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Clinical Pharmacy Interventions In The ICU At A Tertiary Hospital In Jordan

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ABSTRACT

Background: Clinical pharmacists play a crucial role in Intensive Care Units by optimizing medication therapy, preventing adverse drug events, and contributing to improved patient outcomes. Despite their significance, limited data exist on the specific impact of clinical pharmacy interventions in ICUs within Jordan.

Objective: This study aims to identify the types and frequency of clinical pharmacist interventions across four main ICUs namely neonatal, pediatric, medical, and surgical ICUs at a tertiary academic hospital in Jordan. Additionally, it seeks to determine the most frequent treatments associated with these interventions.

Methods: A retrospective descriptive study was conducted at Jordan University Hospital from January 2024 to June 2024. Clinical pharmacist intervention records were reviewed, and data were collected on patient demographics, types of medications, and categories of interventions. The interventions were classified according to a standardized system based on clinical pharmacy guidelines.

Results: Dosage regimen adjustments were the most common intervention across all ICUs, particularly in the NICU (86.7%) and PICU (58%). The MICU had a high rate of interventions related to unnecessary drug therapy (25.6%) and additional diagnostic tests (42.8%). In the SICU, enoxaparin (12.5%) was among the most frequently adjusted medications. Antibiotic stewardship was a key area of pharmacist intervention, with vancomycin being the most frequently adjusted antibiotic across all ICUs.

Conclusion: Clinical pharmacists contribute significantly to patient care in ICUs by ensuring appropriate medication use, preventing errors, and optimizing therapy. The findings support the need for continued integration of clinical pharmacists in ICU teams to enhance patient safety and improve clinical outcomes. Future research should focus on evaluating the long-term impact of these interventions on patient morbidity, mortality, and cost-effectiveness.

Keywords: *Intensive Care Units (ICUs), Retrospective descriptive study, NICU (Neonatal Intensive Care Unit), PICU (Pediatric Intensive Care Unit) MICU (Medical Intensive Care Unit), SICU (Surgical Intensive Care Unit), Dosage regimen adjustments, Antibiotic stewardship*

1. INTRODUCTION

The ICU constitutes a major component of the total health costs especially in relation to inpatient facility. While ICU generally occupies only 5-10% of hospital beds, it is responsible for 20-34% of the total healthcare cost of hospitalization (Arredondo et al., 2021). In the united states, critical care was found to have the highest increase in cost between 2000 and 2010, costing $56.6 billion and $108 billion respectively, despite having an overall reduction of 17% of its available critical care beds. For 2010, the costs of critical care made up 13.2% of total hospital costs and 4.1% of total national health care costs. Furthermore, the share of critical care costs compared to the GDP increased from 0.54% to 0.72%, raising by $4.7 trillion and expecting future increase (Halpern et al., 2016).

Clinical pharmacists are vital members of multidisciplinary teams in ICUs; due to the faced challenges in these environments, including the multiple and complex medication prescriptions of critically ill patients. Clinical pharmacist's interventions have been shown to decrease medication errors, optimize therapeutic outcomes, and increase patient safety (Colin & Nutti., 2022).

Studies in the ICU environment have revealed that measures such as medication review and reconciliation, dose optimization, and antimicrobial stewardship have yielded substantial improvements in the management of adverse events and optimization of patient care (Ho et al., 2013; Chiang et al., 2021). In addition, The integration of a clinical pharmacist at the transfer point from ICU to ward led to a significant reduction in treatment related problems (Heselmans et al., 2015).

Managing infections in the critically ill patients forms the core of clinical pharmacy within the ICUs. Pharmacist engagement in antimicrobial stewardship serves as a valuable tool in the usability of antibiotics also reducing antimicrobial resistance. Additionally, such interventions result in better clinical practices and cost reductions (Mas-Morey et al., 2018; Gu et al., 2023). Antibiotic stewardship by clinical pharmacists has been proven to produce tangible, targeted results; they are responsible for adopting measures that inhibit the misuse of antibiotics as these aspects greatly impacts patient outcomes and costs incurred in the hospital (Leache et al., 2020).

