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Medication appropriateness review: The effect of clinical pharmacist intervention on patients' safety and medication errors

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Abstract

Background: Medication errors are a significant threat to patient safety, often resulting in increased morbidity and mortality. The Medication Appropriateness Index (MAI) is a validated tool to evaluate the suitability of prescribed medications. Inadequate medication review, particularly in complex clinical settings, exacerbates these issues.

Objective:
This study aimed to evaluate the effect of clinical pharmacist-led medication appropriateness reviews on patient safety and medication errors, specifically using the MAI in a Palestinian tertiary care hospital.

Methods: A retrospective cohort study was conducted at Ibn Sina Specialized Hospital, Palestine, including adult inpatients admitted between February 2021 and January 2023 who received at least two medications. A total of 600 patients were enrolled, with 301 in the pre-intervention group and 299 in the post-intervention group. Medication orders were assessed using the MAI by trained personnel, and statistical analyses were performed using SPSS to compare the appropriateness of medications before and after the intervention.

Results: Post-intervention, the proportion of appropriate medications increased from 68.3% to 82.6%, while inappropriate prescriptions were eliminated (decreased from 1.4% to 0%). Clinical pharmacist intervention significantly improved MAI scores across most domains ($p < 0.05$). No significant association was found between polypharmacy and medication appropriateness, while no significant correlation was observed with the Charlson Comorbidity Index. Antimicrobial agents were the most reviewed medications. Overall, 89.35% of pharmacist interventions were accepted and implemented.

Conclusion: The study demonstrates that clinical pharmacist interventions significantly improve medication appropriateness in hospitalized patients, supporting their essential role in multidisciplinary healthcare teams. These findings advocate for expanded pharmacist involvement in medication management to enhance patient safety and reduce medication-related risks. Future studies should assess the long-term impacts of such interventions on clinical outcomes and healthcare utilization in various clinical settings.

Keywords: Clinical pharmacist intervention; Medication appropriateness; Medication Appropriateness Index (MAI); Patient safety; Medication errors; Palestine

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1. Introduction

Patient safety has been one of the major concerns for healthcare providers (KIM, KWON, KIM, and CHO, 2011). Promoting high-quality care that prevents or minimizes harmful risks associated with healthcare practices is a fundamental component of patient safety (Bressan, Mio, and Palese, 2020). Among patient safety issues such as patient identification, transfusion error, falls, and suicide, medication safety has been considered a significant indicator of healthcare quality. Medication error is any preventable event that may cause or lead to inappropriate use of medications or patient harm (Hammoudi, Ismaile, and Abu Yahya, 2018; KIM et al., 2011). Also, medication errors are a significant public health problem and a leading cause of death. They substantially impact the quality of patient care and healthcare institutions in the United States (Rodziewicz, Houseman, and Hipskind, 2022). It is challenging to uncover a consistent cause of errors and, even if found, to provide a consistent, viable solution that minimizes the chances of a recurrent event. Thus, recognizing medication errors and taking appropriate action is critical. As a result, healthcare institutions are strongly encouraged to implement a systematic and organized reporting system to identify potential sources of drug errors.

Several medical centers in more than 100 countries seek to achieve JCI accreditation, which aims to improve patient safety and healthcare quality (7TH Edition JCI). (Lazaryan et al., 2016). As several hospital standards have been published, one of the aspects regarding patient care is Medication Management and use, which includes the organization and management of medication, storing, ordering and prescribing, preparing and dispensing, administration and monitoring. A trained and professional pharmacist must review medication orders or prescriptions according to JCI standards involving the appropriateness of the drug, the dose, frequency, route of administration, therapeutic duplication, drug-drug interactions, and others. (Lazaryan et al., 2016)

