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A health integrated platform for pharmacy clinical intervention data management and intelligent visual analytics and reporting

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ABSTRACT

Objective: Our initiative aimed to improve the system used to capture pharmacist clinical interventions to better support staff to document, manage and identify trends in medication-related problems (MRPs). The aim of the study was to develop an electronic tool which is easily accessible by most electronic devices with secure data storage and access.

Methods: A REDCap® database was designed for documentation of pharmacy clinical interventions. Information documented can be retrieved in real-time and can be integrated to Microsoft Power BI® for real-time data visualisation. The dashboards were customised to display useful information including pharmacy clinical intervention details, common MRPs, common medications involved available to users at real time.

Results: A total of 4343 interventions were documented from July 2022 to March 2023. The most common MRPs were omission of regular medications 876 (20.17%), condition untreated 722(16.62%), and contraindications apparent 451 (10.38%). The most common medications involved include iron 244 (5.62%), enoxaparin 231 (5.32%), macrogol laxatives 208 (4.79%), multivitamin 206 (4.74%), colecalciferol 179(4.12%), tramadol 156 (3.59%).

Conclusion: This study demonstrated the significance of integration of health application tools of REDcap and Power BI in the data management and intelligent visual analytics and reporting.

1. Introduction

Pharmacist clinical intervention is the process of a pharmacist identifying, and making a recommendation in an attempt to prevent or resolve a medication-related problem (MRP).[1] The value and impact of pharmacist clinical interventions are well documented world-wide.[1–4] Documentation is vital to demonstrate the benefit of service delivery in terms of patient morbidity and financial outcomes.[1–4] Documenting pharmacists' clinical interventions is also valuable to identify common institution-specific MRPs. This information can then be used to plan future targeted education for relevant clinical staff, and evaluate pharmacist impact which may subsequently impact hospital resource allocation to pharmacy services.[1–3] The documentation of pharmacist clinical interventions has mostly been through paper-based methods, electronic software such as Microsoft Excel® or Access®, in-house electronic documentation systems, website databases and within the electronic health record.[3,5–8]

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 analysed anually.[2] The analysis was time consuming and required significant data manipulation for each reporting period. Analysis was time consuming because besides MRPs which was entered in codes, all information including medication name, recommendation and action were entered in free text. Analysis also included data cleaning, for instance, colecalciferol may be entered as Vitamin D or Vit D or Vitamin. In March 2016, an efficient, low cost, low resource tool using advanced Excel®, which enabled automatic generation of reports and trends, was developed and implemented.[3] Pharmacists entered the intervention details in the database and relevant statistics including the frequency and percentage of each MRP type, pharmacist recommendation, action and risk could be analysed in real-

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time. The data were continuously accessible and available for use by the health service and individual staff members.[3]

Upon evaluating processes and systems in clinical intervention documentation, several areas for improvement were identified relating to pharmacist workflow. Firstly, the Excel® worksheet, saved in the hospital internal drive, could only be accessed using hospital computing devices or remote access. Secondly, a future-proof database with improved security in transit, in storage and access to information was desired. Inclusion of pharmacy technicians' ability to input clinical interventions was also desired, to recognise their value in identifying and escalating MRPs. Therefore, a documentation tool readily available to both pharmacists and pharmacy technicians, with increased data security and capable of big data utilisation was needed.

2. Objective

The initiative aimed to improve the system used to capture pharmacist clinical interventions, to better support staff to document, manage and identify trends in MRPs. The aim of the study was to develop an electronic tool which is easily accessible by most electronic devices, with secure data storage and access. A key element was to ensure quality improvement principals were embedded to enable regular systematic review of MRPs.

3. Methods

3.1. Study site

The 300-bed (including 100 neonatal cots) study hospital is the only tertiary maternity and gynaecological hospital in Western Australia. More than 6000 births take place annually and it is the only major referral centre in the state for high-risk pregnancies. The hospital also provides services to approximately 5000 women with gynaecological conditions each year. The hospital did not utilise electronic health records and computerised prescriber order entry during the study period. The inpatient areas with ward-based clinical pharmacy services include obstetrics, gynaecology and gynaecological oncology, perinatal mental health, and neonatology. Clinical pharmacy services are also provided in pre-admission clinics. The Society of Hospital Pharmacists Australia (SHPA) Standard of Practice for Clinical Pharmacy was used as a guide in the allocation of pharmacist staffing levels for provision of clinical pharmacy services.[1] Pharmacist clinical interventions made, during the provision of clinical service were documented as recommended in the national standard of practice.[1] Clinical pharmacy service included: medication reconciliation, assessment of current medication management, clinical review of medication prescribed on medication chart (chart review), therapeutic drug monitoring and adverse drug reaction management, contributing to the medication management plan, and facilitating continuity of medication management on discharge or transfer, as recommended by the SHPA Standards of Practice.[1] Most clinical pharmacists at the study site do not attend daily rounds with the medical team, except the neonatal intensive care unit pharmacist and the gynaecological oncology ward pharmacist who attend multidisciplinary team rounds once a week. Medication distribution in the hospital utilises a mixed model of medication imprest system and centralised pharmacy dispensing system. A medication imprest refers to a system with some commonly used medications supplied to the wards as 'ward stock'. Non-imprest medications prescribed for in-patients are dispensed by the centralised pharmacy dispensary once reviewed by the clinical pharmacist.

