Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 9s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Prevalence And Comparative Analysis Of Clinical Pharmacist's Treatment Related Interventions Across Four Icus At A Teaching Hospital

Eman MOh'd Massad[1], Walaa Jihad Ashran[2]

[1]Clinical pharmacy, Institute of public Health, Jordan University

Email ID: E.massad@ju.edu.jo

[2]Clinical pharmacy department, Jordan University hospital

Email ID: Walaajihad@gmail.com

Cite this paper as: Eman MOh'd Massad, Walaa Jihad Ashran, (2025) Prevalence And Comparative Analysis Of Clinical Pharmacist's Treatment Related Interventions Across Four Icus At A Teaching Hospital. *Journal of Neonatal Surgery*, 14 (9s), 148-159.

ABSTRACT

Background: Treatment-related problems (TRPs) are a significant concern in intensive care units (ICUs), where critically ill patients often require complex treatment regimens. Despite their high prevalence, TRPs can be reduced through effective clinical pharmacist interventions. This study aimed to identify and analyze TRPs across different ICU types at a tertiary hospital in Jordan and provide targeted recommendations to optimize pharmaceutical care.

Methods: A retrospective descriptive analysis was conducted using data collected from ICU patients admitted between January and December 2024. The study focused on TRPs identified by clinical pharmacists in neonatal (NICU), medical (MICU), surgical (SICU), and pediatric (PICU) ICUs. Data on TRPs and pharmacist interventions were extracted from electronic medical records, categorized, and analyzed using descriptive statistics.

Results: A total of 10,445 TRPs were identified across the four ICUs. The most frequent TRPs in the NICU were therapeutic drug monitoring (TDM) (34.98%) and dosage regimen issues (32.05%). In the SICU, TDM (37.21%) and medication reconciliation issues (25.58%) were predominant. The MICU exhibited the highest prevalence of dosage regimen problems (30.30%) and a notable need for additional diagnostic tests (12.52%). In the PICU, dosage regimen issues accounted for 38.86% of TRPs, followed by TDM (16.67%). Across all ICUs, the resolution of TRPs improved progressively throughout the study period, with 50% resolved by the fourth quarter.

Conclusions: This study highlights the critical role of clinical pharmacists in managing TRPs and improving patient outcomes in ICUs. The findings emphasize the need for ICU-specific strategies, including enhanced TDM protocols, standardized dosing guidelines, and interdisciplinary collaboration, to address the unique challenges of each ICU type. These results provide a foundation for future quality improvement initiatives aimed at optimizing pharmaceutical care in critical care settings.

Keywords: *clinical pharmacist interventions, treatment related problems, critical care, ICU.*

1. INTRODUCTION

Treatment related problems (TRPs) are a frequent and significant concern in intensive care units (ICUs); where many patients treated in these settings suffer serious illnesses that often require complex treatment regimens. TRPs are two times more frequent in ICU patients than in non- ICU patients (Toukhy et al., 2021). However, it is a consolation that most of these occurrences can be prevented and the likelihood of their occurrence minimized given right use of the drugs. The prevalence of treatment-related problems in ICUs varies across studies. For instance, a study conducted in a Turkish university hospital reported that 71.5% of ICU patients experienced at least one TRP, with dosage errors and drug interactions being the most common issues (Albayrak et al., 2022).

Multiple studies have established that in-patient clinical pharmacists specializing in ICU have reduced TRPs by about 50% (Li et al., 2020). Another study found that 73.9% of critically ill patients admitted to a medical ICU encountered TRPs, and a model of pharmaceutical care applied in intensive care units addressed more than 570 identified therapeutic drug problems, underscoring the significant contribution of clinical pharmacists to the improvement of patient care (Tharanon et al., 2022).

Specific ICUs face unique challenges with TRPs. In neonatal ICUs (NICU), issues such as weight-based dosing errors and drug formulations are prominent (Bekele et al., 2021). In surgical ICUs, perioperative medication errors, such as improper antibiotic use, contribute significantly to TRPs (Escriva Gracia et al., 2021). Specifically, antibiotics and anticoagulants are among the drug classes most frequently associated with TRPs, reflecting common patterns across different ICU settings (Albayrak et al., 2022). In addition; adverse drug events due to dosing errors were a key contributor to TRPs, further raising the importance of precise medication management (Chiang et al., 2021).

Research has established that active roles played by the pharmacists in attending to the ICU patients decrease medical errors, augment the effectiveness of the treatment procedures, and decrease adverse drug effects (Cvikl & Sinkovič., 2020). Also, they offer relevant feedback during multidisciplinary rounds, ensuring evidence-based prescribing and monitoring for drug efficacy and toxicity. The involvement of clinical pharmacists in for patient in ICU also results in efficient reduction of cost by avoiding wastage of the drugs and side effects caused by medication errors (Tasaka et al., 2018).

