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Posted Date: 9 February 2026

doi: 10.20944/preprints202602.0526.v1

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Article

Analysis of Pharmacist Interventions to Reduce Medication-Related Problems in a Neonatal Clinical Care Unit

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Abstract

(1) Background: Medication related problems (MRPs) are a major burden on health care systems. Pharmacists play an important role in preventing and reducing MRPs through clinical review, education, and governance activities. This study analyzed pharmacist interventions within a 100-bed neonatal clinical care unit to better understand MRPs and guide targeted medication safety initiatives. (2) Methods: All pharmacist interventions documented in REDCap® between 01/07/2022 and 30/06/2025 were analyzed identifying MRPs incidence, types, and acceptability following interventions. (3) Results: A total of 873 pharmacist interventions were recorded during the study period. The common frequent MRPs were related to dosing errors (n=320,36.7%), compliance with hospital policy (n=152,17.4%), no indication apparent (n=106,12.1%), drug interactions (n=66,7.6%) and inadequate laboratory monitoring (n=40,4.6%). Of these, 62.4% (n=545) were accepted by prescribers, while 26.1% (n=228) had unknown outcomes at the time of data entry. The majority of interventions documented were from the Neonatal Intensive Care Unit (39.3%), involving medications such as gentamicin (n=46), benzylpenicillin (n=37), caffeine (n=34), parenteral nutrition (n=23), and morphine (n=16) and meropenem (n=16). (4) Conclusions: Regular analysis of pharmacist interventions provides valuable insights into local MRP trends and highlights opportunities for quality improvement and education.

Keywords: pharmacy; medication safety; neonatology; medication error; pharmacist intervention

1. Introduction

Medication related problems (MRPs) are a major burden on health care systems [1]. Pharmacists play an important role in preventing and reducing MRPs through clinical review, education, and governance activities [2]. Published literature indicates that pharmacist practice in the Neonatal Intensive Care Unit (NICU) involves diverse roles, including patient medication chart review, therapeutic drug monitoring and the provision of medication information which enables the prevention and monitoring of MRPs [3–6]. Neonatal patients are vulnerable to medication errors due to the increased need for calculations, dilutions, manipulations of medications and the involvement of off-label use of many medications [7,8]. The medication-use process within the neonatal patients is more complex and has greater consequences resulting from error [9]. Errors due to patient misidentification and overdosing were particularly prevalent in neonates, with 47% of administration errors involving at least tenfold overdoses [9].

Studies highlighted that pharmacist contribution to total parenteral nutrition (TPN) regimens and patient medication chart review is beneficial to patient outcomes [3]. This is consistent with a previous study carried out at the study site [10]. The interventions should be regularly reviewed due to the complexity of medication use in neonates, the high frequency in which high-risk medications used and the potential for serious adverse events of even minor medication errors [7]. The

interventions review is imperative in assisting healthcare systems and providers in understanding, implementing, and augmenting interventions to reduce neonatal medication errors [11].

This is a single center study aimed to evaluate the incidence, types, and causes of MRPs; evaluate the acceptability and actions taken following pharmacist interventions at a tertiary NICU.

2. Materials and Methods

2.1. Study Site

The study hospital, a women and newborn hospital more than 6000 births take place annually. It is the only is the only major referral center in the state for high-risk pregnancies. The neonatal unit provides intensive, high dependency and special care for preterm and sick newborn babies in the state with 2,300 to 2,400 neonatal admissions each year. The neonatal unit has 92 beds, including 30 intensive care beds (Clinical Significance Framework [CSF] level 6) and 62 special care beds (20 CSF level 5 and 42 CSF level 4) [12,13].

The Clinical pharmacy service provided to the neonatal unit include medication reconciliation, assessment of current medication management, clinical review of medication prescribed on medication chart (chart review), therapeutic drug monitoring contributing to the medication management plan, and facilitating continuity of medication management on discharge or transfer, as recommended by the Advanced pharmacy Australia clinical pharmacy standards [2]. The neonatal pharmacist also promoted medication safety through participation in the weekly grand rounds, medication incident trend reporting, and delivery of multidisciplinary education. Additionally, the pharmacist coordinated the review and publication of neonatal medication protocols (n=156) which are accessed by the study hospital and other neonatal units across the state [14].