Apart from antimicrobial stewardship, clinical pharmacists have other more significant functions in ICUs; including elimination of unnecessary drug therapies, suggestions for further testing where necessary, and guarantee of correct medication teaching and matching. The effectiveness of the resulting measures covers the prevention of increased ICU mortality rates and a decrease in the number of post-ICU complications (Alsayed et al., 2024; MacTavish et al., 2019).

Another aspect which needs to be mentioned is the effective cost of clinical pharmacy services. Adverse events prevention, optimization of rational drug therapy, and, in particular, the reduction of the length of stay in the ICU contribute to impressive cost savings (Leache et al., 2020). These outcomes endorse clinical pharmacist's involvement in critical care teams in the short term and longer term.

The study was conducted at an academic tertiary hospital in Jordan. Clinical pharmacists have daily rounds in the four main ICUs of the hospital for about 100 beds. They modify treatment plans in and record it in patients files in "Clinical Pharmacist Recommendation Note". They also categorize the interventions using a classification system adapted from clinical pharmacy guidelines. Within the four ICUs, the clinical pharmacy care process has been optimized and is very consistent with slight modifications to admition or discharge processes depending on the general specialties within each unit to the physicians' rounds/shift work.

These differences contribute to the quality, quantity and cost of health cares without making any difference to the quality of care. This involves accessing the patient clinical database to collect patient detail, conducting a threat analysis of the therapeutic plans and being involved in the Case Conference meetings. Clinical pharmacists are also involved in counseling the medical staff, patient, or his/her family members, and reporting all actions rendered in the hospital with the use of classification system.

To our knowledge, there is a lack of information in Jordan concerning clinical pharmacist interventions in ICUs, though the benefits have been confirmed by other studies. Jordan University Hospital being a tertiary referral center offers a chance to study and describe these contributions extensively.

Objectives

The objectives of this study are to identify the types and frequency of clinical pharmacist interventions in the four main ICUs at a tertiary academic hospital in Jordan and identify the most frequent treatments related to those interventions. The results will help understand their contribution to the improvement of the quality of patient care and determine the prospects for the development of clinical pharmacy in the context of critical care.

2. METHODOLOGY

Study Design

This is a retrospective descriptive study conducted in the ICUs of Jordan University Hospital. The study examines clinical pharmacists' interventions documented from January 2024 to June 2024.

Study Population

The study included ICU patients for whom at least one clinical pharmacy intervention was recorded. Patients admitted to neonatal ICU (NICU), medical ICU (MICU), surgical ICU (SICU) and pediatric ICU (PICU) were included. Patients were selected based on their admission to the ICU and the availability of complete intervention records. Patients who were transformed to other wards within 24 hours were excluded, also patients with no documented interventions were excluded.

Data Collection

Data were extracted from clinical pharmacists' records using a standardized data collection sheet. The variables collected include:

- Patient demographics (age, sex, ICU type, length of stay).
- Types of medications involved.
- Categories of pharmacist interventions

In practice, clinical pharmacy care process includes obtaining treatment information from the electronic medical record; checking the rationality of prescription, especially drug-drug interactions and the efficacy of drug treatment in accordance with doctors' diagnosis and treatment plan; in addition to participating in multidisciplinary rounds and suggesting the plan for drug efficacy monitoring.

Ethical considerations

Ethical approval was obtained from the IRB at Jordan university hospital, all patient data were handled with care and top confidentiality. Any patient identifiers were kept anonymous.

3. RESULTS

Table 1: Patient characteristics among the included ICUs

		Gender			
	N	Female (%)	Male (%)	Age (Mean ± SD)	Length of Stay (Mean ± SD)
NICU	601	280 (46.6)	321 (53.4)	54.72 ± 81.13 days	45.71 ± 61.95
PICU	667	259 (38.8)	408 (61.2)	7.74 ± 11.03	19.15 ± 38.53
SICU	1032	492 (47.7)	540 (52.3)	60.16 ± 19.01	20.56 ± 20.63
MICU	818	392 (47.9)	426 (52.1)	69.13 ± 16.38	25.61 ± 24.86

The analysis of patient demographics and clinical characteristics across the intensive care units (Table 1) highlights the variability in patient populations and their care needs. The Medical ICU (MICU) had the oldest patients, with a mean age of 69.13 ± 16.38 years, and the longest average length of stay (25.61 ± 24.86 days). In contrast, the Neonatal ICU (NICU) treated the youngest patients, with an average age of 54.72 ± 81.13 days. The Pediatric ICU (PICU) primarily served younger patients with a mean age of 7.74 ± 11.03 years, while the Surgical ICU (SICU) treated older patients with a mean age of 60.16 ± 19.01 years, predominantly those recovering from surgical procedures or requiring critical surgical interventions.