Multi-morbidity, chronic diseases, and poly-medication have increased over the last decade and are expected to continue to grow. As a result, several problems with medication therapy arise, such as non-adherence, over-and under prescribing adverse effects, and drug-drug interactions. (Waltering, Schwalbe, and Hempel, 2022), (Köhler et al., 2000). The occurrence of adverse events caused by errors is one of the top 10 causes of disability and mortality in the world. In developed countries, one out of every ten patients suffers an injury while receiving hospital care, with half of these cases being preventable. In addition, it is estimated that 134 million adverse events occur each year in hospitals in underdeveloped nations, resulting in 2.6 million deaths due to improper care. (Afaya, Konlan, and Kim Do, 2021). A study conducted in 2011 showed that the cost of treating medication errors and their consequences related to injuries at the hospital is approximately 3.5 billion dollars per year (Bootman, Wolcott, Aspden, and Cronenwett, 2006; Kim et al., 2011). Moreover, inappropriate prescribing is widespread in older hospitalized patients and may increase the likelihood of hospitalization. If the risk of ADE outweighs the clinical benefit, a medication is considered inappropriate, especially if safer and/or more effective medications are available for the condition. In addition, prescribing medications at high doses, for long periods, and with an increased risk of drug-drug or drug-disease interactions is not suitable. Furthermore, healthcare clinicians are becoming increasingly conscious that excluding potentially beneficial drugs from treatment is also improper. (Vezmar Kovačević et al., 2014),(A. Spinewine et al., 2007), (Cahir, Bennett, Teljeur, and Fahey, 2014)

Aim of the Study

This study aims to evaluate the effect of clinical pharmacist verification regarding medication appropriateness on patients' safety and medication errors.

2. Methodology

2.1. Study Context

The study will be conducted at Ibn Sina Specialized Hospital, Jenin, Palestine, one of the largest hospitals in the West Bank, a tertiary care facility with 96 beds and a total space of 20,000 square meters, seeking to obtain the Joint Commission International Accreditation (JCI).

2.2. Research Design

A retrospective cohort design will be used to achieve the study goals. Descriptive statistics will be used to reveal the frequencies, and correlation will be utilized to understand the association between the medication appropriateness index and the independent variables (Prescriber characteristics, Patient's comorbidities, and the clinical pharmacist intervention).

2.3. Study Population

All patients admitted to the hospital between February 2021 till January 2023 were considered the study population. Therefore, 5843 patients were the total number of patients who were admitted to the hospital during that period.

2.4. Sample Size

The Sample size was calculated by the Raosoft® sample size software of prevalence studies calculated by assuming a 5843 population of patients in the hospitals, followed by a 95% Confidence Interval and a 5% Margin of Error. Therefore, the recommended sample size to be enrolled in this study is 348 patients.

2.5. Sampling frame

2.5.1. Inclusion

In-patients, adults (more than or equal to 18 years old) who received two or more medications during the hospitalization period will be included.

2.5.2. Exclusion

Patients younger than 18 years or those who received less than two medications will be excluded.

After applying the inclusion and exclusion criteria, a simple random sampling method will take place to select the study sample. Figure 2 shows the population, inclusion, and exclusion criteria.

2.6. Data Collection Instrument

The medication review was based on the patient sociodemographic, clinical assessment, and drug history. In addition, the Medication Appropriateness Index was used to assess the outcome measurements (MAI).

The Medicine Appropriateness Index (MAI) uses ten criteria to determine if a medication is appropriate for the Patient was used in different studies (Hanlon and Schmader, 2022), (Schmader et al., 1994).

2.7. Validity and Reliability

The instrument was valid and reliable as per (West, Cordina, and Cunningham, 2012), (Kassam, Martin, and Farris, 2003; Samsa et al., 1994),(Anne Spinewine, Dumont, Mallet, and Swine, 2006).

2.8. Medicine Appropriateness Index (MAI)

The ten criteria of the MAI, phrased as questions, apply to each Patient and drug in question. The following criteria are a drug's indication, drug effectiveness for the Patient's condition, proper dosage and directions, practical directions, drug-drug interaction, drug-disease interaction, unnecessary duplication with other drugs, duration of therapy, and cost-effectiveness. Each criterion for prescribing appropriateness is rated on a scale from 1 to 3, indicating whether the medicine is appropriate, marginally appropriate, or not appropriate. Option Z, which signifies "Do not know," can be selected if further information is needed to answer a question. If a drug is deemed 'Appropriate' or 'Marginally appropriate,' it receives a score of zero. Each medication is assigned a maximum score of 1, 2, or 3 for each of the 10 MAI criteria regarded as 'not appropriate.' For indication and effectiveness, a three-point scale is used. Dosage, proper directions, practical directions, and drug-drug interactions are all given a two-point rating. Drug-disease interactions, cost, duplication, and duration are all given a one-weighted score. As a result, the total cumulative score ranges from 0 to 18. (0 means the drug is appropriate, and 18 represents maximal inappropriateness). (West et al., 2012)

Participants in the data collection will undergo personnel training to have the same precise data collection method. Also, the data collected regarding patient information included patient sociodemographics, hospital departments, diagnosis, patient medical history, and medications obtained from the hospital's patient information system and pharmacy computer system.