3.2. Design

This is a single centre, retrospective study describing the design and implementation of a documentation tool that is readily available, with increased data security and the capability of integration with data visualisation software. The documentation tool was used to validate analytics for descriptive data documented from 1st July 2022 to 31st March 2023. The number of medication charts reviewed were documented by the pharmacists. The occupied bed days during the study period were obtained from WebPAS, a patient administration system used by public hospitals in Western Australia. Both medication charts reviewed and occupied bed days were used in the analysis to provide an overall understanding of clinical pharmacy services, as the pharmacists may not be able to review every medication chart for all patients admitted due to high patient turnover for obstetric patients and limited clinical pharmacy resources for weekend admission.

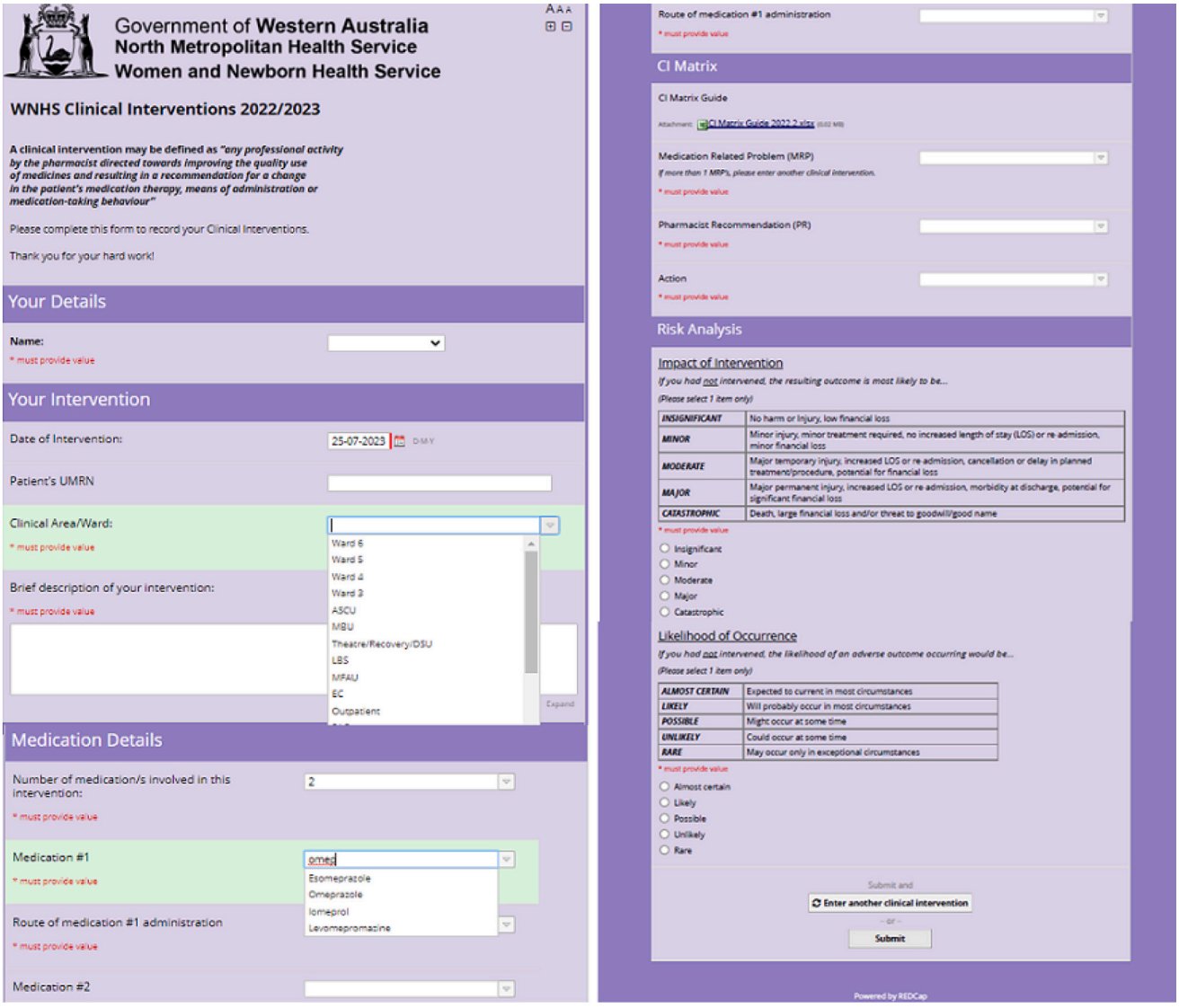
A working group consisting of pharmacists and pharmacy technicians was formed to lead the initiative. To ensure a collaborative approach, stakeholders, including pharmacy technicians, pharmacists, and pharmacy managers, were actively involved in the change management processes from inception. The working group communicated with the pharmacy team via departmental meetings and emails. This enhanced the opportunity for innovation and development of system-based solutions and translated to ownership of the process and successful implementation.