Clinical pharmacy interventions varied across the ICUs. Table 2 presents the distribution of intervention types as a percentage of the total interventions conducted in each ICU with notable differences in the frequency of each type in each ICU. Dosage regimen adjustments were the most common intervention across all ICUs, particularly in the NICU (86.7%), where precise dose calculations are crucial due to the weight and age-dependent pharmacokinetics in neonates. Unnecessary drug therapy was frequently identified in the MICU (25.6%) and SICU (25%) as well as interventions related to medication reconciliation also prevalent in both MICU (25.9%) and SICU (24.4%). In both MICU and SICU patients move frequently between different levels of care and usually have chronic conditions and complex treatment regimens.

Additionally, interventions related to drug or disease monitoring were particularly prominent in the NICU (66.6%) and SICU (49.2%). It should be noted that each patient could have more than one intervention documented at the same time during the same admission.

Recommendations for additional diagnostic tests like antibiotics cultures were most common in the MICU (42.8%).

Table 2: Clinical Pharmacy interventions categories and distribution among the different ICUs

Variables	**MICU f(%)**	**NICU f(%)**	**PICU f(%)**	**SICU f(%)**
Unnecessary Drug Therapy	209 (25.6%)	53 (8.8%)	87 (13%)	258 (25%)
Indicated Drug Not Prescribed	237 (29%)	52 (8.7%)	64 (9.6%)	344 (33.3%)

Dosage Regimen	460 (56.2%)	521 (86.7%)	387 (58%)	513 (49.7%)
Potential / Actual (ADR/Allergy)	29 (3.5%)	8 (1.3%)	10 (1.5%)	7 (0.7%)
Potential / Actual Drug Interaction	10 (1.2%)	601 (100%)	26 (3.8%)	16 (1.6%)
Contraindication for the Medication	9 (1.1%)	1 (0.2%)	5 (0.7%)	30 (2.9%)
Preparation and Administration	56 (6.8%)	185 (30.8%)	194 (29.1%)	200 (19.4%)
Changes in Dose Form or Route of Admin.	42 (5.1%)	7 (1.2%)	12 (1.8%)	80 (7.8%)
Adjust TPN Composition	3 (0.4%)	41 (6.8%)	2 (0.3%)	10 (1%)
Drug or Disease Monitoring	249 (30.4%)	400 (66.6%)	210 (31.4%)	508 (49.2%)
Need for Additional Diagnostic Tests	350 (42.8%)	154 (25.6%)	127 (19%)	70 (6.8%)
Need for Consultation from other specialties	32 (3.9%)	111 (18.5%)	100 (15%)	25 (2.4%)
Medication Reconciliation	212 (25.9%)	3 (0.5%)	13 (1.9%)	252 (24.4%)
Medication Education	6 (0.7%)	4 (0.7%)	7 (1%)	29 (2.8%)
Choice of antibiotic	326 (39.9%)	72 (12%)	94 (14.1%)	157 (15.2%)
Duration of antibiotic treatment	176 (21.5%)	81 (0.2%)	52 (7.8%)	50 (4.8%)

Since dosage regimen interventions were the most frequent across all ICUs, table (3) highlights the most commonly involved medications in this category.

Table 3: The most common medications involved in dosage regimen intervention

ICU	Medication	No. of interventions in 2024
MICU	vancomycin	338
	Imipenem/cilastatin	180
	amikacin	148
SICU	vancomycin	366
	enoxaparin	186
	meropenem	136
PICU	vancomycin	146
	meropenem	144
	amikacin	132
NICU	amikacin	334

	vancomycin	146
	meropenem	64

Vancomycin consistently ranked among the top two medications requiring dosage adjustments across all ICUs. Additionally, carbapenems—part of the β-lactam antibiotic class—and aminoglycosides were consistently among the top three medications necessitating dosage interventions. With the exception of the anticoagulant enoxaparin in the SICU, all these medications were antibiotics highlighting the importance of optimizing postoperative medications, such as anticoagulants and analgesics, for patients recovering from recent surgeries.