2.9. Data management

2.9.1. Data collection

Data Collection Will start after obtaining all needed approvals. Data Collection Personnel will be trained on the study instrument. For data quality control, An expert senior clinical pharmacist will be consulted to evaluate the clinical pharmacists' interventions. Figure 4 explains the data collection plan.

2.9.2. Data Analysis Plan

After data collection, statistical analyses will be completed using the Statistical Package for the Social Sciences (SPSS 21.0) computer program to determine and measure frequencies, central tendency, and correlation between variables (MAI as dependent variable and Patients conditions, clinical pharmacist intervention and prescriber characteristics as independent variables).

3. Results

In this study, 600 patients were enrolled, with 299 participating post-intervention and 301 in the pre-intervention cohort. Patient demographics are detailed in Tables 1 and 2. A slight discrepancy was observed in the Carlson Comorbidity Index scores, with the post-intervention group averaging higher (2.32 ± 2.30). Additionally, a larger fraction of patients were admitted to specialized units: 25.8% to the intensive care unit and 20.4% to the cardiac care unit in respective groups. Antimicrobial drugs were the most commonly evaluated medication class in both cohorts. The incidence of polypharmacy was comparable between pre- and post-intervention groups, at 23.1% and 19.9%, respectively.

Table 1 Descriptive Data of sociodemographics

Patient Characteristics		**Pre - MAI score**			**Post - MAI score**		
		N	**Mean**	**Std. Dev.**	**N**	**Mean**	**Std. Dev.**
1	Age	301	48.18	20.93	299	52.81	21.35
2	Number of medications	260	2.51	3.32	233	2.7	3.34
3	Carlson Comorbidity Index	292	1.68	2.03	297	2.32	2.30

Table 2 Descriptive Data of sociodemographics

Patient Characteristics			**Pre - MAI score**		**Post - MAI score**	
			Frequency	**Percentage**	**Frequency**	**Percentage**
1	Polypharmacy (More than 5)	Yes	60	19.9%	69	23.1%
		No	199	66.1%	162	54.2%
		Not documented	42	14%	68	22.7%
2	Hospital Ward	CCU	87	28.9%	61	20.4%
		ICU	22	7.3%	77	25.8%
		Open Ward	192	63.8%	161	53.8%
3	Drug Class	Anti-convulsant	1	0.1%	23	2.9%
		Analgesic	189	17.9%	18	2.3%
		Anticoagulant	82	7.8%	41	5.3%
		Antiemetics	6	0.6%	8	1%
		Antihypertensive	60	5.7%	5	0.6%

		Antimicrobial	301	28.6%	518	66.4%
		Antiplatelet	135	12.8%	4	0.5%
		Antipsychotic	0	0%	5	0.6%
		Bronchodilator	4	0.4%	1	0.1%
		Corticosteroids	12	1.1%	29	3.7%
		Diuretics	12	1.1%	9	1.2%
		PPIs	112	10.6%	44	5.6%
		Statins	84	8%	28	3.6%
		Other	56	5.3%	47	6%

The clinical pharmacist's intervention led to a notable improvement in medication appropriateness, evidenced by a substantial increase in the Medication Appropriateness Index (MAI) score; none of the medications were deemed inappropriate post-intervention. Furthermore, compliance with the intervention was observed in 697 cases, accounting for 89.35% of the evaluations. The classification of MAI scores for patinets in the pre-and post-intervention periods is shown in Table 3.