This study was conducted at a tertiary premier teaching hospital situated in Jordan- specifically in Amman. The hospital serves as a leading medical teaching, training, research, and clinical service provider in the region. It has bed capacity of 550, 68 ICU beds and 24 surgical operation theatres divided into 8 specialization categories. The hospital also encompasses all major and sub- medical and clinical specialties containing (64) different specialties, and provide as fellowship program in ICUs (Jordan University Hospital., 2024). The hospital provides clinical pharmacy services, specifically since 2022, clinical pharmacists take part in multi-disciplinary rounds in the ICUs. One of the essential tasks and responsibilities of clinical pharmacists working in the ICU involves a thorough assessment and meticulous documentation of all prescribed medication orders. This comprehensive process includes careful evaluation of the patient's history data, detailed medical history, and sensitivity to any critical disharmonies that may arise from the complexities of drug therapy. Furthermore, pharmacists hold the crucial responsibility of identifying high-risk drugs and/or recognizing specific patient conditions that may warrant closer attention. They also proactively provide valuable information regarding any inappropriate dosing, methods of administration, contraindications, and the absence of necessary medical monitoring of the drug therapy being utilized. A checklist was developed for ICU patients, covering most clinical aspects faced by clinical pharmacists in the ICU.

To our knowledge, this is the first study of its type in Jordan, aiming to identify prevalence, and distribution of TRPs across ICU types. Also this is the first study of its kind to address the TRPs among different ICUs. By providing locally relevant data, this study seeks to inform future strategies, and build recommendations for optimizing pharmaceutical care in critical care settings.

Objectives

The objective of this work is to evaluate the prevalence, types, distribution, and clinical significance of treatment-related problems across different ICUs at a tertiary hospital in Jordan, including neonatal ICU (NICU), medical (MICU), and surgical ICU (SICU). This work also aims to provide recommendations tailored according to the results of the analysis.

2. METHODOLOGY

Study Design

The study employed a retrospective descriptive analysis focusing on critically ill patients who were admitted to different ICU units at Jordan University Hospital, tertiary university hospital in Jordan. Clinical pharmacy involvement in the ICU has been a standard of care since 2020. When clinical pharmacists identify TRPs, they promptly report these issues and the corresponding interventions to physicians, ensuring that all actions were documented in the medical records. Subsequently, the acceptance responses from physicians or nurses is monitored. In this work, TRPs and clinical pharmacist interventions in the medical records underwent a meticulous review for data collection spanning from January 2024 to December 2024. All patients with at least one recorded TRP who were admitted to the NICU, MICU, PICU and SICU were included in the analysis. The exclusion criteria included patients who were transferred to other units or who passed away within 24 hours before the completion of data collection. Recommendations were structured based on the analysis results.

Data Collection

Data was extracted from the hospital's electronic records for TRPs. In practice the following measures are reported by clinical pharmacists (Scheme 1), adopted from Cipolle (2012) with some modifications according to local hospital intervention and practices. A checklist was created to assist clinical pharmacists in addressing all critical medical areas commonly associated with TRPs in ICUs. The following table is included with each clinical pharmacist's intervention report in the system.

Scheme 1: Clinical pharmacy ICU checklist

Treatment-Related Problem
Unnecessary drug therapy
Untreated condition
Drug of choice + Drug selection
Dosage regimen
Prescribed drug not administered
Potential/Actual (ADR/Allergy)
Potential/Actual drug interaction
Therapeutic drug monitoring (TDM)
Preparation + Administration
Stability/Storage
Drug and/or Disease monitoring
A need for additional diagnostic tests
A need for consultation
Cost-effectiveness
Medication reconciliation
Dispensing errors
Antibiotics or Anti-infectives
Choice
Duration
Checklist Related to ICU's
Fluids + Electrolytes
Analgesia
TPN
Sedation
Thromboprophylaxis
Stress ulcer
Other
Patient education
Drugs and breastfeeding
Drugs and pregnancy
Clinical Significance
Potentially Severe/High
Important/Moderate
Minor

Acceptance
Accepted
Modified Accepted (M)
Rejected (R)

Data Analysis

Descriptive statistical analysis was performed using IBM SPSS, for Windows, Version 24.0. Data were entered in Microsoft® Office Excel, cleaned, missing records excluded, and then analysis by SPSS was performed. Results were presented in percentages of TRPs for each ICU.

Ethical Considerations

Ethical approval was obtained from the hospital's Institutional Review Board. All patient data was anonymized to ensure confidentiality. The study adhered to the principles of the Declaration of Helsinki.

3. RESULTS

In this part of the work, data related to TRPs in different intensive care units were reviewed and analyzed. In the NICU (Table 1), the most prominent TRPs were related to the dosage regimen, which constituted 32.05% of the total cases. Other problems related to potential or actual drug interactions were also found at 15.53%, in addition to problems with the preparation and administration of medications at 10.68%.

As for antibiotics or anti-infectives, the problems were classified into two main categories: choice of medication and duration of treatment. The results showed that choice of medication was a problem in 33.32% of cases, while duration of treatment was a more common issue at 66.64%.