2.2. Analysis of Pharmacist Interventions Documented

Since 01/07/2022, the pharmacists at the study hospital have been documenting pharmacy clinical interventions on a REDCap® database which is easily accessible by most electronic devices with secure data storage and access [15]. Information documented include Staff Name, Intervention Details, Medication Details, Clinical Intervention Matrix, and Risk Analysis.

All neonatal pharmacist interventions documented in REDCap between 01/07/2022 and 30/06/2025 were analyzed identifying MRPs incidence, types, and acceptability following interventions. A risk analysis of the potential impact of interventions was made using the Australian Standards for Risk Management in which the severity of an MRP was determined by the potential consequence (impact) and likelihood of reoccurrence if the pharmacist intervention was not made. The use of risk analysis of pharmacist interventions was validated in previous studies [10,14]

3. Results

A total of 873 pharmacist interventions were recorded during the 3-year study period from 01/07/2022 to 30/06/2025. The 12-month intervention rate from 01/07/2024 to 30/06/2025 was 3.1 interventions /100 medication charts reviewed.

3.1. Frequency of Medication Related Problems, Medications Involved and Actions Taken Following Pharmacist Interventions

The common frequent MRPs were related to dosing errors (n=320,36.7%), compliance with hospital policy (n=152,17.4%), no indication apparent (n=106,12.1%), drug interactions (n=66,7.6%) and inadequate laboratory monitoring (n=40,4.6%) [Table 1]. Of these, 62.4% (n=545) were accepted by prescribers, while 26.1% (n=228) had unknown outcomes at the time of data entry [Figure 1].

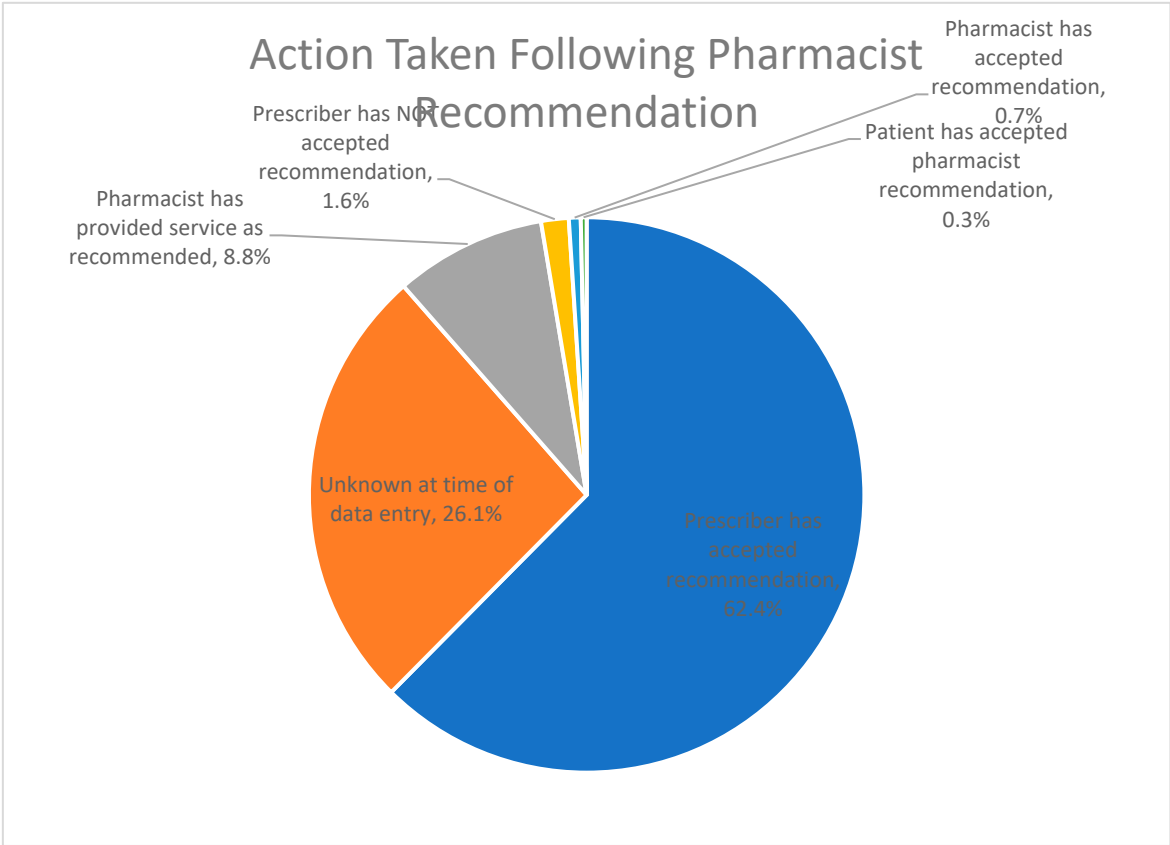


Figure 1. Action Taken Following Pharmacist Recommendation.

