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RESEARCH ARTICLE

Detection of prescription errors by a unit-based clinical pharmacist in a nephrology ward

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Abstract *Objective*: To determine the impact of a clinical pharmacist on detection and prevention of prescription errors at the nephrology ward of a referral hospital. Setting: Nephrology ward of a major referral hospital in Southern Iran. *Method*: During a 4-month period, a clinical pharmacist was assigned to review medication order sheets and drug orders three times a week at the nephrology ward. Besides chart review, the clinical pharmacist participated in medical rounds once a week. The occurrence of prescribing errors, and related harm was determined on hospitalized patients in this ward during the 4 month period. When an error was detected, intervention was made after agreement of the attending physician. *Main outcome measures*: Number and types of prescribing errors, level of harm, and number of interventions were determined. *Results*: Seventy six patient charts were reviewed during the 4-month period. A total of 818 medications were ordered in these patients. Eighty six prescribing errors were detected in 46 hospital admissions. The mean age of the patients was 47.7 ± 17.2. Fifty five percent were male while 45% were female. Different types of prescribing errors and their frequencies were as follows: wrong frequency (37.2%), wrong drug selection (19.8%), overdose (12.8%), failure to discontinue (10.5%), failure to order (7 %), under- dose (3.5%), wrong time (3.5%), monitoring (3.5%), wrong route (1.2%), and drug interaction (1.2 %). The attending physician agreed to 96.5% of the prescription errors detected, and interventions were made. Although 89.5% of the detected errors caused no harm, 4(4.7%) of the errors increased the need for monitoring, 2 (2.3%) increased length of stay, and 2 (2.3%) led to permanent patient harm. *Conclusion*: presence of a clinical pharmacist at the nephrology ward helps in early detection of prescription errors, and therefore potential prevention of negative consequences due to drug administration.

Keywords Clinical pharmacist · Iran · Nephrology ward · Prescription errors

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Impact on Practice

- In Iran there is a need for a clinical pharmacist to work full-time at a nephrology ward.
- In Iran there is an urgent need for guidelines and protocols, especially for the use of immunosuppressive drugs, and the treatment of infections in dialysis and transplant patients.

Introduction

There have been remarkable developments in the measurement and analysis of patient safety since 1999, when the Institute of Medicine published its report: "To Err is Human" [1]. According to this report, 98000 people die each year due to medication errors (ME) occurring in hospitals [1]. The cost of drug-related morbidity and mortality has been estimated to be 76.6 billion per year in the United States [2]. ME may occur at different stages of medication use process including prescribing, transcribing, dispensing, and administration [3], with prescribing errors being the most common [4]. The outcome of ME could range from minimal (or no) patient harm to life-threatening risk. Studies have shown that 26–42% of adverse drug

events (ADEs) are preventable and these preventable ADEs are mainly caused by prescribing and transcribing errors [5]. Adverse events within the hospital lead to morbidity and mortality in up to 6.5% of hospital admissions and are mainly attributed to MEs and ADEs [5, 6].

Clinical pharmacists are essential health-care providers who can help build a safe medication environment and prevent ME [1]. Clinical pharmacy services have been reported to reduce not only costs of therapy, but also morbidity and mortality [7–9]. A study by Leap et al revealed that participation of a clinical pharmacist on physician rounds in an adult intensive care unit (ICU) decreased preventable ADEs at the prescription-writing stage by 66% [9], while Kucukarslan et al found that unit-based clinical pharmacists reduced preventable ADEs at the same stage by 78% [10].

Clinical pharmacy activities in Iran have just begun, and data on their activities are poorly reported. For example, in the city of Shiraz, where this study has taken place, there are only 3 clinical pharmacists who spend most of their time lecturing at the pharmacy school, and two of them have just recently started working part-time at the ICU and Nephrology wards of one of the main university hospitals. Therefore, unfortunately most hospital wards lack a clinical pharmacist at their site. This, along with the fact that prescriptions are not computerized, and there are no standardized protocols to follow, may result in a high frequency of ME in our hospital wards.

Aim of the study

Considering the fact that clinical pharmacists have just recently started working alongside the physicians in Iran, it is important to evaluate their positive effects on the health-care setting including their contribution to early detection of ME. So far no study has been performed in Iran to evaluate the role of a unit-based clinical pharmacist in improving patient safety and outcomes.

Due to high daily drug consumption, special dose requirements, frequent changes in drug regimen, presence of concurrent diseases, and use of drugs that require therapeutic monitoring, the end stage renal disease (ESRD) population is most prone to ME. We hypothesize that a unit-based clinical pharmacist at the nephrology ward might be able to reduce patient harm by early detection or prevention of ME.