Since antibiotic-related interventions accounted for the highest proportion of clinical pharmacist interventions across all ICUs, a detailed analysis was conducted to identify the utilization of specific antibacterial classes in each ICU. Table 4 summarizes the distribution of pharmacist interventions across different antibiotic groups in each ICU.

A total of **1,229 pharmacist interventions related to antibacterial agents** were recorded across the four ICUs (**MICU, NICU, PICU, SICU),** as confirmed by the extracted data from the intervention records. The breakdown of these interventions per ICU is as follows**: MICU:** 257, **NICU:** 320**, PICU**: 337 and 315 in the SICU. Certain antibiotic classes, such as **aminoglycosides and beta-lactams,** were **overrepresented in NICU and PICU,** whereas **antifungals and broad-spectrum antibiotics** were more commonly prescribed in **SICU and MICU. Beta-lactam antibiotics** had the highest frequency of interventions among all antibiotic groups across ICUs. This highlights their widespread use and the need for modifications due to resistance patterns, especially when used empirically.

Glycopeptides ranked second, with **vancomycin** being the only glycopeptide used in the hospital. Clinical pharmacists adjusted vancomycin levels using **t**he **Area Under the Curve (AUC) calculator,** ensuring optimal therapeutic levels. **Aminoglycosides** were particularly notable in **NICU (48.75%)**, being frequently used due to their broad-spectrum activity against **gram-negative pathogens**, their role in **neonatal sepsis treatment**, and their **synergistic effect with beta-lactams**. Prophylactic **antibiotic eye drops** were also commonly used in NICU.

In SICU, **fluoroquinolones (13.02%) and polymyxins -such as colistin - (3.81%)** were more frequently involved in pharmacist interventions compared to other ICUs. This suggests a **higher prevalence of multidrug-resistant (MDR) infections in postoperative patients**, necessitating the use of **broad-spectrum or last-resort antibiotics**.

The **PICU had a notably higher intervention rate for macrolides (9.20%)** compared to other ICUs, suggesting their frequent use for **respiratory infections such as pneumonia and atypical bacterial infections** in pediatric patients. In contrast, macrolide use in NICU was minimal (0.94%), likely due to **limited indications in neonates and concerns over safety.** The mean antibiotic usage varied across ICUs, with **NICU and PICU having the highest mean usage**.

The **standard deviation values were high**, indicating substantial variability in prescribing patterns. Certain antibiotic classes exhibited **highly skewed distributions**, reflecting **ICU-specific prescribing patterns.** Using the Chi square test, the **P-Value** is 2.25×10^{-63} indicates a **strongly significant** association between **antibiotic class usage and ICU type.**

Table 4: Antibacterial groups related to the interventions

Class	**MICU (f/%)**	**NICU (f/%)**	**PICU (f/%)**	**SICU (f/%)**
Aminoglycosides	41 (15.95%)	156 (48.75%)	45 (13.35%)	24 (7.62%)
Antibiotic Eye Drops	1 (0.39%)	18 (5.63%)	5 (1.48%)	0 (0%)
Antifungals	1 (0.39%)	0 (0%)	0 (0%)	1 (0.32%)
Antimycobacterials	2 (0.78%)	0 (0%)	0 (0%)	0 (0%)
Beta-lactams	97 (37.74%)	50 (15.63%)	130 (38.58%)	121 (38.41%)
Fluoroquinolones	17 (6.61%)	1 (0.31%)	6 (1.78%)	41 (13.02%)
Glycopeptides	70 (27.24%)	75 (23.44%)	83 (24.63%)	74 (23.49%)
Lincosamides	1 (0.39%)	0 (0%)	3 (0.89%)	2 (0.63%)
Macrolides	2 (0.78%)	3 (0.94%)	31 (9.20%)	2 (0.63%)
Nitroimidazoles	19 (7.39%)	3 (0.94%)	3 (0.89%)	18 (5.71%)