Table (1) TRPs problems and therapeutic outcomes in the neonatal intensive care unit (NICU)

NICU(n=2452)	Frequency (%)
1. Treatment Related Problem	
Unnecessary drug therapy	48 (1.94)
Untreated condition	24 (0.97)
Drug of choice and drug selection	24 (0.97)
Dosage regimen	785 (32.05)
Potential/Actual (ADR/Allergy)	24 (0.97)
Potential/Actual drug interaction	381 (15.53)
Therapeutic drug monitoring (TDM)	858 (34.98)
Preparation & administration	261 (10.68)
Stability Storage	24 (0.97)
A need for additional diagnosis	48 (1.94)
2. Antibiotics or anti-infectives	
Choice	817 (33.32)
Duration	1635 (66.64)
Improved therapeutic outcome	1178(48)

Regarding the SICU, the proportion of problems related to untreated cases was 6.98%, while the choice of medication or type of treatment (4.65%). High rates of potential or actual drug interactions were observed in 6.98%, along with dose management in the same proportion, highlighting the need for a greater focus on monitoring optimal doses through TDM, which constituted the highest proportion of problems (37.21%). The problem of medication reconciliation was also a significant problem in 25.58%. complete analysis in Table 2.

Table (2) TRPs and expected outcomes in the surgical intensive care unit (SICU)

SICU=3774	Frequency(%)
1. Drug Related Problem	
Untreated condition	263(6.98)
Drug of choice and Drug selection	176(4.65)
Dosage regimen	263(6.98)
Potential/Actual (ADR/Allergy)	263(6.98)
Therapeutic drug monitoring (TDM)	1403(37.21)
Preparation & administration	88(2.33)
Drug and/or Disease monitor	176(4.65)
A need for additional diagnosis	88(2.33)
A need for consultation	88(2.33)
Medication reconciliation	967(25.58)
2. Antibiotics or anti-infectives	
Choice	1957(51.71)
Duration	1825(48.29)

TRPs and expected outcomes in MICU (Table 3) revealed that the most prominent problems were related to dose management (30.30% (1163 cases), followed by problems with TDM (23.06%) (883 cases). Other problems such as unnecessary treatment (10.53% (404 cases) and the need for additional diagnosis 12.52% (480 cases) were also observed. As for antibiotics, the percentage of choice of anti-infective medications was 68.78% (2640 cases), while the percentage of focus on the duration of treatment was 31.14% (1198 cases). This indicates a great emphasis on choosing the most appropriate medications and determining the necessary duration of treatment to ensure the best therapeutic outcomes for patients.

Table (3) TRPs and expected outcomes in the medical intensive care unit (MICU)

MICU(n=3832)	Frequency (%)
1. Drug Related Problem	
unnecessary drug therapy	404(10.53)
Untreated condition	25(0.66)
Drug of choice & drug selection	10(2.63)
Dosage regimen	1163(30.30)
Potential/Actual (ADR/Allergy)	101(2.63)
Potential/Actual drug	25(0.66)
Therapeutic drug monitoring (TDM)	883(23.06)
Preparation & administration	51(1.32)
Drug and/or Disease monitor	429(11.19)
A need for additional diagne	480(12.52)
A need for consultation	25(0.66)
Medication reconciliation	25(0.66)

Antibiotics or anti-infectives	
Choice	2640(68.78)
Duration	1198(31.14)

In PICU, the largest problem was related to dose management, which was recorded in 38.86% (151 cases). This was followed by problems in choosing the right medication in 9.52% (37 cases), and problems related to medication or disease monitoring in 6.35% (25 cases). Problems with drug interactions were limited to 0.79% (3 cases).

With regards to antibiotics, the choice of anti-infective medications represented 70% (271 cases) of cases, while the duration of treatment represented 30% (116 cases).

Table (4) TRPs problems and expected outcomes in the pediatric intensive care unit (PICU)

PICU(n=387)	Frequency(%)
1. Drug Related Problem	
unnecessary drug therapy	**18(4.76)**
Untreated condition	**3(0.9)**
Drug of choice & drug selection	**37(9.52)**
Dosage regimen	**151(38.86)**
Potential/Actual (ADR/Allergy)	**3(0.9)**
Potential/Actual drug interaction	**3(0.9)**
Therapeutic drug monitoring (TDM)	**64(16.67)**
Preparation & administration	**43(11.11)**
Stability Storage	**3(0.9)**
Drug and/or Disease monitor	**25(6.35)**
A need for additional diagnosis	**28(7.15)**
A need for consultation	**6(1.59)**
Medication reconciliation	**3(0.9)**
Antibiotics or anti-infectives	
Choice	**271(70)**
Duration	**116(30)**

Clinical pharmacists were responsible for categorizing the severity of treatment-related problems (TRPs) using a modified version of the severity classification system for drug-related problems (DRPs). This system was adapted from the medication error index developed by the National Coordinating Council for Medication Error Reporting and Prevention (Tharanon et al., 2022). The severity levels were defined as follows: TRPs classified as minor correspond to DRPs with no harm in the original system, TRPs categorized as moderate/important align with DRPs with potential harm, and TRPs deemed potentially severe or highly significant correspond to DRPs involving harm, which may result in death.). As shown in figure 1, In the MICU, the vast majority of cases (95.96%, 3677 cases) were classified as moderately or significantly important, while 3.03% (116 cases) were classified as high or likely important, and only 3.03% (39 cases) were classified as low or unimportant.