3.3. Data entry in REDCap® database

The Initial phase of the project planning was to explore and identify a suitable communication platform which is easy to use and access, convenient, and minimally resource dependent. Western Australia (WA) Health recently deployed the Research Electronic Data Capture (REDCap®) platform within its environment to assist with data management and workflow design.[9,10] It is a user-friendly, secure web-based application free to WA Health employees that allows the design of electronic forms and workflows as well as a comprehensive audit trail.[9–12] Data is encrypted in transit and in storage, while access to the database is via secure transfer to web browser.[11,12] REDCap® was identified as the most suitable platform for its innovation as a paperless, no cost, ease of use system that is supported by state-wide Health Support Services.[9,10]

Design of the REDCap® clinical interventions platform was based on the previous clinical intervention documentation matrix guide.[1,3] A clinical intervention documentation matrix guide (including the MRP, Pharmacist Recommendations and Actions Taken classifications) used in the study hospital was created based on the Pharmaceutical Society of Australia (PSA) and the SHPA models for intervention documentation.[1,3]. Information documented was divided into 5 sections: Staff Name, Intervention Details, Medication Details, Clinical Intervention Matrix, and Risk Analysis (Fig. 1). A risk analysis of the potential impact of interventions was made using the Australian Standards for Risk Management endorsed by the SHPA in which the severity of an MRP was determined by the potential consequence (impact) and likelihood of reoccurrence.[1–3] A guide to MRP matrix is available on the REDCap data entry webpage (Fig. 1). The data entry is simple, with a brief description of MRP as a single free text field, and remaining data entry data entry selected from prefilled options, either from a drop-down tab including clinical/ward area, medication name, medication-related problem or radio button for impact of intervention and likelihood of occurrence (Fig. 1). Medications listed in the Australian Medicines Handbook were included in the database, and users can select the medication name using the drop-down tab or type in the first few letters of the medication name to allow for auto-completion (Fig. 1).[13] REDCap® data entry can be performed on ward computers, handheld computers, and smart devices with internet access. It also allows data entry by multiple users simultaneously. Users are unable to manipulate the data once submitted. However, in the event of a data entry error, users can notify the clinical supervisor who can correct the error, inclusive of a traceable audit trail.

On 1st April 2022, the new clinical interventions platform was implemented in the hospital.



Medication Related Problem (MRP)				Pharmacist Recommendation (PR)	
Drug Selection		**Undertreated**		Dose increase	R1
Duplication	D1	Condition undertreated	U1	Dose decrease	R2
Drug Interaction	D2	Condition untreated	U2	Drug change	R3
Wrong drug	D3	Preventative therapy required	U3	Drug formulation change	R4
Incorrect strength	D4	Prescribing omission of regular medications	U4	Drug brand change	R5
Inappropriate dosage form	D5	Other untreated indication problem	U0	Dose schedule/frequency change	R6
Contraindications apparent	D6	**Monitoring**		Prescription not dispensed	R7
No indication apparent	D7	Laboratory monitoring	M1	Other changes to therapy	R8
Other drug selection problem	D0	Non-laboratory monitoring	M2	**Referral**	
Over or underdose		Other monitoring problem	M0	Refer to prescriber	R9
Prescribed dose too high	O1	**Education**		Refer to pharmacist (when identified by intern/technician)	R10
Prescribed dose too low	O2	Consumer requests drug information	E1	Refer to pharmacist for PIM/PPMC service	R11
Incorrect or unclear dosing instructions	O3	Consumer requests disease management advice	E2	Refer to hospital	R12
Other dose problem	O0	Other education or information problem	E0	Refer for a medicines review	R13
Compliance		**Not classifiable**		Monitoring: laboratory	R14
Under-use by consumer	C1	Not classifiable under another category	N0	Monitoring: non-laboratory	R15
Over-use by consumer	C2	Technician Intervention	N1	Other referral required	R16
Erratic use of medication	C3	Hospital policy or protocol	N2	**Providing Information**	
Intentional drug misuse	C4	**Toxicity or adverse reaction**		Provide education or counselling session	R17
Difficulty using dosage form	C5	Toxicity, allergic reaction or ADR present	T1	Provide written summary of medication/s	R18
Other compliance problem	C0	Documented ADR to drug	T2	Provide dose administration aid	R19
				Provided other information	R20
Action (A)				**PPMC/PIM**	
Prescriber				Pharmacist has partner charted regular medication/s (PPMC)	R21
Prescriber accepted recommendation	A1			Pharmacist has partner charted new medication/s (PPMC)	R22
Prescriber has not accepted recommendation	A2			Pharmacist has continued regular OTC medication/s (PIM - continuation)	R23
Pharmacist				Pharmacist has initiated new OTC medication/s (PIM - initiation)	R24
Pharmacist has accepted recommendation	A3				
Pharmacist has not accepted recommendation	A4				
Pharmacist has provided service as recommended	A5				
Patient					
Patient has accepted pharmacist Recommendation	A6				
Patient has not accepted pharmacist recommendation	A7				
Unknown at time of recording MRP	A0				

Fig. 1. Clinical Interventions Redcap Data Entry and Matrix Guide.