Table 3 The proportions of medication the in the pre and post intervention phases according to medication appropriateness classifications

Appropriateness	**Pre-MAI score**		**Post-MAI score**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Appropriate	720	68.3%	644	82.6%
Marginally Appropriate	319	30.3%	136	17.4%
Inappropriate	15	1.4%	0	0.0%

Patients on fewer than five medications exhibited the highest rates of medication appropriateness. However, no significant correlation was found between polypharmacy and MAI scores. Post-intervention, approximately 43% of medication orders underwent review by the clinical pharmacist for appropriateness, revealing a significant relationship between medication appropriateness and the pharmacist's review (p-value < 0.000).

The analysis showed no significant correlation between the Carlson Comorbidity Index and medication appropriateness during either phase of the intervention. Conversely, as outlined in Table 4, all components of the MAI score significantly correlated with the intervention phase (p-value < 0.05), with most components showing a decrease in mean scores. Specifically, Practical directions saw a marked reduction from an average of 0.55 to 0.005. Mean values for drug indication, effectiveness, drug-drug interactions, correct dosage, and directions decreased to 0.57 (1.17), 0.57 (1.18), 0.15 (0.52), 0.028 (0.24), and 0.013 (0.16), respectively. Conversely, in the post-intervention phase, the average scores for drug-disease interaction and duplication rose to 0.014 (0.12) and 0.12 (0.33), respectively.

Table 4 Comparing means of the MAI Items for post and pre-intervention

MAI Items		**N**	**Mean**	**Std. Deviation**	**Sig. (2-tailed)**
Drug indication	Pre MAI	1054	0.9393	1.39192	0.000
	Post MAI	782	0.5662	1.17269	
Effectiveness	Pre MAI	1054	0.9820	1.40838	0.000
	Post MAI	782	0.5739	1.17877	
Correct dosage	Pre MAI	1054	0.2638	.67704	0.000
	Post MAI	782	0.0285	.23579	

Correct directions	Pre MAI	1054	0.2448	.65578	0.000
	Post MAI	782	0.0130	.15960	
Practical directions	Pre MAI	1054	0.5541	.89550	0.000
	Post MAI	782	0.0053	.10114	
DDI	Pre MAI	1054	0.2960	.71055	0.000
	Post MAI	782	0.1466	.52036	
Drug-disease interactions	Pre MAI	1054	0.0047	.06874	0.04
	Post MAI	782	0.0142	.11790	
Duplication	Pre MAI	1054	0.0313	.17423	0.000
	Post MAI	782	0.1221	.32692	
Duration of therapy	Pre MAI	1054	0.5588	.49676	0.000
	Post MAI	782	0.3053	.46020	
Expense	Pre MAI	1054	0.3264	.46911	0.000
	Post MAI	782	0.2003	.39981	

4. Discussion

This investigation aligns with previous studies that have underscored the efficacy of pharmacist-led interventions in enhancing Medication Appropriateness Index (MAI) scores for hospitalized patients, particularly among elderly, as evidenced by several research findings (Beckett, Crank, and Wehmeyer, 2012; Bergkvist, Midlöv, Höglund, Larsson, and Eriksson, 2009; Burnett, Scott, Fleming, Clark, and McElnay, 2009; Gillespie et al., 2013; Léguillon et al., 2023; Nachtigall, Heppner, and Thürmann, 2019). Our study corroborates these findings, demonstrating that clinical pharmacist interventions significantly reduce medication errors and inappropriateness, as indicated by improved MAI scores. This underscores the value of incorporating clinical pharmacists into multidisciplinary healthcare teams to enhance patient outcomes through improved medication prescribing practices. The inclusion of clinical pharmacists not only augments the frequency and quality of medication reviews and clinical interventions but also shows a notable improvement in medication appropriateness, with a significant reduction in inappropriate prescriptions across all MAI domains, excluding duplication. Similar to our primary outcome results, the differences in the mean MAI score were improved and greater in the clinical pharmacist intervention compared without the clinical pharmacist. (Khazaka et al., 2021).