Table 1. Medication Related Problem (MRPs) documented by the pharmacist in the Neonatal Clinical Care Unit.

MRP	Number of MRP	% of MRP
N2 - Hospital policy or protocol	152	17.4%
O3 - Incorrect / unclear dosing instructions	134	15.3%
D7 - No indication apparent	106	12.1%
O2 - Prescribed dose too low	92	10.5%
D2 - Drug interaction	66	7.6%
O1 - Prescribed dose too high	66	7.6%
M1 - Laboratory monitoring	40	4.6%
U3 - Preventative therapy required	32	3.7%
D1 - Drug duplication	29	3.3%
O0 - Other dose issue	28	3.2%
U2 - Condition untreated	24	2.7%
D0 - Other drug selection issue	21	2.4%
E0 - Other education or information service provided	20	2.3%
D6 - Contraindications apparent	16	1.8%
D3 - Wrong drug	10	1.1%
D5 - Inappropriate dosage form	7	0.8%
C2 - Over-use by patient	5	0.6%
D4 - Incorrect strength	5	0.6%
U1 - Condition undertreated	5	0.6%
U0 - Other untreated indication and/or issue	3	0.3%
U4 - Prescribing omission of regular medications	3	0.3%
N1 - Technician intervention	2	0.2%
T0 - Other toxicity/ADR issue	2	0.2%

C0 - Other compliance issue	1	0.1%
E1 - Patient requests medication information	1	0.1%
M0 - Other monitoring required/recommended	1	0.1%
N0 - Not classifiable under another category	1	0.1%
T1 - Toxicity, allergic reaction or ADR present	1	0.1%
Total	873	

The majority of interventions documented were from the Neonatal Intensive Care Unit (39.3%), involving medications such as gentamicin (n=46), benzylpenicillin (n=37), caffeine (n=34), parenteral nutrition (n=23), and morphine (n=16) and meropenem (n=16) [Table 2]. A total of 515 (59%) MRPs were rated as high- and extreme-risk (Figure 2).

