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The Role of Clinical Pharmacy in Preventing Prescribing Errors in the Emergency Department of a Governmental Hospital in Jordan: A Pre-Post Study

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Abstract

Background: Clinical pharmacists have a vital role in intercepting prescribing errors (PEs) but their impact within a Jordanian hospital emergency department (ED) has never been studied. **Objective:** To evaluate the impact of clinical pharmacy services on PEs and assess predictors of physicians' acceptance of clinical pharmacists' interventions. **Setting:** This study was conducted in the ED of the largest governmental hospital in Jordan. **Method:** This was a pre-post study conducted in October and November 2019 using a disguised observational method. There were 2 phases: control phase (P0) with no clinical interventions, and active phase (P1) where clinical pharmacists prospectively intervened upon errors. The clinical significance of errors was determined by a multidisciplinary committee. The SPSS software version 24 was used for data analysis. **Main Outcome Measure:** PEs incidence, type, severity, and predictors for physicians' acceptance. **Results:** Of 18003 patients, 8732 were included in P0 and 9271 in P1. PEs incidence decreased from 24.6% to 5.4%. Contraindication, drug selection, and dosage form error types were significantly reduced from 32.6%, 9.1%, and 3.7% (P0) to 12.6%, 0.0%, and 0.0% (P1), respectively. Albeit not statistically significant, drug-drug interaction, drug frequency, and allergy error types were reduced from 4.9%, 3.1%, and 0.1% to 4.5%, 2.5%, and 0.0%, respectively. Significant and serious errors were significantly reduced from 68.7% and 3.0% (P0) to 8.9% and 1.8% (P1), respectively. During P1, most errors were minor (89.3%, 1574/1763), and lethal errors ceased. Predictors for physicians' acceptance were: significant errors (OR 3.1; 95% CI 2.6-4.3; P = 0.03) and non-busy physicians (OR 2.1; 95% CI 1.6-2.7; P = 0.04). **Conclusion:** Clinical pharmacists significantly reduced PEs in the ED by 76%; most of interventions were significant. Policymakers are advised to implement active clinical pharmacy in the ED.

Keywords

medication errors, clinical services, medication safety, physician prescribing

Impact on Practice

- The provision of clinical pharmacy services in emergency departments significantly decreases prescribing errors.
- Clinical pharmacists can intervene to prevent potential serious and life-threatening errors in emergency departments.
- Continual professional development programs are required to enhance the clinical skills of hospital pharmacists.

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Introduction

Prescribing errors (PEs) are common, occurring in in 50% of hospital admissions[1,2] and preventable. The incidence of PEs in the UK has been reported to be 8.4%[3] and in Saudi Arabia PEs incidence ranged from 7.1% to 94% of prescriptions.[4] Although PEs can occur in any medical ward, the emergency department accounts for a large number of medication errors.[5] Clinical pharmacists (CPs) are vital healthcare professionals mitigating medication errors, particularly PEs in hospitals.[6-18] Moreover, CPs have a crucial role in preventing PEs in EDs before reaching patients.[17,19-21] There is much evidence from around the world highlighting the impact of pharmacists on medication safety.[6,11,12,22,23] There is less evidence from the Middle East, however, an Iranian study reported that CPs identified 498 errors; most of CPs' recommendations were accepted by physicians[24] and another Iranian study showed that half of CPs' interventions were deemed moderate to life-saving.[25] Within Jordan, a study tracked CPs' recommendations at a university hospital and found that around 70% of physicians accepted CPs' interventions.[26] Clinical pharmacy services in the ED are less studied, traditionally being outside of the typical hospital pharmacist duties. However, the potential benefit of clinical pharmacists in the ED is increasingly recognized[27] and studies have shown the impact ED pharmacists can have in this setting. In the USA, CPs reduced medication errors by 80% and saved over 800 000$ annually at an emergency department of children's hospital.[28] In Iran, medication errors rate was reported to be high in the ED, many of these errors were related to prescriptions.[29]

However, clinical pharmacy services are not actively implemented in Jordanian hospitals, especially with the ED. Most pharmacists working in the ED setting in Jordan are pharmacists without special clinical training.[30-33] Whereas Pharmacists who have undertaken clinical training in Jordan take an active role in managing clinical conditions, such as hyperglycemia, chronic kidney disease, asthma, and dyslipidemia.[30-33] Having such specialist clinical pharmacists working in the ED could have a positive impact on ED patient care. However, there is a scarcity of studies related to clinical pharmacy contributions in PEs detection in the emergency department. Our study was the first pre-post study in the Middle East to investigate the impact of CPs in preventing PEs in the emergency department. Our primary hypothesis was that the implementation of clinical pharmacy services in the emergency department would result in a considerable reduction of PEs.