3.4. Data analysis by integrating REDCap® data in Power BI® dashboard

Information documented in REDCap® can be retrieved in real-time within the platform. Data can also be exported into Microsoft Excel®, allowing ease of analysis and reporting.[9–12] Additionally, REDCap® data can be integrated with Microsoft Power BI®, enabling real-time data analysis and interactive visualisation of information within custom fields.[14] The use of the Power BI platform to create a pharmacist intervention dashboard has recently been reported with positive outcomes.[8,15]

The Power BI® dashboard for pharmacy clinical interventions at the study site was designed to be interactive, allowing the user to explore multiple variables with graphic illustrations. The dashboards were customised to include useful information including pharmacy clinical intervention details, common MRPs, common medications involved and outcomes of MRPs and trend analysis. Trend analysis has shown to support the pharmacy team in evidence-based decision-making, such as education planning, quality improvement initiatives, business cases and monitoring of key performance indicators in the study hospital.[2,3] The information enables targeted, site-specific education to be provided to medical, nursing and midwifery staff.[16,17] Pharmacist interventions have also demonstrated the important activities of clinical pharmacy services in a clinical setting in optimising patient care in medication management.[18] The dashboard made a complex process of trend analysis simpler and allowed us to learn from MRPs to improve our medication management systems. The Power BI® dashboard was set to integrate with data documented in the REDCap® database.

3.5. Evaluation of the new system

The pharmacist intervention dashboard was made available to all pharmacy staff. Feedback was sought from the pharmacists following the implementation of new system in the fortnightly Clinical Pharmacist Meeting.

Human Research Ethics approval was gained from the relevant Quality Improvement Committee (Approval number: GEKO 49355).

4. Results

The Power BI® dashboard for clinical interventions is shown in Figs. 2-4. There was a total of 4343 MRPs documented from 1st July 2022 to 31st March 2023, of which the highest areas of interventions were made on: obstetric ward 3 (1557, 35.85%); gynaecology ward 6 (1101, 23.35%); obstetric ward 5 (1025, 23.60%); the Adult Special Care Unit (220, 5.07%); Mother Baby Unit (88, 2.03%); Special Care Nursery 2 West (83, 1.91%); Special Care Nursery 3 (73,1.68%) (Fig. 2). There were 94 interventions identified by staff who are not pharmacists, these interventions were documented by either pharmacy interns or pharmacy technicians. During the study period, a total of 24,964 medication chart reviews were documented, indicating an intervention rate of 17 interventions per 100 medication charts reviewed. A total of 44,281 occupied bed days were recorded for inpatient areas with ward-based clinical pharmacy services, indicating a rate of 9.8 interventions per 100 occupied bed days.

4.1. Medication-related problems

The most common MRPs were omission of regular medications (876, 20.17%), condition untreated (722, 16.62%), contraindications apparent (451, 10.38%), condition undertreated (296, 6.82%) and incorrect/unclear dosing instructions (276, 6.36%). The most common medications involved include iron (244, 5.62%), enoxaparin (231, 5.32%), macrogol laxatives (208, 4.79%), multivitamin (206, 4.74%), colecalciferol (179, 4.12%) and tramadol (156, 3.59%) (Fig. 2).

4.2. Pharmacist recommendation

Pharmacist recommendations are shown in Fig. 3. The top recommendations included referring to prescriber (1725, 39.72%), pharmacist charted a medication for continuation of therapy (429, 9.88%), referral