Methods

This was a cross-sectional study performed in a 15-bed nephrology ward of a university hospital in Shiraz. In this medical ward, the process of medication ordering and administration consists of a hand-written system: physicians prescribe medication orders on patient files and nurses transcribe these medication orders on administration charts.

The study was performed during a 4-month period. Patients were under the care of three attending nephrologists and four internal medicine residents who rotated responsibilities on a monthly basis. Standard practice at the ward included daily medical rounds by the attending nephrologist and the resident in charge. Students and interns also participated in daily clinical rounds. The nephrologist assessed the patients and made recommendations, and the resident would make changes to the prescriptions according to the recommendations made, and adjust drug doses. Teaching rounds were performed at least twice a week depending on how busy the schedule of the attending physician was. It should be noted that the study was carried out in a university hospital, and being a training environment, attending physicians attempted to allow trainees autonomy in decision making.

During the period of study, from December 2008 through March 2009, patient files, laboratory data, and physician orders were reviewed by a clinical pharmacist that attended the ward three times a week during morning hours. Any prescription error identified by the clinical pharmacist, and whether it was accepted by the physician and resulted in an intervention was documented. Besides reviewing physician's orders, the clinical pharmacist attended the teaching rounds once a week. Therefore, some of the recommendations were made prospectively during the teaching rounds. It should be noted that clinical pharmacy in Iran is a PhD program. During the program the clinical pharmacist has to pass 18 months of hospital rotations successfully. Therefore it is worth mentioning that the clinical pharmacist participating in this study was fully trained.

Prescribing error was defined as incorrect drug selection, dose, dosage form, frequency, route, or instructions. Incorrect drug selection was based on indication, contraindication, known allergies, existing drug therapy, and other factors [3]. Monitoring error, defined as failure to use appropriate clinical or laboratory data for adequate assessment of patient response to prescribed therapy [3], was also considered as prescribing error in this study. A prescription order may have more than one error associated with it.

All medication errors were classified according to the severity of the consequence it caused, using the definitions provided by Hartwig, Denger, and Schneider [3]. The severity of the consequence of the ME could range from a potential error that did not reach the patient (level 0), up to an error that resulted in patient death (level 6).

Data were analyzed using SPSS version 12 and expressed as mean ± SD or percentages as appropriate. Prescription error rate was determined as the ratio of the number of prescription errors to the number of medication orders ×100.

Results

During the 4 month period there were 177 admissions to the nephrology ward. About half of the patients were hospitalized for performance of a kidney biopsy and therefore were discharged the next day. Ninety two patients were hospitalized more than 3 days and of these, 76 were evaluated for prescription errors. A total of 818 medications were prescribed for these patients and 86 prescription errors were identified in 46 (60.5%) of the admissions. The rate of prescription errors was 10.5 per 100 medication orders. Table 1 demonstrates the demographic characteristics of the patients. Type of prescription errors and their frequencies are listed in Table 2.

The attending physician agreed to 96.5% of the prescription errors and interventions were made. Table 3 illustrates the severity category of the observed prescribing errors. About 90% of the prescription errors resulted in no harm. Table 4 indicates some examples of different types of prescribing errors.

Although evaluation of transcription errors were not considered in our study, the clinical pharmacist found 3 transcription errors accidentally while checking the administration charts. All 3 were due to inappropriate dosing [ceftazidime ordered as every 24 h (Q24h) was transcribed as every 12 h (Q12h), vancomycin ordered as Q72h was transcribed as Q12h, and 1 ampoule of calcium gluconate was transcribed as 5] resulting from poor handwriting of the resident. Fortunately the wrong dosing of calcium gluconate did not reach the patient (potential error, level 0), otherwise it could have been life-threatening.

As shown in Table 5, most errors were related to immunosuppressive and anti-infective medications, each contributing to 38.4% (33) of the prescription errors. About 88% (29) of the prescription errors related to immunosuppressives were due to "wrong frequency", while most errors related to anti-infectives were due to wrong drug selection (30.3%), over dosing (30.3%), and forgetting to discontinue (21.2%).