Aim of the Study

The study aimed to: (1) assess the impact of clinical pharmacy services on the rate of prescribing errors; and (2) assess the predictors of physicians' acceptance of CPs' prescribing error interventions in the emergency department of a large governmental hospital in Jordan.

Ethics Approval

The study was approved by the Ministry of Health in Jordan, the Administrative Committee of Al Bashir Hospital (Code. MOH REC 1900051), and the Institutional Review Board (IRB) at the University of Petra (no. 7H-06-2019).

Method

Study Design and Setting

This study was a pre-post study conducted in the emergency department of the biggest governmental hospital in Jordan over 8 weeks from early October 2019 to the end of November 2019. The study was divided into 2 phases (Figure 1): retrospective pre-intervention control phase (P0) and prospective intervention active phase (P1). The study was carried out in a 45-bed emergency department of Al-Bashir Hospital, where more than 600 000 patients receive healthcare annually. There were 3 rotating shifts in the emergency department per day and the total number of emergency department doctors was 77; either general practitioners or emergency department specialists. The total number of pharmacists in the emergency department was 8. Most of them had 3 to 5 years of experience in hospitals and none of them had clinical pharmacy practice training. There were 3 doctors for each 8-hour shift. In the emergency department, doctors diagnosed patients and wrote prescriptions on the electronic patient record (EPR), "Hakeem©". In order to minimize the Hawthorne effect doctors were blinded to the study aim. We used the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist as a guide to reporting our study.[34]

Data Collection

During the P0 phase, data were collected retrospectively by disguised direct observation over 4 weeks by the research team, which included a Senior CP (DAQ) and a CP (AAM). The research team had access to all data in the EPR, such as: history of present illness, past medical history, medical images, laboratory tests, current and past medications, allergies, in-patient and out-patient clinic visit notes, and medication orders. The research team met each day to agree upon the occurrence and type of errors recorded and these were recorded using a standardized PE reporting form to calculate incidence of PEs. For ethical reasons, during the P0 phase, the research team communicated all detected errors to the head of the emergency department and emergency department pharmacists. During the P1 phase, the CP (AAM) provided full clinical pharmacy services: interviewing patients, performing medication use reviews, contacting physicians to resolve potential PEs within 1 to 3 hours of prescribing. They also recorded physicians' acceptance of CP's interventions. The Senior CP (DAQ) simultaneously investigated, reviewed, and confirmed all potential PEs during the P1 phase. One