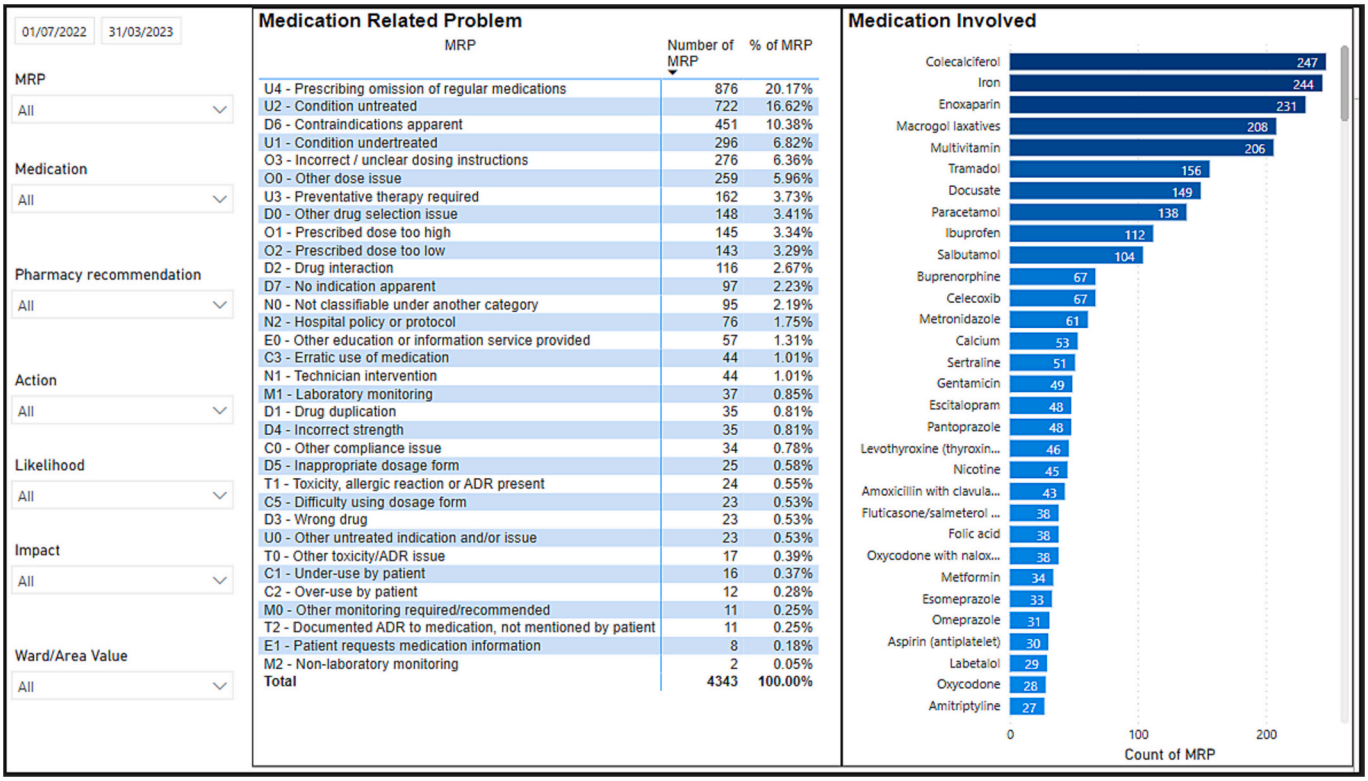
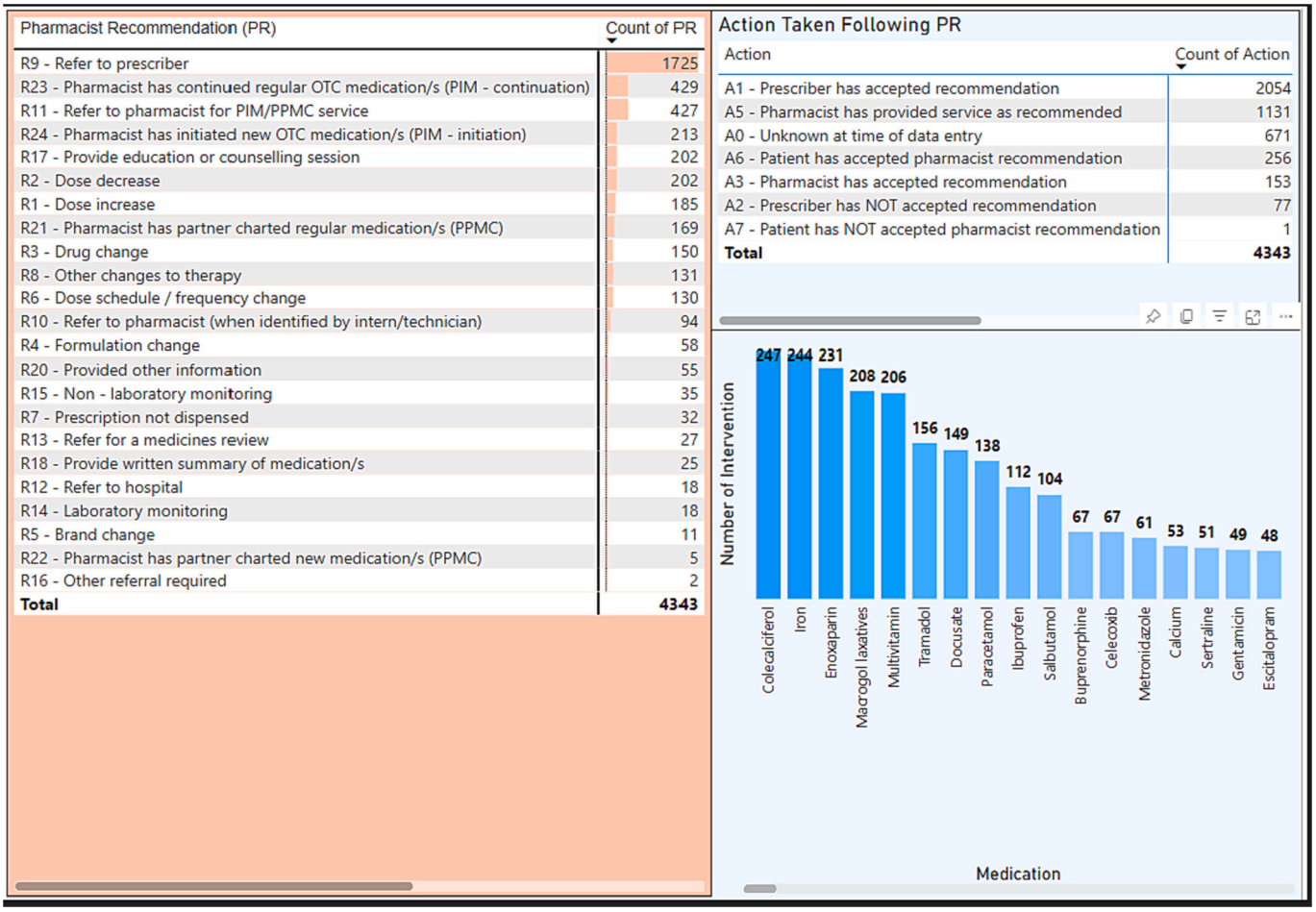


Fig. 2. Common Medication Related Problem and Medications Involved.