Others	0 (0%)	1 (0.31%)	15 (4.45%)	7 (2.22%)
Oxazolidinones	2 (0.78%)	3 (0.94%)	4 (1.19%)	8 (2.54%)
Polymyxins	0 (0%)	9 (2.81%)	7 (2.08%)	12 (3.81%)
Rifamycins	1 (0.39%)	1 (0.31%)	2 (0.59%)	1 (0.32%)
Tetracyclines	3 (1.17%)	0 (0%)	3 (0.89%)	4 (1.27%)
Total	**257**	**320**	**337**	**315**
mean	**15**	**18.8**	**19.8**	**18.5**
SD	**28.26**	**4.98**	**35.77**	**32.73**

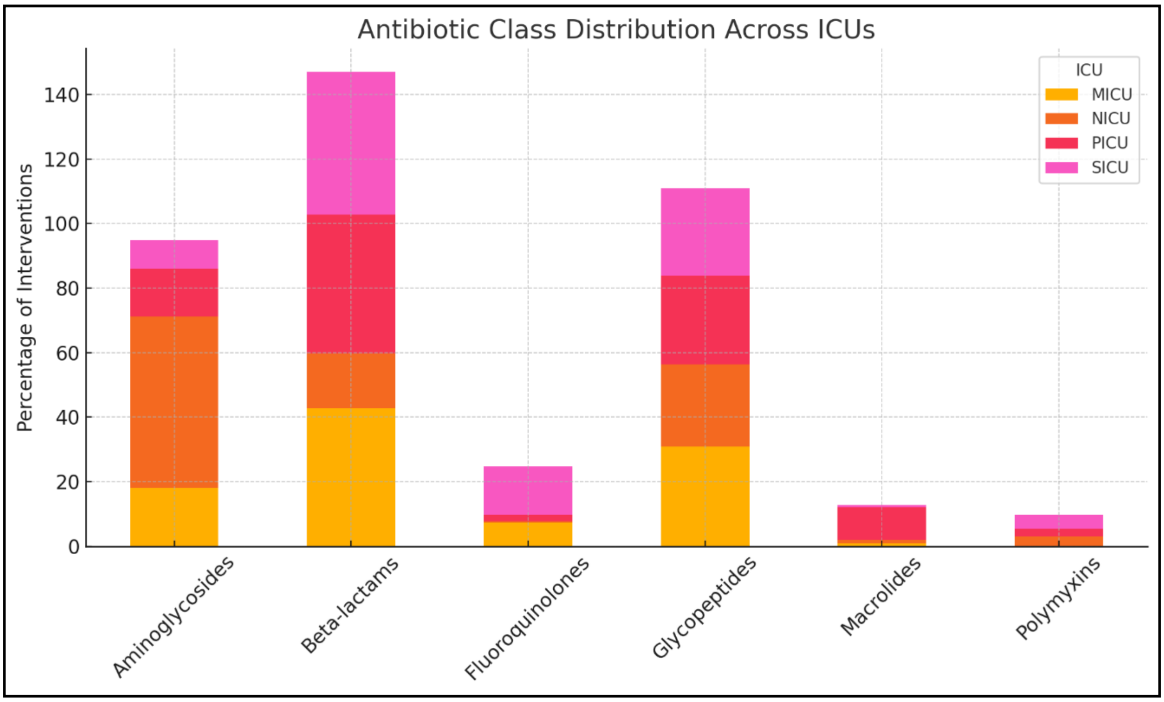

Figure (1). Antibiotic class distribution across ICUs

The **Chi-square test result**:

- **Chi-square statistic** = **312.32**
- **p-value** = **1.53 × 10^{-57}**

Analysis of Top Non-Antibiotic Medications in ICUs

Table 5 shows the top drug related to interventions other than antibiotics in each ICU. The percentage of each intervention is from the total number of interventions in that specific unit.