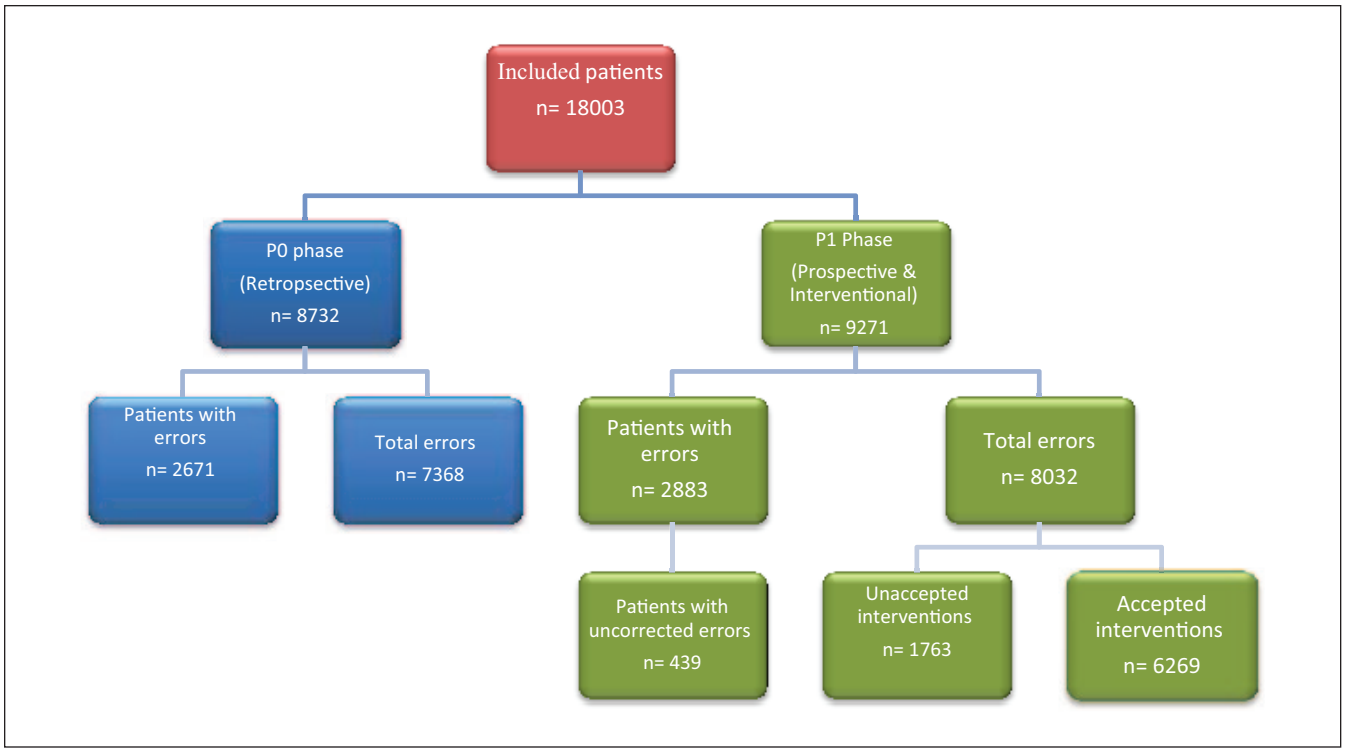

Figure 1. Classification patients and errors during P0 and P1 phases.

working shift was randomly selected in each data collection day: the morning shift (8:00 AM-4:00 PM), the evening shift (4:00 PM-12:00 AM) or the night shift (12:00 AM-8:00 AM). During both phases, CPs used the same PE reporting form and the same operational definitions which were adopted from Dean Franklin's article.[35] A PE can be defined as *"a clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant reduction in the probability of treatment being timely and effective or increase in the risk of harm when compared with generally accepted practice."*[35] All emergency department patients classified with non-life threatening injuries during the study period were included. Patients with life-threatening injuries and patients from other wards, who came to the emergency department pharmacy to have their medicines dispensed, were excluded. Clinical pharmacists' interventions not associated with PEs were also excluded.

Piloting

A small-scale preliminary study was conducted in order to evaluate feasibility, time and practicality prior to conducting the full-scale study. Piloting was conducted in the emergency department for 3 days per each phase. As a result of piloting, many modifications to the data collection method were made; for example: prospective observation was adopted instead of the originally planned retrospective method to ensure reliability and reproducibility of results and we decided to contact physicians within 3 hours instead of 7 days to increase physicians' ability to recall the details of the cases.

PEs Incidence

Abdel-Qader et al's formulae[36] were adopted to calculate the incidence of PEs; this was calculated as the total number of PEs divided by the total number of medication orders recorded plus those omitted in error. A medication order is a direction given by a physician to dispense and administer a medication for a certain medical indication.[37] A prescription may contain one or more medication orders.

Severity of PEs

A multidisciplinary committee, comprised of an independent senior emergency department physician, a senior clinical pharmacist (DAQ) and a clinical pharmacist (AAM), assessed the severity of PEs. The committee had access to each case's brief clinical information, such as: demographics, diagnosis, drug selection, dose, frequency, duration, hypersensitivity, contraindications, and microbiology investigation results (including antibiotic susceptibilities of any identified pathogens) against the British National Formulary (BNF; 74th edition) and the CP intervention notes. Overhage and Lukes' severity scale[38] was used to grade errors into