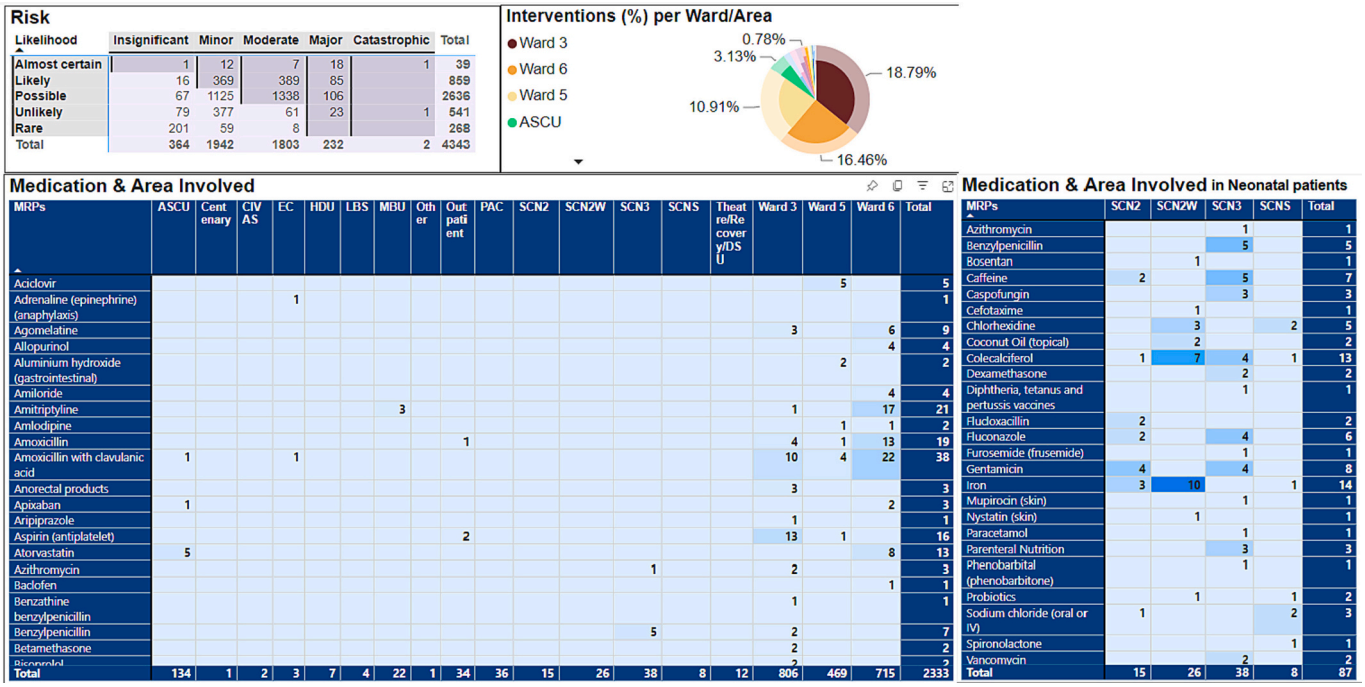


Pharmacist Recommendation (PR)	Count of PR
R9 - Refer to prescriber	1725
R23 - Pharmacist has continued regular OTC medication/s (PIM - continuation)	429
R11 - Refer to pharmacist for PIM/PPMC service	427
R24 - Pharmacist has initiated new OTC medication/s (PIM - initiation)	213
R17 - Provide education or counselling session	202
R2 - Dose decrease	202
R1 - Dose increase	185
R21 - Pharmacist has partner charted regular medication/s (PPMC)	169
R3 - Drug change	150
R8 - Other changes to therapy	131
R6 - Dose schedule / frequency change	130
R10 - Refer to pharmacist (when identified by intern/technician)	94
R4 - Formulation change	58
R20 - Provided other information	55
R15 - Non - laboratory monitoring	35
R7 - Prescription not dispensed	32
R13 - Refer for a medicines review	27
R18 - Provide written summary of medication/s	25
R12 - Refer to hospital	18
R14 - Laboratory monitoring	18
R5 - Brand change	11
R22 - Pharmacist has partner charted new medication/s (PPMC)	5
R16 - Other referral required	2
Total	**4343**

Action Taken Following PR

Action	Count of Action
A1 - Prescriber has accepted recommendation	2054
A5 - Pharmacist has provided service as recommended	1131
A0 - Unknown at time of data entry	671
A6 - Patient has accepted pharmacist recommendation	256
A3 - Pharmacist has accepted recommendation	153
A2 - Prescriber has NOT accepted recommendation	77
A7 - Patient has NOT accepted pharmacist recommendation	1
Total	**4343**

Fig. 3. Pharmacist Recommendation (PR) and Action Taken Following PR.