In the PICU, the vast majority (98.98%, 383 cases) were moderately or significantly important, while only 1.03% (2 cases) were classified as high or likely important. These figures reflect that all cases admitted to this unit were considered to be of high importance in the context of treatment.

In the NICU, 100% of all treatment-related issues (2452 cases) were rated as moderate or important clinically significant. While in the SICU, all cases were assessed for clinical significance, with 9.43% (357 cases) being of high or possible significance, while 90.48% of cases were of moderate or important significance, with 3418 cases being of moderate or

important significance.

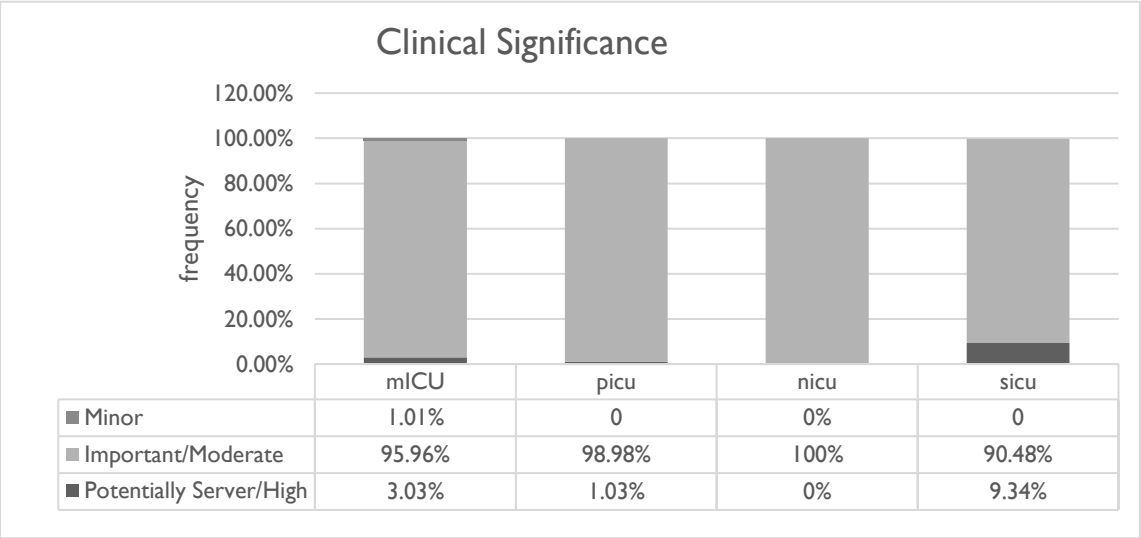

Figure (1) Stacked Column Bar Chart for Clinical significance of TRPs in intensive care units: analysis of percentages of cases by significance levels.

Regarding the acceptance of interventions (Figure 2), in NICU, 100% of cases were accepted with a frequency of 2452 TRPs, reflecting a positive response from physicians and practitioners to accept the therapeutic procedures followed. In SICU, the data showed that 96.36% of cases with a frequency of 3633 cases were accepted, with 36.4% (1373 cases) being accepted in a modified form, which may indicate the need to adapt treatment according to individual circumstances.

In the MICU, 79.56% of cases (3044 cases) were accepted, while only 0.93% (36 cases) were rejected, with 19.44% of cases (746 cases) not being clearly defined, reflecting some doubts or modifications in therapeutic decisions. In the PICU, the majority of cases were accepted (94.99%) (367 cases), while 4.08% were modified (16 cases), and only 1.02% (4 cases) were rejected. The most frequent TRPs in each ICU are summarized in table 5.

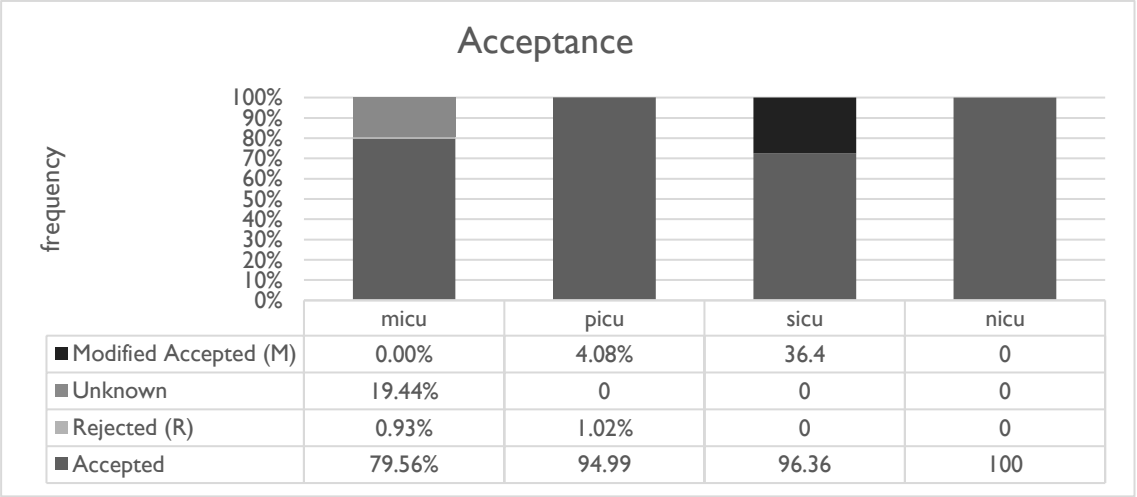

Figure (2) Stacked Column Bar Chart for Accepted in intensive care units: analysis of percentages of cases by significance levels