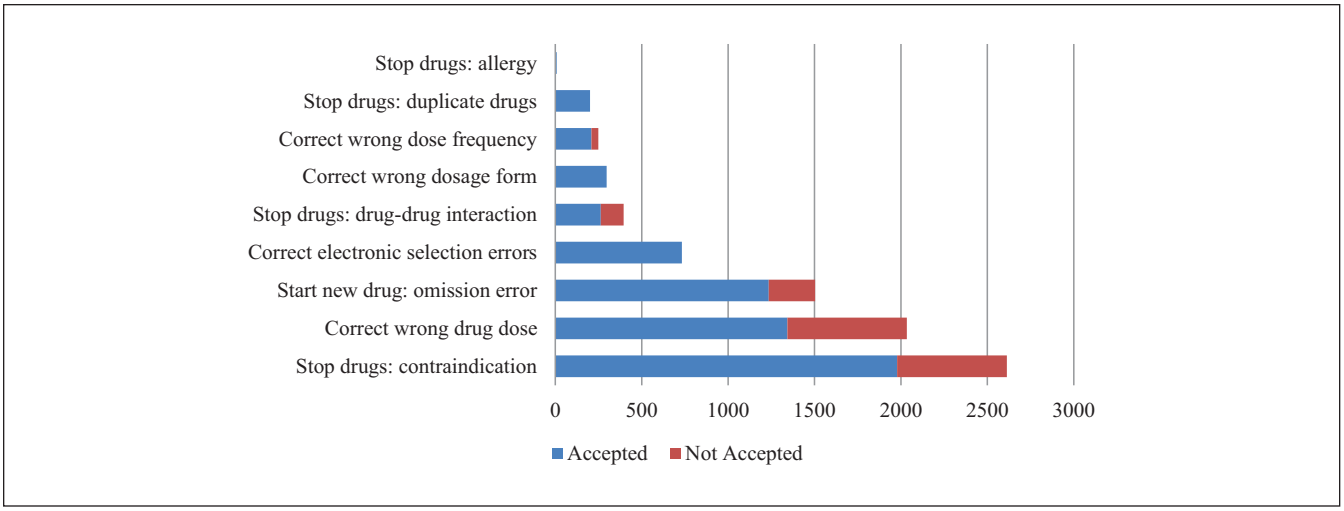

Figure 2. Acceptance of clinical pharmacists' intervention based on error types during P1 phase.

lethal, serious, significant, and minor. Any disagreement was resolved by discussion.

Interrater Reliability

The Kappa statistic was used to test the interrater reliability. A kappa value below 0.5 was considered poor reliability, above 0.5 and below 0.7 moderate reliability, above 0.7 good reliability, and above 0.8 great reliability.[39]

Predictors

Predictors of physicians' acceptance of CPs' interventions were studied using multivariate logistic regression. Independent variables were compiled from the literature and those related to current medical practice in Jordan and included error severity, therapeutic category of ordered medication, type of error, and non-busy physicians (a physician was considered non-busy if he had less than 5 patients to deal with at the time of the CP's intervention). To enhance reliability of regression, errors were categorized into significant (lethal, serious, and significant) and insignificant (minor) errors. Binary physicians' acceptance (Yes/No) was the dependent variable. Only statistically significant predictors were listed in the results.

Multicollinearity Test

Multicollinearity is a statistical measure in which 2 or more predictor variables in a multiple regression model are highly correlated. If there is no linear relationship between predictor variables, they are said to be orthogonal or uncorrelated.[40] To ensure accuracy of regression analysis results, guidelines state that the threshold for multicollinearity probability is when variance inflation factor=3. If it is >3, it will be problematic.

Data Analysis

Statistical tests of data, such as descriptive analysis, logistic regression, multicollinearity test, and interrater reliability, were performed using the Statistical Package for Social Science (SPSS) software Version 24.

Results

Overview of Results

Of 18 003 patients included in our study, 8732 were included during the P0 phase and 9271 during the P1 phase. The CP intervened upon 8032 PEs during the P1 phase and 6269 interventions were accepted by physicians (Figure 2). The CP reduced significantly PE incidence by 76.0%; from 24.6% (P0 phase) to 5.4% (P1 phase). The number of PEs per patient decreased from 0.8 to 0.2. Except for figures related to PEs, no other statistically significant differences were found between P0 and P1 phases. Demographic characteristics of patients, clinical data, medication orders and incidence of PEs during P0 phase (October 2019) and P1 phase (November 2019) are shown in Table 1.