Table 5: Top drugs in each ICU (other than antibiotics)

ICU Type	Drug	Percentage of intervention (%)
MICU	omeprazole	2.2%
	albumin	1.2%

	hydrocortisone	0.8%
NICU	Caffeine Citrate	1.3%
	Dobutamine	0.8%
	Furosemide	0.8%
PICU	Paracetamol	2.1%
	Midazolam	1.3%
	Ibuprofen	1.3%
SICU	Enoxaparin	2.0%
	Albumin	1.1%
	Hydrocortisone	1.6%

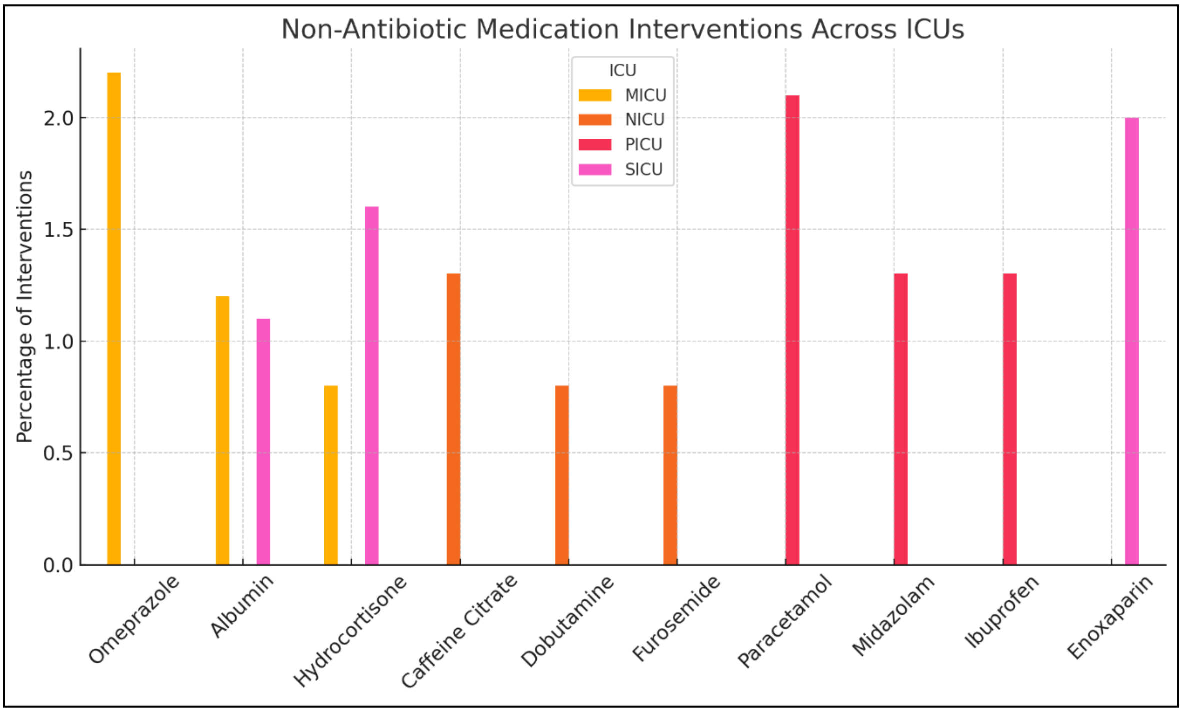

Figure (2). Non-Antibiotic medication intervention across ICUs

 Chi-**square statistic** = **41.26**

 p-**value** = **0.0388**

Patients in the Medical ICU (MICU) are typically older adults with multiple comorbidities, necessitating careful medication management to prevent adverse effects and drug interactions. Among the most frequently intervened non-antibiotic drugs, omeprazole is primarily used for preventing stress-related mucosal damage, a common concern in critically ill patients, and often requires adjustments between its different formulations. Albumin is widely utilized for fluid balance management and hypoalbuminemia, though it is frequently flagged for unnecessary use. Hydrocortisone interventions mainly involve dosage adjustments and reassessments of its necessity.

In the Neonatal ICU (NICU), the most commonly intervened non-antibiotic drugs include caffeine citrate, dobutamine, and furosemide. Caffeine citrate plays a vital role in treating apnea of prematurity and is regularly adjusted by clinical pharmacists. Dobutamine interventions generally focus on administration rates and compatibility with other fluids, given its role as an inotropic agent. Furosemide adjustments are often made based on laboratory findings and the patient's fluid status to ensure appropriate diuretic therapy.