Risk

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic	Total
Almost certain	1	12	7	18	1	39
Likely	16	369	389	85		859
Possible	67	1125	1338	106		2636
Unlikely	79	377	61	23	1	541
Rare	201	59	8			268
Total	364	1942	1803	232	2	4343

Medication & Area Involved

MRPs	ASCU	Centenary	CIVAS	EC	HDU	LBS	MBU	Other	Outpatient	PAC	SCN2	SCN2W	SCN3	SCNS	Theatre/Recovery/DSU	Ward 3	Ward 5	Ward 6	Total
Aciclovir																	5		5
Adrenaline (epinephrine) (anaphylaxis)				1															1
Agomelatine																3		6	9
Allopurinol																		4	4
Aluminium hydroxide (gastrointestinal)																	2		2
Amiloride																		4	4
Amitriptyline							3									1		17	21
Amlodipine																	1	1	2
Amoxicillin									1							4	1	13	19
Amoxicillin with clavulanic acid	1			1												10	4	22	38
Anorectal products																3			3
Apixaban	1																	2	3
Aripiprazole																1			1
Aspirin (antiplatelet)									2							13	1		16
Atorvastatin	5																	8	13
Azithromycin													1			2			3
Baclofen																		1	1
Benzathine benzylpenicillin																1			1
Benzylpenicillin													5			2			7
Betamethasone																2			2
Bisoprolol																2			2
Total	134	1	2	3	7	4	22	1	34	36	15	26	38	8	12	806	469	715	2333

Medication & Area Involved in Neonatal patients

MRPs	SCN2	SCN2W	SCN3	SCNS	Total
Azithromycin			1		1
Benzylpenicillin			5		5
Bosentan		1			1
Caffeine	2		5		7
Caspofungin			3		3
Cefotaxime		1			1
Chlorhexidine		3		2	5
Coconut Oil (topical)		2			2
Colecalciferol	1	7	4	1	13
Dexamethasone			2		2
Diphtheria, tetanus and pertussis vaccines			1		1
Flucloxacillin	2				2
Fluconazole	2		4		6
Furosemide (frusemide)			1		1
Gentamicin	4		4		8
Iron	3	10		1	14
Mupirocin (skin)			1		1
Nystatin (skin)		1			1
Paracetamol			1		1
Parenteral Nutrition			3		3
Phenobarbital (phenobarbitone)			1		1
Probiotics		1		1	2
Sodium chloride (oral or IV)	1			2	3
Spironolactone				1	1
Vancomycin			2		2
Total	15	26	38	8	87

Fig. 4. Medication Related Problems Rated as High and Extreme Risk.
Note:Figures with darker legends were interventions rated as high and extreme risk according to risk matrix[1].

to a credentialed pharmacist for Pharmacist Medication Charting service which include medication initiation and partnered charting (427, 9.83%), and pharmacist initiated new medication (213, 4.90%). A total of 18 pharmacists were involved in interventions relating to charting medications for continuation or initiation of therapy (1069, 24.61%). The common medications charted by the pharmacist were multivitamins ($n = 93$), macrogol laxatives ($n = 81$), iron ($n = 66$), colecalciferol ($n = 64$) and salbutamol ($n = 43$). With regards to action following pharmacist recommendation, physicians accepted 2054 interventions, resulting in an acceptance rate of 47.29%. Pharmacist recommendation which was not accepted by the prescriber was low (1.77%). Other actions taken following pharmacist recommendation documented included pharmacist has provided service resolving the MRP identified (26.0%), action unknown at the time (15.5%), and patient has accepted pharmacist recommendation (5.9%).

4.3. Risk analysis

A total of 2349 (54%) MRPs were rated as high- and extreme-risk (Fig. 4). The common high- and extreme-risk MRPs for obstetrics, gynaecology and gynaecological oncology patients involved enoxaparin, opioids, analgesics including non-steroidal anti-inflammatories, anti-infectives, antidepressants, salbutamol, antihypertensives and hypoglycaemics. In neonatal patients, the medications involved in high- and extreme-risk MRPs included gentamicin, caffeine, total parenteral nutrition and other anti-infectives (Fig. 4).

4.4. Evaluation of the new system

The new data entry was very well received by the pharmacy team for its convenience, accessibility, and ease of use. However, it was requested that multiple medications could be documented under one intervention entry instead of only one medication for each entry. For instance, for an omission of 5 regular medications on admission, for the same patient, the data entry would be more convenient if only one intervention needed to be documented, listing all 5 medications involved rather than 5 separate interventions. On 1st July 2022, an improved version of REDCap® database was launched as a result.

The new data entry system improved data quality with drop-down menus of ward names and medication names, ensuring data consistency for all users. Previously, a significant amount of time was required to clean the data prior to analysis when compiling reports for other studies.[2,3] With the new system in place, visual analytics and reporting of pharmacist intervention is available in real-time without data curation.