Types of Prescribing Errors Detected

As shown in Table 2, the proportion of contraindications, electronic drug selection, and wrong dosage form error types were significantly reduced from 32.6%, 9.1%, and 3.7% (P0 phase) to 12.6%, 0.0%, and 0.0% (P1 phase), respectively. Drug-Drug interaction, wrong drug frequency, and allergy error types were insignificantly reduced from 4.9%, 3.1%, and 0.1% to 4.5%, 2.5%, and 0.0%, respectively. The proportion of wrong dose and omission errors were significantly increased from 25.3% and 18.7% (P0 phase) to 37.2% and 43.2% (P1 phase), respectively.

Table 1. Characteristics of Patients and Results During P0 and P1.

Code	Characteristic	P0 phase (control)	P1 phase (post-intervention)	*P* value of difference
A	Number of included patients	8732	9271	>.05
B	Mean age in years (range)	17.3 ± 9.7 (2-66)	21.5 ± 11.2 (1-71)	>.05
C	Gender (No., %)			
	Male	(4768, 54.6%)	(4849, 52.3%)	>.05
	Female	(3964, 45.4%)	(4422, 47.7%)	>.05
D	Mean length of stay (h)	9 ± 6	7 ± 4	>.05
E	Patients with co-morbidities (No., %)	(1030, 11.8%)	(881, 9.5%)	>.05
F	Total number of medication orders	28816	32449	>.05
G	Total number of omission errors	1169	263	<.05
H	Mean number of medications per patient (range)	3.3 ± 1.7 (1-7)	3.5 ± 1.1 (1-6)	>.05
J	Number of patients with PEs	2671	493	<.05
K	Number of medication orders for patient with PEs	6921	2131	<.05
L	Total number of PEs	7368	1763	<.05
M	PEs per patient, {M = L/A}	0.8	0.2	<.05
N	PEs per medication order, {N = L/F}	0.25	0.05	<.05
O	PEs incidence, {O = L/(F+G) × 100%}	24.6%	5.4%	<.05

Note. Data in B, D, and H are presented in mean ± standard deviation. PEs = prescribing errors.

Table 2. Types and Examples of Errors During P0 (Control) and P1 Phase (Post-Intervention).

Type of error	Example 7368	P0 phase (n, %)	P1 phase (n, %)	*P* value of difference
Contraindication (wrong drug)	A 1-year-old child, diagnosed with acute bronchitis and had history of moderate asthma, the prescription contained *diclofenac sodium* 12.5 mg suppository.	(2403, 32.6)	(224, 12.6)	<.05
Wrong drug dose	A 47-year-old male patient suffered from severe cramping pain with history of ulcerative colitis, the prescription contained *hyoscine butyl bromide* 10 mg tablet 3 times per day.	(1864, 25.3)	(655, 37.2)	<.05
Omission error	A 2-year-old child suffered severe diarrhea and fever. The prescription contained just *paracetamol* without oral rehydration solution.	(1378, 18.7)	(761, 43.2)	<.05
Electronic selection errors	A 12-year-old male patient suffered from street dog bite in his leg, the prescription contained *ranitidine* injection.	(670, 9.1)	(0.0, 0.0)	<.05
Drug-drug interaction	A 64-year-old male patient suffered from acute back pain. Patient was on: *enalapril maleate, aspirin, and metformin.* The prescription contained *naproxen sodium DS* 500 mg tablet BID to be taken for 14 days.	(361, 4.9)	(78, 4.5)	>.05
Wrong dosage form	A 2-year-old child suffered from diarrhea and fever. Prescription contained *metronidazole* 250 mg tablet.	(273, 3.7)	(0.0, 0.0)	<.05
Wrong dose frequency	A 23-year-old patient suffered from severe pain due to shoulder trauma. Prescription contained *diclofenac sodium* 75 mg extended-release tablet TID.	(228, 3.1)	(45, 2.5)	>.05
Duplicate drugs	A 17-year-old patient suffered from gastric ulcer. Prescription contained *omeprazole* 20 mg tablet (entered twice).	(184, 2.5)	(0.0, 0.0)	<.05
Allergy	A 49-year-old patient suffered from acute bronchitis with history of Type-1 penicillin allergy. Prescription contained *ceftriaxone* (Rocephin®) 1 g IM injection.	(7, 0.1)	(0.0, 0.0)	>.05
Total		(7368, 100)	(1763, 100)	

Table 3. Clinical Significance Prescribing Errors During P0 and P1 Phase.