Table 5: The most frequent TRPs across different ICUs

ICU's type	1st most frequent TRP	2nd most frequent TRP	3rd most frequent TRP
NICU	TDM (34.98 %)	Dosage regimen (32.05%)	Potential/Actual drug interaction (15.53%)

SICU	TDM (37.21%)	Medication reconciliation 25.558%	Untreated condition , Potential/Actual (ADR/Allergy), Dosage regimen, (6.89)
MICU	Dosage regimen (30.30%)	TDM (23.06%)	A need for additional diagnosis (12.52%)
PICU	Dosage regimen (38.86%)	TDM (16.67)	Preparation and administration (11.11%)

The measurement of resolved TRPs in ICUs rose steadily during all months of the year (Table 6), reaching 46% at the first quarter and 48% by the 3rd quarter before achieving its maximum level at 50% in the final quarter. This demonstrates a rising trend in success rates of clinical pharmacists when they address treatment-related problems throughout ICUs.

Table 6: Percentage of total resolved TRPs per each quarter

Quarter	Months	Percentage of Resolved TRPs
1st Quarter	January, February, March	46%
2nd Quarter	April, May, June	45%
3rd Quarter	July, August, September	48%
4th Quarter	October, November, December	50%

4. DISCUSSION

This study focused on revealing the patterns of TRPs in different types of ICU, including NICU, SICU, MICU, and PICU. The study's results are consistent with previous research and identify certain patterns, which needs further interpretation.

In the NICU, TDM accounted for 34.98% of TRPs, similar to Shirzad-Yazdi et al. (2024), who found that neonates often require precise monitoring due to their limited metabolic capacity and high risk of drug accumulation. Dosage regimen issues, representing 32.05% of TRPs, reflected the challenge of accurate weight-based dosing and immature organ function, as also noted by Acharya et al. (2023). Potential or actual drug interactions (15.53%) were notable, which can be attributed to polypharmacy and the use of antibiotics, sedatives, and electrolytes in neonates, as supported by Martins et al. (2019). Neonates exhibit significant physiological differences compared to older children and adults, including higher body water content and reduced plasma protein binding, which can alter drug distribution and efficacy. These factors complicate the determination of appropriate dosing regimens, increasing the risk of both underdosing and overdosing (Bansal et al., 2024). Other factors, both those specific to neonates and the challenges of their care, affect medication errors in NICUs. Error provoking environments (high noise levels, poor lighting, frequent interruptions) account for a large proportion of medication administration errors in NICUs (Henry Basil., 2022). In addition, dilution or preparation of small doses of many medications can cause inaccuracies. The additional complexity is due to the use of adult strength formulations that require modification for neonatal use, which has the potential to increase dosing errors (Noella et al., 2022).

Regarding the SICU, TDM was also the most frequent TRP to be identified; contributing to 37.21% of the cases. It is of particular importance to monitor the level of the drug in blood for patients before and after surgery due to significant changes in blood flow, variation in gastrointestinal motility in patients undergoing different surgical procedures and interactions related to post-surgical use of medications like analgesics and anticoagulants (Blaser et al., 2018). Such finding accustoms the need to pay much attention in high-risk medications in the surgical patients especially the antibiotics as well as the anticoagulants Çakir et al. (2024) also confirmed the need for the therapeutic drug monitoring in the surgical ICU to reduce toxicity and avoid suboptimal level. The second most identified TRP was 25.58% concerning medication reconciliation. This illustrates the challenges that accompany frequent transitions of care and the temporary medications hold or restart. In the same vein; MacTavish et al., (2019) revealed that reduction of errors among surgical patients was greatly enhanced by pharmacists' reconciliation. Other less severe but still important TRPs with the SICU include untreated conditions, and dosage regimen issues denote the difficulty that is associated with perioperative medication management in the SICU population of this study. In the perioperative setting there are many transitions, for example from the operation room to the SICU where effective communication is essential. A study of medication errors in perioperative settings revealed nearly 75 percent of the reported events were attributed to communication breakdowns in transfers. These lapses can lead to omissions in treatment plans, resulting in untreated conditions (Cierniak et al., 2018). Additionally, SICU patients often require intricate

medication regimens, including anesthetics, analgesics, anticoagulants, and antibiotics. The necessity for rapid adjustments in response to a patient's changing status increases the risk of dosage errors (Bowdle et al., 2016).