The Pediatric ICU (PICU) sees frequent interventions involving paracetamol, midazolam, and ibuprofen. Paracetamol is extensively used, with pediatric dosing based on body weight, requiring close monitoring for potential liver toxicity. Midazolam is frequently employed for procedural sedation, necessitating pharmacist interventions regarding administration route, rate, and preparation method. Ibuprofen interventions are often related to reassessing its necessity in the pediatric population.

In the Surgical ICU (SICU), clinical pharmacists play a crucial role in managing medications that need to be discontinued or resumed post-surgery, as well as ensuring adherence to surgical prophylaxis guidelines. The most commonly intervened non-antibiotic drugs in SICU include enoxaparin, albumin, and hydrocortisone. Enoxaparin, as an anticoagulant, is regularly adjusted to maintain appropriate dosing. Albumin, similar to its use in MICU, is frequently flagged for unnecessary administration. Hydrocortisone is often initiated and discontinued under the guidance of clinical pharmacists to ensure its appropriate use.

4. DISCUSSION

The analysis of clinical pharmacy interventions reveals distinct patterns across the different ICU types, reflecting tailored approaches to patient care based on the unique clinical demands of each unit. The results demonstrate **ICU-specific trends in medication optimization, antimicrobial stewardship, and patient safety considerations. For** example, in MICU patients are usually intubated and have several comorbidities (Mohammad et al., 2022). And for the NICU, TPN is common, and the neonates usually suffer different syndromes (Kim et al., 2018).

The **Medical ICU (MICU)** had the **oldest patient population (mean age: 69.13 ± 16.38 years)** and **longest hospital stay (25.61 ± 24.86 days),** which is consistent with the complex comorbidities and chronic illnesses requiring prolonged monitoring. In contrast, the **Neonatal ICU (NICU)** had the youngest patients (**54.72 ± 81.13 days**), with **extensive variability in age (high SD),** likely due to a mix of premature and full-term neonates.

The **Surgical ICU (SICU)** had an average patient age of **60.16 ± 19.01 years.** The **Pediatric ICU (PICU)** served **young children (mean age: 7.74 ± 11.03 years)** with a significantly shorter **average length of stay (19.15 days)** than MICU, likely due to faster recovery in pediatric patients.

The most common type of intervention reported in the MICU was dosage regimen adjustment (56.2%); this could be attributed to the fact that dosing requires extra considerations to ensure it meets the needs of patients with medical comorbidities. This is in support of other studies pointing out that dosage optimization is a key intervention to check adverse events occurrences and optimize drug therapeutic impact; especially in elderly patients with polypharmacy (Cvikl & Sinkovič, 2020).

Also, a considerable extent of the interventions reported targets avoidance of unnecessary drugs (25.6%) and the requirement for further diagnostic workup (42.8%), which reinforces the position of clinical pharmacists in removing ineffective treatments and establishing the correct diagnosis to inform the management plan (Colin & Nutti, 2022). Studies have also shown that pharmacist interventions can lead to significant cost savings by reducing ICU length of stay and optimizing drug use (Muñoz-Pichuante & Villa-Zapata, 2020). Previous research also indicated that pharmacists' interventions in the ICU are effective in reducing the risk of occurrence of potential ADEs (Agius et al., 2024).

The largest proportion of dosage regimen adjustments was recorded in the Neonatal ICU (86.7%) due to the special pharmacotherapeutic requirements of newborns, especially in cases when mild deviations from approved dosing regimens may have critical consequences. According to previous studies, the present finding complies with the level of pharmacist engagement in addressing neonatal medication and drug risks and enhancing safety (Kim et al., 2014). In addition, drug or disease monitoring (66.6%) and preparation and administration interventions (30.8%) underscore the constellation and complex preparations necessary for neonates (Hou et al., 2023).

In the hospital's Pediatric ICU, most medications involved dose regulation (58%) and disease or drug monitoring (31.4%). This is supported by studies, showing the significant reduction in medication errors when clinical pharmacists are actively involved in pediatric ICUs (Hisham et al., 2016). The high percentage of preparation and administration interventions (29.1%) also points to a high degree of difficulty related to pediatric formulations and the techniques of their administration reflecting challenges with **liquid formulations, dose accuracy, and compatibility issues** (Leache et al., 2020).