Severity	Examples	P0 phase (control)	P1 phase (post-intervention)	*P* value of difference
Significant	*Cefalexin* and *chlorpheniramine* written for adult patient suffered from severe headache (P0 phase).	(5066, 68.7%)	(157, 8.9%)	<.05
Minor	*Paracetamol* prescribed for a 2-year-old feverish child; the omitted dose of the drug was added by the pharmacist (P1 phase).	(2074, 28.1%)	(1574, 89.3%)	<.05
Serious	Adult patient experienced moderate cough, the prescription contained *fluvoxamine maleate* (P0 phase).	(221, 3.0%)	(32, 1.8%)	<.05
Lethal	A 49-year-old patient suffered from acute bronchitis with history of Type-1 penicillin allergy. Prescription contained *ceftriaxone* (Rocephin®) 1 g IM injection (P0 phase).	(7, 0.1%)	(0, 0.0)	>.05

Physicians' Acceptance of Clinical Pharmacists' Interventions

As illustrated in Figure 2, the overall acceptance rate of CPs' interventions was 78.1% (n=6269/8032). Physicians accepted all CPs' interventions related to antibiotic allergy (100%, n=8/8), duplicate drugs (100%, n=201/201), wrong dosage form (100%, n=297/297), and electronic prescribing selection errors (100%, n=732/732). However, the lowest rate of acceptance was for clinical interventions related to wrong drug dose (66.0%, n=1343/2034) and drug-drug interactions (66.7%, n=263/395).

Clinical Severity of Prescribing Errors

The proportion of significant and serious errors were significantly reduced from 68.7% and 3.0% (P0 phase) to 8.9% and 1.8% (P1 phase), respectively. During P1 phase, most of errors were minor (89.3%, 1574/1763), and lethal errors disappeared. More details about severity of PEs during P0 and P1 phases were summarized in Table 3.

Predictors for Physicians' Acceptance

Predictors of physicians' acceptance (Table 4) were: PEs with significant severity (OR 3.1; 95%CI 2.6-4.3; $P=.03$) and non-busy physicians (OR 2.1; 95%CI 1.6-2.7; $P=.04$). The results showed no chance for multicollinearity (all VIFs <3.00); our regression analysis process was accurate and specific.

Discussion

Although clinical pharmacists (CPs) have an essential role in optimizing pharmacotherapy in the emergency department, clinical pharmacy services in EDs are not actively implemented in Middle Eastern countries. Therefore, our study aimed to study the impact of CPs on reducing PEs in the emergency department of a large governmental hospital in Jordan. Our results showed that CPs decreased the incidence of PEs in the emergency department from 24.6% to 5.4% (76.0% drop in PEs incidence). This significant enhancement of pharmaceutical care could be explained by the clinical expertise CPs possess to identify and correct PEs coupled with the amount of clinical information that CPs had access to (via EPR) during the interventional phase (P1). Our methodology was robust since both control and active phases were performed on the same ward with similar conditions including physicians, CPs, therapeutic protocols, EPR, and consecutive time periods.

However, our study has a number of limitations. Since we included only one emergency department in our research, during a relatively short interventional period, our findings cannot be generalized. However, our study was performed in the largest and busiest hospital in Jordan and almost all EDs in Jordan operate using similar therapeutic protocols as well as possessing comparative administrative and technical systems. Hence, our study highlights the potential role of clinical pharmacy services in the emergency department. Although our study aim was disguised from emergency department physicians, we cannot exclude the possibility of the Hawthorne effect completely, especially during the interventional phase. However, the emergency department had more than 70 physicians working different shifts so it is expected that physicians' behaviors were not significantly affected by the presence of the CP.