In the MICU, dosage regimen problems were the most common TRP observed in this study, contributing to 30.30 percent of the cases. This was in tandem to findings by Ayhan et al. (2022) that showed slightly higher dosing error incidences in Medical ICUs because of factors such as polypharmacy and comorbidities. MICU patients often stay for extended periods, leading to changes in pharmacokinetics and pharmacodynamics over time, necessitating dose adjustments. Also organ dysfunction, such as hepatic or renal impairment, is common in MICU patients and necessitates careful adjustment of medication dosages (Kane-Gill et al., 2010 and Póvoa et al., 2021) Complex dosing calculations, especially in patients with fluctuating renal function or those requiring weight-based dosing, can lead to errors (Bilbao-Meseguer et al., 2022). TDM, having contributed 23.06% of TRPs in this study, thus, points to the need for accurate drug monitoring in the MICU. This is in line with Hisham et al. (2016) who established that enhanced vigilance of drug levels cut down on mistakes in medical ICUs. Also, the request for diagnostic tests (12.52%) indicates the dependence on the diagnostic approach as a way to initiate therapy, especially in patients with multiple organ failure or infections. Similarly, Abu-Oliem et al. (2013) called for application of diagnostics to enhance the management of patients in MICU. The presentation of infections can be atypical and the source not apparent. Early and accurate identification of the infectious agent and its source is necessary to initiate appropriate antimicrobial therapy. Detection and localization of infection is commonly performed by blood cultures, tissue cultures and advanced imaging techniques such that treatment can be timely and effective (Fatemi et al., 2021).

Dosage regimen related problems were the most common TRP derived from the PICU at 38.86%. This underlines the importance of appropriate dose adjustments in dose-related drugs in children in order to avoid any unfavorable consequences of the smallest changes in the dosage. For the same reason, Shirzad-Yazdi et al. (2024) also identified that dosing errors were the most common type of TRP in pediatric ICUs. TDM was present more commonly in this study's PICU population at 16.67% and problems in preparation and administration as discussed above in the NICU. These outcomes correspond with Martins et al. (2019) who pointed to the dangers of preparation mistakes in pediatric care as a result of the requirement for individualized formulations.

Standardized protocols function as instrumental tools to address TRPs. Pharmacotherapy expertise from clinical pharmacists helps enhance protocol refinement for detecting drug-related issues while preventing medication problems between healthcare professionals. The research demonstrated how clinical pharmacists effectively detect and manage problems related to treatments and drugs during ICU stay (Özgan et al., 2024). The active involvement of clinical pharmacists in ICU teams has been associated with significant improvements in medication management. A study conducted in a medical ICU demonstrated that pharmacists' participation led to more individualized and optimized pharmacological treatments, with ICU physicians fully accepting 80.2% of the pharmacists' suggestions (Cvikl et al., 2022).

Based on the study results, recommendations are presented below in table 7.

Table 7: recommendations based on the study results:

ICU Type	Key Finding	Recommendation
NICU	TDM was the most frequent TRP (34.98%).	- Implement neonatal-specific TDM guidelines and use real-time monitoring systems for high-risk medications like antibiotics and sedatives. - Develop dosing charts and integrate automated dosing calculators into electronic medical records to minimize errors. - Advocate for pediatric-friendly drug formulations to reduce preparation errors and ensure accuracy. - Conduct regular training on neonatal pharmacokinetics and medication safety to improve dosing accuracy. - Standardize handovers and document medication changes comprehensively to avoid errors.
SICU	TDM was the most frequent TRP (37.21%).	- Develop TDM guidelines emphasizing anticoagulants and antibiotics. Conduct pharmacist-led workshops on optimizing perioperative medication dosing. - Implementing standardized handoff protocols to ensure continuity of care, developing comprehensive medication management guidelines tailored to the perioperative setting, and increasing the involvement of clinical pharmacists in the SICU to oversee complex medication regimens and

		provide staff education.
MICU	Dosage regimen issues were most frequent (30.30%).	- Implementing standardized dosing protocols that account for organ dysfunction and disease complexity. - Enhancing interprofessional communication and ensuring thorough documentation practices. - Incorporating clinical pharmacists into the MICU team to provide expertise in pharmacotherapy management. - Utilizing computerized provider order entry (CPOE) systems with integrated decision support to minimize calculation errors.
PICU	Dosage regimen issues were most frequent (38.86%).	- Standardized Weight Measurement Protocols: Implementing strict protocols for obtaining and documenting patient weights can reduce errors in weight-based dosing. - Development of Pediatric Formulations: Advocating for and utilizing pediatric-specific drug formulations can minimize the need for dose modifications and associated errors. - Enhanced Monitoring Systems: Employing clinical decision support systems that alert clinicians to necessary dose adjustments based on real-time patient data can improve dosing accuracy.