Our results revealed an increase in the proportion of appropriate medications from 68.3% in the pre-intervention phase to 82.6% post-intervention,This is comparable to a study where the intervention group's mean MAI scores per patient decreased overall to 7.45 (Walsh, O'Riordan, Kearney, Timmons, and Byrne, 2016). Despite no observed correlation between the Charlson Comorbidity index and medication appropriateness in our study, the broader literature has yet to establish a definitive link between MAI scores and outcomes such as mortality or hospital admissions(Walsh et al., 2016) . The challenge of polypharmacy, particularly its association with potentially inappropriate medication due to elevated adverse event risks or inefficacy, was also explored. Our findings indicate that polypharmacy did not significantly impact medication appropriateness as the percentage of polypharmacy in the pre- and post-intervention were 19.9% and 23.1%, respectively. However, another study reported that 94.1% of the patients with comorbidities and polypharmacy had at least one criterion for drug inappropriateness according to the MAI , as well as that patients taking more than 10 drugs had a significantly higher presence of inappropriateness (Lopez-Rodriguez et al., 2020).

Prospective studies have linked lower MAI scores with decreased medication-associated hospitalizations, rehospitalizations, drug-related difficulties, and enhanced prescribing practices (Hellström et al., 2011; Lund, Carnahan, Egge, Chrischilles, and Kaboli, 2010; Shanika et al., 2018), highlighting the potential for improved medication management to mitigate drug-related issues. Although these outcomes were not explicitly addressed in our study, lower MAI scores will eventually lead to reduced drug-related problems.

In the intervention group, the proportion of inappropriate prescriptions dropped in all ten MAI areas, while in the control groupl, it increased in five domians. In contrast, in our study the post-intervention group’s mean MAI decreased for all MAI domians with the exception of the duplication item.(Patterson et al., 2014) Regarding the MAI items, the

highest mean of MAI score in the pre-intervention phase was effectiveness and drug indication , while another study reported that incorrect dosages is the second commonly encountered types of inappropriatness with 18.5% wrong dosages (West et al., 2012)and in other studies. (Phillips et al., 2001; Schmader et al., 1994)

Gastric (50.6%) and central nervous system (23.9%) medication classes were the most frequently associated with appropriateness issues (Hanlon et al., 2004); however, our investigation identified antimicrobial medications as the predominant class in in the pre and post-intervention 28.6% , 66.4% respectively, as well as analgesics (17.9%) and PPI (10.6%) in the pre-intervention period.Additionally, the pervasive issue of medication inappropriateness leading to increased adverse drug events, healthcare utilization, and mortality emphasizes the importance of targeted interventions (Hamilton, Gallagher, and O'Mahony, 2009). Our findings indicated that, prior to the intervention, the medication was deemed marginally appropriate or inappropriate in percentages of 30.3% and 1.4%, respectively. However, in an in-patient setting and emergency department, the rate of inappropriate prescription was found to be 55.1% and 78.3%, respectively. (Hanlon et al., 2004; West et al., 2012).

This study represents a pioneering effort in Palestine to evaluate the impact of clinical pharmacists on medication appropriateness within clinical settings, particularly emphasizing interventions in critical care units where adverse events and polypharmacy are notably prevalent. Despite its innovative approach, the study acknowledges limitations such as its single-setting design, reliance on two clinical pharmacists for MAI application, and the MAI's inability to address broader medication use concerns such as patient adherence and the cause of adverse drug reactions. The retrospective design also poses challenges related to potential confounding factors and missing data in the electronic health records including missing data of medication lists on admission or medication history which reflects the reduced activity of medication reconciliation, which could affect the evaluation of clinical interventions.

5. Conclusion

In conclusion, our findings advocate for the integration of clinical pharmacists into healthcare teams as a strategy to improve medication management, reduce adverse events, and enhance care quality for patients with complex medication regimns. Future research should extend the assessment of clinical pharmacists' roles across multiple hospitals and settings to validate the generalizability of these findings and explore the impact of clinical pharmacists in diverse clinical scenarios.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study was conducted in compliance with ethical principles. No patients' personal information was collected for the study, and patient confidentiality was strictly maintained throughout. All aspects of the study protocols, including access to and use of the patient clinical information, were approved by the Ibn Sina Specialized Hospital's Institutional Review Board (IRB). Verbal and written consent was obtained, and all methods were performed in accordance with the relevant guidelines and regulations. Only the primary investigator had access to the patient data after obtaining the necessary approvals from the hospital administration. Any discovered medication errors during the study were reported to the hospital's quality department, with the responsibility for addressing the errors resting solely with the hospital administration and not the research team.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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