Consistent with our findings, clinical interventions of emergency department pharmacists in Australia reduced PEs per patient by 71% and PEs per drug order by 76% between the control and active periods.[13] In addition, CPs' interventions reduced the rate of PEs from 14.1% to 5.1% in a surgical intensive care unit in Germany.[6] Similarly, CPs' interventions significantly influenced the implementation of recommendations to identify and correct PEs in the UK.[11] In Spain, a study conducted on a pediatric ward concluded that CPs' interventions had a major impact on reducing PEs.[12] As described previously, many other studies conducted in the UK, USA, India, Iran, Pakistan, and Germany emphasized the important role of clinical pharmacy services in reducing PEs.[8-10,17,18,22-25,28,41] However, almost all these studies were not interventional, and did not use measures to minimize the Hawthorne effect. Furthermore, many of them did not

Table 4. Predictors for Physicians' Acceptance (Phase 1).

Dependent variables	Independent variables (predictors)	Odds ratio	*P* value	95% CI for odds	
				Lower	Upper
Physicians' acceptance (Yes)	Severity (significant)	3.1	.03	2.6	4.3
	Physician's status (non-busy)	2.1	.04	1.6	2.7

perform statistical tests to ensure the reliability of the severity ratings and logistic regression model. Therefore, their results may not reflect strong reliable outcomes regarding the impact of CPs on PEs.

Clinical interventions in our study succeeded to correct different types of errors, most of which were: wrong drug, drug selection errors, and wrong dosage form. Allergy-related errors disappeared during the interventional phase. However, the proportion of a few error types, such as omission and wrong dose, increased; this was mainly due to physicians' rejection of pharmacists' recommendations. Physicians' poor adherence to the guidelines, physicians lacking EPR and electronic prescribing skills and the overcrowded environment of the emergency department might have contributed to errors. In addition, emergency department pharmacists, located in the emergency department pharmacy, had no access to life-threatening cases that required immediate intervention and notification to physicians. Consistent with our results, most of the clinical interventions of emergency department pharmacists in Australia during the active period were related to requests for the prescription of drugs indicated but not prescribed.[13] In a nephrology ward in Iran, most CPs' interventions aimed to correct wrong frequency (37.2%) and wrong drug selection (19.8%).[14] In a Dutch intensive care unit, most CPs' recommendations were due to drug or dose omission.[16] Therefore, it is expected that types of errors and CPs' recommendations would be different based on the ward type, geographic location and level of staff training.

Most PEs during our study were considered significant, which was consistent with the literature.[6,15] Our study showed high acceptance of physicians to recommendations of CPs, especially when errors were not debatable, such as: electronic selection errors, wrong dosage form, or when errors were potentially life-threatening. However, our results showed that physicians rejected more than one-third of CPs' interventions related to wrong drug dose and drug-drug interactions. Physicians' poor knowledge on updated therapeutic guidelines and drugs' pharmacodynamics and pharmacokinetic properties might have contributed to this result. To investigate physicians' acceptance more deeply, we used multivariate logistic regression; our results showed that physicians were 3.1 times more likely to accept significant interventions (significant, serious, and lethal errors) than insignificant recommendations (minor errors). In addition, our findings emphasized that non-busy physicians were 2.1 times more likely to accept CPs' interventions than busy physicians, who dealt with large number of patients in a short period of time. Many measures can be taken to improve physicians' response to clinical pharmacy services, such as: increasing the number of physicians, workshops to raise awareness of the significance of clinical pharmacy interventions, and the implementation of an active and cooperative clinical pharmacy program, which can identify and correct errors before they harm patients.

In summary, implementation of clinical pharmacy services in the emergency department can significantly minimize the number of PEs, particularly significant and serious errors, which may cause severe harm to patients. This would help reduce potential mortality and morbidity in the emergency department setting, particularly for vulnerable patients. Our study showed that clinical pharmacists successfully intervened on wrong drug, electronic drug selection, and wrong dosage form; thus, efficiently preventing PEs that may eventually lead to high rate of mortality and morbidity.[42-44] Policy makers should implement continual professional programs for hospital pharmacists to enhance their clinical skills. Further studies to collect data from other wards and hospitals are necessary to better investigate the impact of clinical pharmacy services in Jordan.

Conclusion

Clinical pharmacists significantly decreased PEs in the emergency department by 76.0%; the majority of interventions were accepted by physicians. Health officials in Jordan are encouraged to utilize our findings and implement clinical pharmacy services to enhance patient care.

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Declaration of Conflicting Interests

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