Table 1 Demographic characteristics of study patients ($n = 76$)

Age, Mean ± SD (range), yr	47.7 ± 17.2 (20–86)
Sex, No (%)	
Male	42 (55.3)
Female	34 (44.7)
Number of patients with ESRD	52(68.5%)
Number on dialysis	23(44%)
Number with a functioning transplant	29 (56%)
Number of comorbid conditions, Mean ± SD (range)	5.1 ± 1.7 (2–10)
Diabetes	14 (27%)
Hypertension	43 (83%)
Total number of medications ordered	818
Number of medications per patient, Mean ± SD (range)	10.8 ± 4.9 (2–25)
Number of patients with prescription error	46
Number of prescription errors (rate: number of errors/number of orders ×100)	86 (10.5%)

Table 2 Types of prescription errors

Type of error	No (%)
Wrong frequency	32 (37.2)
Wrong drug selection	17 (19.8)
Overdose	11 (12.8)
Forgot to discontinue	9 (10.5)
Forgot to order	6 (7)
Under dose	3 (3.5)
Wrong time	3 (3.5)
Monitoring	3 (3.5)
Wrong route	1 (1.2)
Interaction	1 (1.2)

Discussion

Drug therapies are important parts of medical care, contributing to prescribing errors and other drug-related problems. Keeping up with the growing number of prescription medications is a major challenge for the physicians. Numerous studies have found that pharmacists can improve patient safety and outcomes by preventing adverse events and recommending optimal therapies and dosages [11, 12]. Pharmacists need to make themselves more available to physicians, and physicians need to recognize and utilize the expert knowledge of pharmacists. Fortunately with the introduction of clinical pharmacy, pharmacy practice has changed significantly. Pharmacist's attention began to shift from the medication itself to the interaction between the patient and the medication. However, achieving true change has been a challenge, and many hurdles still remain to be overcome. In Iran many patients and physicians still have not fully understood the concept of the pharmacists as a key member of the healthcare team. Surprisingly this is also the case in developed countries,

Table 3 Severity categories of observed prescription errors

Harm category	Number (%)
No error occurred (potential error, level 0)	1 (1.2%)
Error occurred that did not result in patient harm (level 1)	77 (89.5)
Error occurred that resulted in the need for increased patient monitoring, but no patient harm (level 2)	4 (4.7)
Error occurred that resulted in the need for increased patient monitoring, with a change in vital signs (level 3)	–
Error occurred that resulted in the need for treatment with another drug or an increased length of stay (level 4)	2 (2.3)
Error occurred that resulted in permanent patient harm (level 5)	2 (2.3)
Error occurred that resulted in patient death (level 6)	–

revealing the fact that this evolution is not happening fast enough. Sad to say, in a recent Medscape article [13] four physicians were asked to discuss how doctors can stay current on drug information, and not one of them suggested turning to a pharmacist for assistance.

One way to achieve true change and overcome the barriers would be to perform studies that can demonstrate how a pharmacist could produce better clinical and economic outcomes to patient care. Numerous studies have found that pharmacists can improve patient safety and outcomes [14–23]. However, no study has been performed in Iran, because clinical pharmacy is a new profession and at the moment, only a few clinical pharmacists are practicing in this country. Only two observational studies are published so far, reporting the frequency of medication errors within a teaching hospital in Iran [24, 25].

Our study was the first in this country to evaluate the early detection of prescription errors by a unit-based clinical pharmacist. About 70% of the patients studied were ESRD patients who were on dialysis (44%) or had undergone a kidney transplant (56%).

Several studies have shown that ambulatory hemodialysis patients are at risk of medication-related problems [26–30]. Risk factors for drug-related problems include: $\geq$5 prescribed medications, $\geq$12 drug doses daily, $\geq$4 changes in the drug regimen during the past 12 months, the presence of more than 3 concurrent disease states, a history of non-adherence, and the presence of drugs that require therapeutic monitoring [31]. ESRD patients fulfill all these criteria. According to the United States Renal Data System (USRDS) hemodialysis patients take a median of 8 medications for an average of 5 comorbid conditions [32, 33]. In a study performed on critical care patients, impaired renal function was a risk factor for adverse drug outcomes [34]. Manley et al have shown that the number of comorbid conditions and presence of diabetes in ambulatory hemodialysis patients were considered as risk factors for medication-related problems [35].