Similar to the MICU, the task most emphasized in SICU included dosage regimen adjustment with 49.7% followed by factors such as unnecessary drug use (25%) and medication reconciliation at (24.4%) likely due to **frequent patient transitions** and complex treatment regime. Pharmacists' heavy involvement in managing these problems underlines the major role they play in minimizing postoperative problems and refining medicine usage (Mohammad et al., 2022).

The high frequency of antibiotic involvement in dosage adjustments aligns with findings from Rybak (2020) and Kollef (2013), which reported frequent adjustments of vancomycin, carbapenems, and aminoglycosides due to their need for therapeutic drug monitoring (TDM) and concerns about multidrug resistance. These medications are among the most closely monitored in critically ill patients, as highlighted by Nicolau (2008). Antibiotics are also among the most commonly prescribed drugs in hospitals, providing clinical pharmacists with ample opportunities to intervene.

The study confirmed **1,229 pharmacist interventions related to antibiotics,** with significant variation in **antibiotic class use** by ICU type (**p-value = 2.25×10^{-63},** highly significant association.

Beta-lactams (e.g., meropenem, imipenem, penicillins) were the most frequently adjusted class across ICUs, highlighting widespread **empirical prescribing and necessary modifications due to resistance patterns.** Vancomycin consistently ranked as either the first or second most frequent medication associated with dosage adjustments across all ICUs emphasizing the importance of **therapeutic drug monitoring (TDM) using the AUC method. Aminoglycosides (e.g., amikacin) were particularly overrepresented in NICU (48.75%),** likely reflecting their role in **neonatal sepsis treatment.**

Notably, **SICU had the highest fluoroquinolone and polymyxin interventions,** reflecting a **higher burden of multidrug-resistant (MDR) infections** postoperatively.

Beyond antibiotics, pharmacists highly intervened in **proton pump inhibitors (PPIs), anticoagulants, corticosteroids, inotropes** and albumin.

5. RECOMMENDATIONS

Clinical pharmacists play a pivotal role in antibiotic stewardship programs by ensuring the appropriate selection, dosing, and duration of antibiotics. TDM is particularly valuable in optimizing antibiotic efficacy while minimizing toxicity by considering patient-specific factors, as pharmacokinetics can vary significantly among ICU patients. Medications like vancomycin and aminoglycosides, with their narrow therapeutic indices and altered pharmacokinetics in critically ill patients, are especially challenging to manage. Furthermore, the high risk of infections in ICUs exacerbates these complexities.

Recommendations include enhancing training for clinical pharmacists in antibiotic pharmacokinetics and pharmacodynamics, as well as strengthening antibiotic stewardship programs. Addressing the overuse of omeprazole, albumin and corticosteroids in MICU and SICU, implement pain management guidelines to optimize paracetamol and ibuprofen while minimizing their toxicity risks specially in PICU.

Future research should focus on identifying patterns of pharmacist interventions and evaluating their impact on patient outcomes. Such studies can guide resource allocation and help prioritize training initiatives to further improve the quality of care in ICUs.

To increase the effective use of clinical pharmacy services in intensive care units (ICU), the following areas must be targeted for increasing the scope of pharmacist exposure and to fine-tune some key service interventions. It is necessary to have at least one clinical pharmacist in each ICU to resolve the specific treatment related issues. The care strategies for NICU/PICU can stress weight-based dosing and age-appropriate therapies, and SICU/MICU can stress postoperative care and polypharmacy. To alleviate antimicrobial resistance, more reinforcement of antimicrobial stewardship programs across all the ICUs is necessary and important because these critically ill patients consume large quantities of beta-lactams, aminoglycosides, and glycopeptides. Telepharmacy services can be integrated into a system and offer 24-hour pharmacist staffing in areas where resources are scarce and decision making can be done concurrently during interprofessional conferences.

Furthermore, strong monitoring mechanisms to capture the effects of pharmacists' interventions, for instance, fewer ADEs, saving costs and shortens ICU stays would be useful in advocating for clinical pharmacy services. Further studies are needed to identify long-term effects of pharmacy interventions and its cost benefit analysis to lead health policy and funding in optimal directions, to maintain the benefits reaped in ICU care. From these areas, it can be concluded that clinical pharmacists can optimize therapeutic benefits and decrease risks to patients in ICUs.

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