This study recommends that the management of TRPs in ICU requires more specific approaches to be developed. Some of the TRPs could have been minimized by increased pharmacist participation, dosing and reconciliation guidelines, as well as ICU specific monitoring procedures. According to Mohammad et al. (2020), clinical pharmacists are crucial in handling of TRPs and enhancing patient success as they constantly screen for and juxtapose care plans. Utility of decision aids could improve the accuracy of TDM and dosage modifications through technology integration. Expanding clinical pharmacy services to additional areas of care, such as the emergency department and regular medical floors, complements existing services and protocols while also aiding in the reduction of treatment-related problems. Overall, with clinical pharmacist-provided drug protocol management, substantial reductions were noted in the length of stay, the total cost of care, drug costs, laboratory costs, and complications.

In addition, to maintain and enhance the positive trajectory in TRP resolution, it is essential to implement these targeted strategies:

Continuous Professional Development: The system must provide a persistent training structure for clinical pharmacists to boost both their skills and competency level.

Interprofessional Collaboration: Effective use of clinical pharmacist expertise requires open communication along with collaborative work approaches among healthcare staff.

Resource Allocation: The implementation of clinical pharmacists into ICU teams requires sufficient personnel with specialized resources.

Standardization of Protocols: Standard operating procedures together with guidelines should be implemented as part of clinical pharmacy service management improvements throughout the ICU.

This work has some limitations; the analysis is retrospective, which prevents causal conclusions, and the lack of systematic outcome data constrains knowledge of the implications of TRP. Further research should be directed towards investigating the outcomes of interventions by the pharmacists in relation to the resolution of TRP and patients. The study scope can be considered more broadened than the previous works, including not only ICU but also its recovery phases.

REFERENCES

[1] Abdelaziz, K., & Abdelrahim, M. E. (2015). Identification and categorisation of drug-related problems on admission to an adult intensive care unit. *European Journal of Hospital Pharmacy, 22*(3), 138–141.

[2] Abu-Oliem, A., Al-Sharayri, M., & Hakuz, N. (2013). A clinical trial to investigate the role of clinical pharmacist in resolving/preventing drug related problems in ICU patients who receive anti-infective therapy. *Jordan Journal of Pharmaceutical Sciences, 6*(3), 239–246.

[3] Acharya, U., Shankar, P. R., Palaian, S., Dangol, R., Jha, N., & Thakur, A. (2023). Pattern of drug therapy related problems encountered by clinical pharmacists in a critical care setting in Nepal. *Pharmacy Practice (Granada), 21*(2), 13.

[4] Alam, K., Sharan, Y., Ghosh, N., Sarraf, D. P., & Sah, A. K. (2020). Pattern of medication related problems in patients admitted to intensive care units at a Teaching Hospital in Western Nepal: a Pharmacovigilance Study. *Journal of Pharmaceutical Sciences and Research*, *12*(10), 1282-1287.

[5] Albayrak, A., Başgut, B., Bıkmaz, G. A., & Karahalil, B. (2022). Clinical pharmacist assessment of drug-related problems among intensive care unit patients in a Turkish university hospital. *BMC Health Services Research*, *22*(1), 79.

[6] Ayhan, Y. E., Karakurt, S., & Sancar, M. (2022). The effect of the clinical pharmacist in minimizing drug-related problems and related costs in the intensive care unit in Turkey: A non-randomized controlled study. *Journal of Clinical Pharmacy and Therapeutics*, *47*(11), 1867–1874.

[7] Bansal, N., Momin, S., Bansal, R., Venkata, S. K. R. G., Ruser, L., & Yusuf, K. (2024). Pharmacokinetics of drugs: newborn perspective. *Pediatric Medicine*, *7*.

[8] Bekele, F., Bereda, G., Tamirat, L., Geleta, B. A., & Jabessa, D. (2021). "Childrens are not just "little adults". The rate of medication related problems and its predictors among patients admitted to pediatric ward of southwestern Ethiopian hospital: A prospective observational study. *Annals of Medicine and Surgery*, *70*, 102827.

[9] Bilbao-Meseguer, I., Barrasa, H., Rodríguez-Gascón, A., Asín-Prieto, E., Maynar, J., Sánchez-Izquierdo, J. Á., ... & Isla, A. (2022). Optimization of levetiracetam dosing regimen in critically ill patients with augmented renal clearance: a Monte Carlo simulation study. *Journal of Intensive Care*, *10*(1), 21.

[10] Blaser, A., Starkopf, J., Moonen, P. J., Malbrain, M., & Oudemans-van Straaten, H. (2018). Perioperative gastrointestinal problems in the ICU. *Anaesthesiology Intensive Therapy*, *50*(1).

[11] Bowdle, T. A., Jelacic, S., & Nair, B. (2016). Evaluation of perioperative medication errors. *Anesthesiology*, *125*(2), 429-431.

[12] Çakir, A., Memiş, H., Gün, Z. Ü., & Biçakcioglu, M. (2024). Evaluation of drug-related problems of intensive care unit patients by clinical pharmacists: A retrospective study. *Turkish Journal of Pharmaceutical Sciences*, *21*(4), 274–280.

[13] Cierniak, K. H., Gaunt, M. J., & Grissinger, M. (2018). Perioperative medication errors: uncovering risk from behind the drapes. *Penn Patient Saf Advis*, *15*(4), 22-38.

