our results suggest a relative rise in Gram-positive *S. aureus* as a BSI pathogen in Sylhet.

In South Asia, broadly, *S. aureus* is a frequent bloodstream pathogen. A 10-year surveillance from Nepal (2012–2022) found *S. aureus* in 44% of BSIs[6], though Gram-negatives (*Acinetobacter* 18%, *Pseudomonas* 9%, *Klebsiella* 8%) were also substantial. We found 69.9% isolates of *S. aureus,* which exceeds that finding from Nepal. Similarly, a pediatric hospital in Pakistan reported 37.5% *S. aureus* and 14.8% MRSA among septic children[4]. Other Indian reports have noted *Staphylococcus* spp. as leading causes in some series (e.g. >20% in certain ICUs), though

Enterobacterales often dominate overall[6,13]. Thus, while *S. aureus* is clearly an important pathogen for septicemia, the finding from our study is unusually high. Unlike reports from Bangladesh pediatrics or ICUs[7,8], data from South Asia resemble our distribution more closely, possibly due to similar community-acquired infection patterns.

Our observation of >70% resistance to third-generation cephalosporins is in line with many regional studies. In the Nepal cohort, 61–81% of Enterobacterales were 3rd-generation cephalosporin–resistant (ESBL producers)[6]. In The Gambia (sub-Saharan Africa), 90% of *Klebsiella* bloodstream isolates carried ESBLs[14]. A study from Pakistan noted only ~20% sensitivity for ceftriaxone in *S. aureus* and very low susceptibility for Gram-negatives[4]. Data from Bangladesh also report high cephalosporin resistance: e.g. *Acinetobacter* showed 61% resistance to cefixime[15]. Moreover, WHO reports indicate >40% of *E. coli* and >55% of *K. pneumoniae* globally resist third-generation cephalosporins[2]. Thus, our finding (>70% resistance to cefixime/ceftazidime) is unfortunately not exceptional. Similarly, azithromycin resistance was 75.9% in our study; a Dhaka tertiary lab found 68.9% of *S. aureus* resistant to azithromycin[16]. Such macrolide resistance may limit use even for presumed staphylococcal sepsis.

Imipenem was 86.8% sensitive in our isolates (only 10.4% resistance). This high carbapenem efficacy is echoed by other Bangladeshi data: a nearby Sylhet study reported 89% *S. aureus* susceptibility to imipenem[12]. In contrast, Gram-negatives in ICU settings have shown growing carbapenem resistance (e.g. 26.9% *E. coli* in Dhaka 2017)[5]. However, Western data are also indicating rising carbapenem resistance over time[17]. Doxycycline was similarly effective in our study (88.7% sensitive); another study from Sylhet reported 81% *S. aureus* sensitivity to doxycycline[12]. Amikacin showed 82.5% sensitivity in our study. In Ghana, amikacin retained 90.5% susceptibility[18], and in Turkey it was >90% effective[19]. Thus our data support that aminoglycosides and tetracyclines remain useful "reserve" drugs while combating septicemia.

The observed trends likely reflect a mix of pathogen ecology and antibiotic resistance. The high *S. aureus* proportion may result from community skin infections or intravenous device use; Bangladesh has high rates of skin and soft tissue infection with *S. aureus*[16]. The persistence of imipenem and doxycycline efficacy suggests these drugs have been used more sparingly. Conversely, the massive 3rd-generation cephalosporin resistance is likely driven by decades of liberal cephalosporin use and poor infection control. Azithromycin resistance might be co-selected by linkage with other resistance genes[16]. Environmental factors (e.g. antibiotic contamination of water) and veterinary antibiotic use in poultry farms and fisheries significantly contributes to the development of antimicrobial resistance[20].

Our findings have immediate relevance for Bangladeshi clinicians and policy-makers. Empirical regimens relying on cephalosporins or macrolides will likely fail in sepsis. Instead, early use of carbapenems or other effective agents may be required for severe BSIs. Doxycycline and amikacin might be considered for less critical cases or in combination. Public health actions must include strengthening AMR surveillance: our single-center data suggest that the national burden of drug-resistant septicemia is "silent" but substantial. Vaccination and infection prevention (hand hygiene, clean birth practices) could reduce sepsis incidence. On a policy level, regulations to curb antibiotic misuse (OTC sales, agricultural use) are essential. Similar WHO recommendations emphasize preserving last-resort antibiotics and monitoring AMR trends[2].
Further research should include multicenter surveillance to map Septicemia epidemiology across Bangladesh. Prospective studies are needed to link resistance patterns with clinical outcomes. Molecular epidemiology could track clones and resistance genes (e.g. *mecA*, ESBL genes). Given the dynamic nature of AMR, periodic repetition of such surveys is warranted. Finally, interventions (antibiotic stewardship programs, public education) should be implemented and evaluated for impact on resistance trends[1,2].

Study Limitations
This study has some limitations, including a single-center design, which may not fully represent national trends. Additionally, molecular characterization of resistance genes was not performed, which could have provided deeper insights into resistance mechanisms.

Conclusion:
Our study reinforces that *Staphylococcus aureus*, *E. coli*, and *Pseudomonas spp.* are leading causes of septicemia in Bangladesh. The extremely high resistance to cefixime, ceftazidime, azithromycin, and fosfomycin underscores the need to abandon these agents in empirical regimens. The relatively low resistance to imipenem, amikacin, and doxycycline provides some therapeutic optimism, but this must be balanced with strong stewardship to preserve their efficacy. Ultimately, combating AMR in septicemia will require coordinated clinical, policy, and research efforts across both national and international levels.

Author contributions
Chakroborty P conceptualized and designed the study, supervised data collection, performed data analysis, and drafted the manuscript; Chakroborty P and Ahmad R contributed to sample collection, microbiological testing, and data entry; Khatoon M and Benzamin M provided overall supervision, critical revision of the manuscript, and guidance on study methodology. All authors reviewed and approved the final manuscript and agree to be accountable for all aspects of the work.

Data Availability Statement
The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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Conflict of Interest Disclosure
The authors declare no conflict of interest.

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