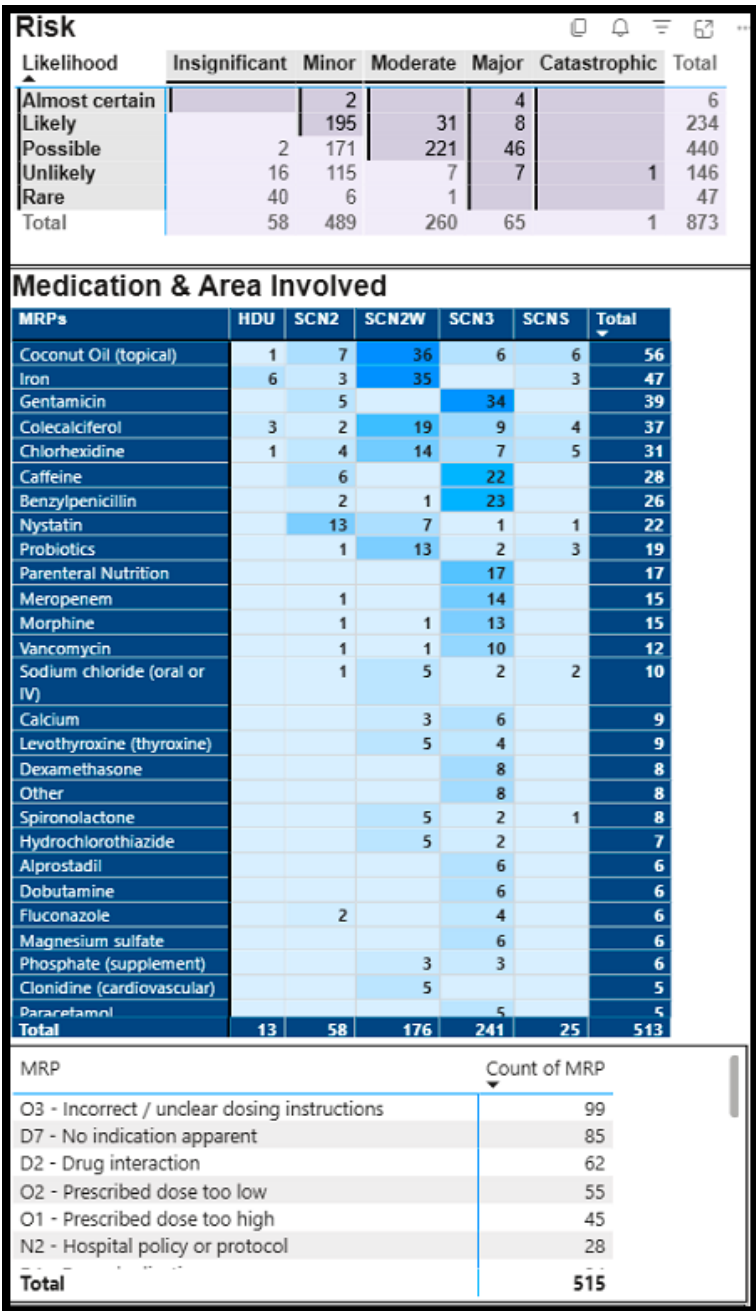


Figure 2. Medication Related Problems Rated as High and Extreme Risk using Risk Assessment Matrix assessing the likelihood and consequence/impact of a MRP if the pharmacist intervention is not made. Note: Figures with darker legends were interventions rated as high and extreme risk according to risk matrix [10,14].

Table 2. Pharmacist Recommendation (PR) following identifying Medication Related Problems in the Neonatal Clinical Care Unit.

Pharmacist Recommendation (PR)	Count of PR	% of PR
R9 - Refer to prescriber	454	52.0%
R1 - Dose increase	85	9.7%
R2 - Dose decrease	65	7.4%
R20 - Provided other information	58	6.6%
R6 - Dose schedule / frequency change	39	4.5%
R7 - Prescription not dispensed	39	4.5%
R12 - Refer to hospital	36	4.1%
R8 - Other changes to therapy	29	3.3%
R18 - Provide written summary of medication/s	25	2.9%
R14 - Laboratory monitoring	11	1.3%
R16 - Other referral required	9	1.0%
R4 - Formulation change	8	0.9%
R3 - Drug change	6	0.7%
R15 - Non-laboratory monitoring	4	0.5%
R10 - Refer to pharmacist (when identified by intern/technician)	2	0.2%
R17 - Provide education or counselling session	2	0.2%
R11 - Refer to another pharmacist	1	0.1%
Total	873	

Table 2. Medications involved in the Neonatal Intensive Care Unit pharmacist interventions.

Ward/Area Value	SCN3*	SCN2*	HDU*	SCN2W*	SCNS*	Total
MRPs						
Coconut Oil (topical)	15	20	2	58	6	101
Colecalciferol	15	12	5	57	7	96
Iron	3	15	9	65	4	96
Gentamicin	46	8	1			55
Probiotics	8	15	1	23	7	54
Chlorhexidine	11	16	1	18	6	52
Nystatin	9	30		12	1	52
Caffeine	34	14				48
Benzylpenicillin	37	7		3		47
Parenteral Nutrition	23	2				25
Morphine	16	1		1		18
Meropenem	16	1				17
Other	9			4		13
Vancomycin	10	1		1		12
Calcium	6			5		11
Levothyroxine (thyroxine)	5			5		10
Paracetamol	6			4		10
Sodium chloride (oral or IV)	2	1		5	2	10
Chloramphenicol	5	2		2		9
Dexamethasone	9					9
Hydrochlorothiazide	2	1		5		8

Spironolactone	2			5	1	8
Fluconazole	5	2				7
Alprostadil	6					6
Dobutamine	6					6
Magnesium sulfate	6					6
Phosphate (supplement)	3			3		6
Clonidine (cardiovascular)				5		5
Benzathine benzylpenicillin	2	2				4
Caspofungin	4					4
Heparin	4					4
Omeprazole				4		4
Other drugs for electrolyte imbalance	1	1	2			4
Oxycodone				4		4
Pregabalin				4		4
Tapentadol				4		4
Nystatin (skin)		2		1		3
Aciclovir	2					2
Epoetin alfa	2					2
Flucloxacillin		2				2
Probiotic				2		2
Sodium chloride	2					2
Azithromycin	1					1
Bosentan				1		1
Cefazolin	1					1
Cefotaxime				1		1
Diphtheria, tetanus and pertussis vaccines	1					1
Fentanyl				1		1
Folic acid				1		1
Furosemide (frusemide)	1					1
Levetiracetam	1					1
Linezolid	1					1
Meningococcal vaccines		1				1
Mupirocin (skin)	1					1
Pentoxifylline (oxpentifylline)	1					1
Phenobarbital (phenobarbitone)	1					1
Tamsulosin				1		1
Tramadol				1		1
Total	341	156	21	306	34	858