Table 4 Examples of different prescribing errors in different harm categories

Type of error/harm category	Description/pharmacotherapist recommendation and intervention
Wrong frequency (level 1)	Cyclosporine ordered Bid (9AM, 5PM) instead of Q12h. Frequency was corrected.
Wrong drug selection (level 4)	Prescription of imipenem in a patient with frequent convulsions. Imipenem was switched to meropenem.
Overdose (level 1)	Cefazolin 1 g Q6h in a patient undergoing hemodialysis. It was suggested to discontinue the drug since it was prescribed as prophylaxis for surgery and the patient was already on vancomycin for treatment of infection.
Forgot to discontinue (level 1)	Forgot to discontinue imipenem after abdominal infection was ruled out. Imipenem was discontinued.
Forgot to order (level 5)	Forgot to order another antibiotic in place of pipracillin/tazobactam (that was not available) to treat a foot infection, and patient was not on any antibiotics for 48 h. Imipenem was suggested by the clinical pharmacist, and administered. A toe was amputated.
Under dose (level 1)	Vancomycin 1 g/d instead of 1 g Q12h. Dose was corrected.
Wrong time (level 1)	Calcium carbonate ordered at the same time as mycophenolate mofetyl. It was suggested to separate administration of drugs by 2 h.
Monitoring (level 2)	Despite serum potassium of 6 meq/l the patient was still on 10 meq KCl three times per day. KCl was discontinued.
Wrong route (level 1)	IV ciprofloxacin for treatment of a simple UTI. It was suggested to switch to oral ciprofloxacin. (The price of each vial of ciprofloxacin is 20 times the oral dosage form in Iran)
Interaction (level 2)	Prescription of omeprazole in a patient who was on warfarin. This led to an increase in the International Normalized Ratio. Warfarin dose was decreased.

Table 5 Medication class involvement

Medication class	Number (% occurrence)
Immunosuppressive	33 (38.4)
Antibiotics	33 (38.4)
Cardiac	3 (3.5)
Antithrombotic	3 (3.5)
Cholesterol lowering	2 (2.3)
Analgesic	2 (2.3)
Renal bone disease	1 (1.2)
Anemia	1 (1.2)
Gastrointestinal	1 (1.2)
Others	7 (8.1)

A mean of 10.8 ± 4.9 (median: 9.5) medications were prescribed for our patients. Medication regimens changed often, for example calcium, phosphate binders, and antihypertensive drugs were often changed due to consistent changes in serum calcium and phosphorus levels, and in blood pressure. Our ESRD patients had 5.1 ± 1.7 comorbid conditions. Fourteen (27%) had diabetes and 43 (83%) had hypertension. In a study performed by Manley et al on 133 ambulatory hemodialysis patients during a 10 month period, a mean of 12.5 ± 4.2 medications were prescribed, and patients had 6.4 ± 2 comorbid conditions [36].

Eighty six prescription errors were identified by the clinical pharmacist during the four-month period, and the physician acceptance rate was 96.5%. The rate of prescription error in our study was 10.5%. Most errors were due to "wrong frequency", "wrong drug selection" and "wrong dose", accounting for 37%, 20%, and 16% of the prescribing errors, respectively. Ninety one percent of the "wrong frequency" errors were related to immunosuppressive medications, while about 60% (10/17) of "wrong drug selection" and 86% (12/14) of "wrong dose errors" were related to antibiotics. In the study by Manley et al. [36] on ambulatory HD patients, during a 10-month period, the rate of medication-related problems (MRP) were 6.6 per 100 medication orders in which the most common MRP was related to "medication dosing" (33.5%). Wang et al performed a study on 37 post-renal transplant patients in a renal transplant clinic for 15-months. During this period the pharmacist made 55 pharmacotherapy recommendations. Most of these recommendations (34.5%) were for "medication selection" [23]. These results show that although we have only reported the "prescription errors" during a 4-month period, we still have higher rate of errors compared to other studies performed on similar patient population that had included all MRP during a longer period of time. However it should be mentioned that our setting and clinical pharmacy service was different from the above studies. In this study, patient files, order charts and laboratory data were reviewed by the pharmacist in a retrospective manner three times a week. There was no patient interview. Wang et al performed a prospective trial in which the pharmacist interviewed the patients once a week, while Manley et al conducted a patient interview once a month. Both studies were conducted in an ambulatory clinic compared to our study which was conducted in a hospital setting on hospitalized patients. It is obvious that medications should be monitored more frequently in hospitalized patients due to instability of patients and frequent order changes. One limitation to this study was that prescription errors were underestimated because the clinical pharmacist did not work everyday and full time. If prescriptions were reviewed on a daily basis, and transcription, and administration errors were also evaluated, the error rate would have been much higher. It is natural to have a high rate of transcription errors when prescriptions and transcriptions are hand-written. The 3 transcription errors noted by the clinical pharmacist coincidentally, confirms this fact. Although the wrong dosing of calcium gluconate did not reach the patient, this was a potential error that could have led to higher levels of error and even death. Another limitation of the study, and in fact another reason for underestimation of prescription errors were that patient interview by the pharmacist was not in the service. Patient's medical and drug history would help identify errors related to contraindications, drug interactions or allergies in a more prospective manner. Although the clinical pharmacist reviewed patient files, there was a possibility that some information was not documented in the file by the in-charge resident. In a setting of acute general (internal) medicine admissions, pharmacists obtained better medication histories than many physicians, and also identified more medication doses and frequencies [37]. Fertleman et al. proposed that having a pharmacist present when prescribing decisions were made, would have a significant impact on medication safety and costs in UK district general hospitals [38].