The integration of data entered via REDCap® with the visual dashboard has allowed data analysis to be performed instantaneously. Users can obtain specific data by selecting the appropriate filters on the dashboard. Filters for date, MRP, medication, pharmacist recommendation, action, likelihood, impact and ward are available on the left side of each PowerBI dashboard, as shown in Fig. 2. For instance, one can filter a specific medication, the intervention type, ward, MRP and pharmacist recommendation using the interactive dashboard. Trend analysis over time may be performed by setting different date ranges using the date filter. Graphic reports of the analysis, such as Figs. 2-4, can be generated for relevant reports instantaneously by adjusting the filters.

Access to the PowerBI dashboard can be granted to relevant clinicians including medical, nursing and midwifery staff within the health organisation. The preference at the time was for the pharmacy to continue reviewing the intervention trends using the dashboard, and provide regular targeted, site-specific education for the medical, nursing and midwifery staff.[16,17]

5. Discussion

The common medications involved in the MRPs documented were comparable to previous studies reported[2,3] and another Australian Women Health Unit.[19] The two most common MRPs were omission of regular medications and condition untreated. The second most common pharmacist recommendation was related to pharmacist medication charting. This reflected the hospital Pharmacist Medication Charting (PMC) service, which was established in August 2020. Under the framework, credentialed pharmacists can chart medications for the continuation or initiation of unscheduled, Schedule 2 or Schedule 3 medications during admission, and the partnered charting of Schedule 4 and Schedule 8 medications during admission with medical staff.[20,21] Pharmacist-partnered charting initiatives have previously demonstrated feasibility and improved patient safety, reducing medication error rates.[22] The number of interventions documented relating to PMC reflects the successful implementation of the initiative in the hospital.

The pharmacy intervention dashboard enables trend analysis for a particular medication following change of practice or education intervention. For instance, there was a higher number of interventions compared to previous reports involving enoxaparin, with 5.3% ($n = 231$) of interventions documented during the 9-month period of this study, compared with 2.8% ($n = 299$) of interventions documented over 5 years in a previous study.[3] This may be due to the new hospital Venous Thromboembolism (VTE) Guideline and VTE risk assessment tool which has resulted in more women deemed appropriate for enoxaparin therapy for VTE prophylaxis.[23] The education following the guideline update may have increased the awareness of VTE assessment and recommended anticoagulation for a wider scope of patients, hence the potential increased reporting of MRPs involving enoxaparin.

The pharmacy intervention dashboard also enables comparison of various aspects of interventions with other sites with similar settings, including pharmacist recommendations, acceptance rate and risk assessment. The acceptance rate of pharmacy interventions by prescribers in the study is consistent with previous studies.[24,25] Some interventions identified were resolved by the pharmacists and patients. For instance, the pharmacists addressed more than 25% of the MRPs identified and most of these were addressed with the PMC service.

Common high-risk MRPs for neonatal, obstetric, and gynaecology and gynaecological oncology patients showed similar trends as previous reports.[2,3] The high- and extreme-risk MRPs on neonatal wards involved high-risk antimicrobials where the prescribed dose was too high (caspofungin, gentamicin), and the unintended medication prescribed due to look-alike, sound-alike medications (flucloxacillin instead of fluconazole). This is consistent with previous reports discussing the complexity of medication use in neonates with higher use of high-risk medications.[26,27]

This study demonstrated the significance of integration of health application tools of REDCap® and Power BI® in data management and intelligent visual analytics and reporting. It also highlighted the feasibility and potentially usability of the new system in the documentation of pharmacy clinical interventions. The automated tools developed in the study helped to generate valuable reports in a timely manner.

Limitations of the study include the variability that lies within individual pharmacy staff in the documentation of clinical interventions. This includes interpretation of the type of intervention and the risk assessment of MRP, as well as underreporting of interventions by the staff. Several measures are in place to address such limitations, including the use of pre-filled options in data entry and the matrix guide on the data entry page to provide guidance and consistency in documentation (Fig. 1). The designation of this user-friendly, easy to access health integrated platform is also aimed to promote reporting of interventions.

6. Conclusion

The integration of REDCap® with Power BI® in the data

management and visualisation of pharmacy clinical interventions has shown to be effective and feasible in the study hospital. Users could access reporting and analytics immediately with real time data. The integration is recommended for consideration in other pharmacy departments of similar settings.

CRediT authorship contribution statement

Jennifer Frestel: data curation, data analysis, visualisation, writing – original draft, formal analysis. **Stephanie Teoh:** conceptualisation, methodology, data curation, data analysis, writing – original draft. **Claire Broderick**: conceptualisation, data curation, methodology, writing – review & editing. **Anna Dao**: data curation, methodology, visualisation, writing – review & editing. **Monica Sajogo**: conceptualisation, data curation, methodology, writing – review & editing.

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Ethical statement

Human Research Ethics approval was gained from the Women and Newborn Health Service Quality Improvement Committee (Approval number: GEKO 49355) at King Edward Memorial Hospital.

Declaration of Competing Interest

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

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