[14] Cipolle, R. J., Strand, L. M., & Morley, P. C. (2012). *Pharmaceutical care practice: the patient-centered approach to medication management* (pp. 435-644). New York: McGraw-Hill Medical.

[15] Cvikl, M., & Sinkovič, A. (2020). Interventions of a clinical pharmacist in a medical intensive care unit–A retrospective analysis. *Bosnian Journal of Basic Medical Sciences*, *20*(4), 495.

[16] Escriva Gracia, J., Aparisi Sanz, A., Brage Serrano, R., & Fernandez Garrido, J. (2021). Medication errors and risk areas in a critical care unit. *Journal of Advanced Nursing*, *77*(1), 286-295.

[17] Henry Basil, J., Premakumar, C. M., Mhd Ali, A., Mohd Tahir, N. A., & Mohamed Shah, N. (2022). Prevalence, causes and severity of medication administration errors in the neonatal intensive care unit: a systematic review and meta-analysis. *Drug Safety*, *45*(12), 1457-1476.

[18] Hisham, M., Sivakumar, M. N., & Veerasekar, G. (2016). Impact of clinical pharmacist in an Indian Intensive Care Unit. *Indian Journal of Critical Care Medicine: Peer-Reviewed, Official Publication of Indian Society of Critical Care Medicine*, *20*(2), 78–83.

[19] Jordan University Hospital., 2024, retrieved from:

[20] https://hospital.ju.edu.jo/medical/juhospital/Lists/HospPages_List/Disp_page.aspx?UrlTitle=aboutus&utm_source=chatgpt.com

[21] Kane-Gill, S. L., Jacobi, J., & Rothschild, J. M. (2010). Adverse drug events in intensive care units: risk factors, impact, and the role of team care. *Critical care medicine*, *38*, S83-S89.

[22] Li, X. X., Zheng, S. Q., Gu, J. H., Huang, T., Liu, F., Ge, Q. G., ... & Shi, L. W. (2020). Drug-related problems identified during pharmacy intervention and consultation: implementation of an intensive care unit pharmaceutical care model. Frontiers in Pharmacology, 11, 571906.

[23] MacTavish, P., Quasim, T., Purdie, C., Ball, M., Barker, L., Connelly, S., & McPeake, J. (2020). Medication-related problems in intensive care unit survivors: Learning from a multicenter program. *Annals of the American Thoracic Society*, *17*(10), 1326–1329.

[24] Martins, R. R., Silva, L. T., & Lopes, F. M. (2019). Impact of medication therapy management on pharmacotherapy safety in an intensive care unit. *International Journal of Clinical Pharmacy*, *41*(1), 179–188.

[25] Mohammad, R. A., Betthauser, K. D., Korona, R. B., Coe, A. B., Kolpek, J. H., Fritschle, A. C., & Stollings, J. L. (2020). Clinical pharmacist services within intensive care unit recovery clinics: An opinion of the critical care practice and research network of the American College of Clinical Pharmacy. *Journal of the American College of Clinical Pharmacy, 3*(7), 1369–1379.

[26] Noella, N. Y. I. R. A. M. B. A. R. U. S. H. I. M. A. N. A. (2022). *Identifying medication errors in the neonatal intensive care unit in two hospitals in Rwanda: a cross-sectional study* (Doctoral dissertation, University of Rwanda).

[27] Özgan, B., Ayhan, Y. E., Apikoglu, S., & Karakurt, S. (2024). Clinical pharmacist interventions in nutrition-and drug-related problems in critically ill patients with renal dysfunction: a non-randomized controlled study. *Frontiers in Medicine*, *11*, 1473719.

[28] Póvoa, P., Moniz, P., Pereira, J. G., & Coelho, L. (2021). Optimizing antimicrobial drug dosing in critically ill patients. *Microorganisms*, *9*(7), 1401.

[29] Shirzad-Yazdi, N., Taheri, S., Vazin, A., Shorafa, E., Abootalebi, S. N., Hojabri, K., & Shafiekhani, M. (2024). Drug-related problems among pediatric intensive care units: Prevalence, risk factors, and clinical pharmacists' interventions. *BMC Pediatrics, 24*(1), 714.

[30] Tasaka, Y., Tanaka, A., Yasunaga, D., Asakawa, T., Araki, H., & Tanaka, M. (2018). Potential drug-related problems detected by routine pharmaceutical interventions: safety and economic contributions made by hospital pharmacists in Japan. *Journal of pharmaceutical health care and sciences*, *4*, 1-11.

[31] Tharanon, V., Putthipokin, K., & Sakthong, P. (2022). Drug-related problems identified during pharmaceutical care interventions in an intensive care unit at a tertiary university hospital. *SAGE Open Medicine*, *10*, 20503121221090881.

[32] Toukhy, A., Fayed, S., Sabry, N., & Shawki, M. (2021). The impact of an established pharmaceutical care pathway on drug related problems in an intensive care unit. *The American journal of the medical sciences*, *362*(2), 143-153.