*SCN 3 Level 3 neonatal unit (Neonatal Intensive Care Unit) (CSF level 6); other neonatal units are Level 2 neonatal unit (CSF level 4 and 5) [12,13].

4. Discussion

This study evaluated pharmacist intervention patterns in a neonatal unit. Compared with a previous study conducted at the same hospital, the pharmacist intervention rate increased from 1.0 intervention/100 medication charts reviewed to 3.1 interventions/100 medication charts.[10]. At the

study hospital, pharmacists manually documented interventions using a paper-based system when performing clinical pharmacy services from 2001 to 2015. Interventions were subsequently transcribed into an Excel® spreadsheet and analyzed annually [10]. The pharmacist intervention documentation was transitioned to an advanced Microsoft Excel® spreadsheet in 2016 [16]. In 2022, an easy-to-use, readily accessible online platform on REDCap was introduced to improve efficiency in data entry and data analysis [15]. These initiatives may be one of the contributing factors to the increased intervention rates in this study compared to the previous study.

Medication-related problems (MRPs) involving medication dose remained as the most common MRPs, although reduced from our previous study of 47.67% of interventions documented in January 2005 to December 2014 to 36.7% of the pharmacist interventions [10]. Other studies on medication errors showed similar trends [6,8,17]. Pharmacist interventions made for MRPs related to hospital policy or protocol has increased to 17.4% from 10.69%, while the pharmacist interventions involving laboratory monitoring have been consistent in this study 4.6% compared to 4.92% [10].

Following pharmacist interventions, 454 (52%) were referred to the prescriber, 85 (9.7%) medication doses were increased while 65 (7.4%) medication doses were decreased. Besides medication review, the pharmacists also provided education or information on medication in 85 (9.7%) cases. Similar to previous studies carried out in the unit, the high- and extreme-risk MRPs on neonatal wards involved high-risk medications including antimicrobials e.g. caspofungin, vancomycin and gentamicin, morphine, dobutamine and total parenteral nutrition [10,14]. This is consistent with previous reports discussing the complexity of medication use in neonates with higher use of high-risk medications [7,17].

The pharmacy intervention trend analysis reflected change of practice for one specific medication. Coconut oil which has a complex administration regime based on neonatal gestational age, accounted for the highest MRPs. It was not reported in the earlier study as it had not yet been introduced into practice [10,14]. Although the consequence or impact for MRPs on coconut oil is low, the high incidents of pharmacist interventions (n=101) has renders it to be one of the high risks MRPs in the neonatal unit according to the risk matrix. Iron has remained very similar treatment protocol maintained to be the second most common medication in both studies [10,14].

Limitations of the study include: the underreporting of interventions by the pharmacists and the variability that lies within individual pharmacists in the documentation of clinical interventions. Measures in place to address such limitations include the continuous monitoring and analysis of pharmacist interventions in the study site, as long -term data provides greater number of records enable in-depth statistical analyses and examination of trends.

5. Conclusions

Our study demonstrates that hospital pharmacists play an integral role in ensuring neonatal medication safety and contribute to the reduction of MRPs in a neonatal unit. Regular analysis of pharmacist interventions provides valuable insights into local MRP trends and highlights opportunities for quality improvement and education.

Author Contributions: Conceptualization, ST and TL; methodology, ST and TL.; software, ST.; formal analysis, ST.; investigation, ST; data curation, ST; writing—original draft preparation, ST.; writing—review and editing, TL, GD, MF and NM.; visualization, TL and GD; supervision, ST; project administration, MF and NM. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Human Research Ethics approval was gained from the Women and Newborn Health Service Quality Improvement Committee (Approval number: GEKO 66020) at King Edward Memorial Hospital.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author(s).

Acknowledgments: The authors would like to acknowledge the contribution of the pharmacists at King Edward Memorial Hospital in documenting their valuable clinical interventions for the health service.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

MRP Medication Related Problems
NICU Neonatal Intensive Care Unit

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