The physician acceptance rate was 96.5% in our study. This was similar to the Wang et al study in which the physician acceptance rate for the pharmacotherapy recommendations was 96% [23]. The acceptance rate was also 96% from the renal transplant team reported by Chisholm et al. [39], but an 88% acceptance rate was reported by Galt [40].

In this study most recommendations were related to immunosuppressive (39.5%) and anti-infective medications (37%) and cardiovascular agents accounted for only 9.3% of the prescription errors. This was not consistent with the study performed by Wang et al. [23] in which recommendations for anti-infective drugs were relatively few (4.4%), and most pharmacotherapy recommendations

were for cardiovascular agents (32.6%). Cardiovascular agents had also the highest MRP (30%) in the study by Manley et al. [35]. In a pooled analysis on ambulatory hemodialysis patients, cardiovascular-related medications accounted for 29.7% of MRP [41].

Although most of our errors caused no harm, it should be emphasized that if not identified by the clinical pharmacist, they could have caused serious therapeutic problems. Dosing of cyclosporine as Bid (9AM and 5PM) instead of Q12h, would have led to a lower trough level in the morning than in the evening, causing problems in the dose adjustment of this drug leading to graft rejection or drug toxicity. Under-dosing of vancomycin may have led to severe infection, interaction of warfarin with omeprazole may have caused severe bleeding and even death, and continuation of potassium administration would have caused cardiac arrhythmias and even sudden death in the patient with high potassium level.

The high rate of prescription errors in our study may be due to several reasons: 1. Paper-based medical records are used as primary source of all medical information, and physicians are not responsible for any computerized registrations of inpatients. 2. The pharmacist within hospital pharmacy does not have access to patients' files and his/her only responsibility is to distribute the prescribed drugs to the ward. 3. The unavailability of a full-time unit-based clinical pharmacist to review all patient files and medication orders on a daily basis. According to a study performed in a pediatric intensive care setting, a full-time unit-based clinical pharmacist substantially decreased the serious medication error rate, but a part-time pharmacist was not as effective [22]. 4. Medical residents were not fully trained. Our study was performed in a university teaching hospital, and medical faculty members (attending physicians) attempted to allow their trainees to practice independently. In Iran medical faculty members are specialists who have treatment, teaching, and research responsibilities. However, due to patient overload, and involvement in therapeutic activities, they spend less time in educational activities [42, 43], which have to be their major responsibilities. This certainly would result in increased number of prescribing errors by the in-charge resident. A significant percentage of prescription errors in this study were dosing errors by a resident during daytime working hours. There is a continued need to enhance local resident education using a service-specific clinical pharmacist to focus on appropriate dosing especially in regard to antibiotics. This was also a major problem by a study performed in a pediatric surgical service [44]. 5. Lack of medication protocols and treatment guidelines. In fact every faculty has his/her own treatment algorithm, and there is no consensus guideline available on the ward for trainees to refer to.

Conclusion

In conclusion, a unit-based clinical pharmacist can help identify ME, contribute to rationalization of drug therapy, and potential prevention of negative consequences leading to increased medication safety. This study clearly shows the need for a clinical pharmacist to work full-time at the nephrology ward. We hope this study will contribute to increase the number of clinical pharmacists in our hospitals. Our work provides openings for future discussions with physicians to develop drug protocols and prescription policies in the hospitals. In fact, our nephrologists have been convinced that there is an urgent need for guidelines and protocols especially for immunosuppressive drugs, and also for the treatment of infections in dialysis and transplant patients. It is planned to start writing such protocols with the help of a group of attending physicians, the nephrology ward clinical pharmacist, and the hospital clinical microbiologist. Future prospective studies should be planned to detect how the rate of medication errors would change within the nephrology ward when all patients are interviewed by the pharmacist at the time of hospital admission, and when guidelines and protocols are implemented. The results may be a better proof to the fact that a ward-based clinical pharmacist can prevent negative consequences related to medications.

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Conflict of Interest None.

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