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CLINICAL STUDY

Frequency, types, and direct related costs of medication errors in an academic nephrology ward in Iran

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Abstract

Medication errors are ongoing problems among hospitalized patients especially those with multiple co-morbidities and polypharmacy such as patients with renal diseases. This study evaluated the frequency, types and direct related cost of medication errors in nephrology ward and the role played by clinical pharmacists. During this study, clinical pharmacists detected, managed, and recorded the medication errors. Prescribing errors including inappropriate drug, dose, or treatment durations were gathered. To assess transcription errors, the equivalence of nursery charts and physician's orders were evaluated. Administration errors were assessed by observing drugs' preparation, storage, and administration by nurses. The changes in medications costs after implementing clinical pharmacists' interventions were compared with the calculated medications costs if the medication errors were continued up to patients' discharge time. More than 85% of patients experienced medication error. The rate of medication errors was 3.5 errors per patient and 0.18 errors per ordered medication. More than 95% of medication errors occurred at prescription nodes. Most common prescribing errors were omission (26.9%) or unauthorized drugs (18.3%) and low drug dosage or frequency (17.3%). Most of the medication errors happened on cardiovascular drugs (24%) followed by vitamins and electrolytes (22.1%) and antimicrobials (18.5%). The number of medication errors was correlated with the number of ordered medications and length of hospital stay. Clinical pharmacists' interventions decreased patients' direct medication costs by 4.3%. About 22% of medication errors led to patients' harm. In conclusion, clinical pharmacists' contributions in nephrology wards were of value to prevent medication errors and to reduce medications cost.

Keywords

Clinical pharmacy services, cost, drug-related problems, medication errors, nephrology

History

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Introduction

Medication errors have been defined as ''failure in the treatment process that lead to or has the potential to lead to harm to the patient''.[1,2] Medication errors may occur at each five stages of drug ordering and delivery including prescription, transcription, dispensing, administration, or monitoring.[1,2] Medication errors occur in 2–14% of hospitalized patients and lead to 44,000 to 98,000 annual deaths in the United States.[3] Medication errors, as a subgroup of drug-related problems, are highly prevalent among chronic kidney disease (CKD) and dialysis patients due to altered drugs' pharmacokinetics, presence of multiple complex co-morbidities, polypharmacy, and high susceptibility to drug toxicity.[4–6] Some reports show that more than 85% of CKD patients experience at least one medication error.[7] Untreated indications and incorrect dosage are common types of medication errors among CKD and hemodialysis patients.[5–9]

Clinical pharmacists play important roles in detection and prevention of medication errors.[4–8] Clinical pharmacy services started during last two decades in a few teaching hospitals in Iran. There are few reports on medication errors surveillance in hospitalized patients in Iran and clinical pharmacists' interventions to prevent or reduce these errors. The available studies from Iran in infectious diseases and nephrology wards and emergency departments showed that incorrect drug dosage, frequency, or treatment durations, unauthorized drugs, and untreated indications were common types of medication errors in these wards that were prevented by clinical pharmacists.[10–14] Three of these studies have been performed during different times in the same infectious diseases wards with similar findings. As a result, familiarity of physician and nurses with clinical pharmacists' interventions and subsequently with medication errors, did not prevent happening errors on the same drugs. Taken together, persistent involvement of ward-based clinical pharmacists in the patient care managements is a permanent need for the medical wards. Complexity of pharmacotherapy in patients admitted to nephrology wards and their susceptibility to serious

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consequences of medication errors necessitates continued surveillance of medication errors and persistence of pharmaceutical care in nephrology wards.

Aim of the study

This study was aimed to evaluate the frequency, types, clinical significance, and direct related costs of medication errors in an Iranian academic nephrology ward detected by clinical pharmacists.

Methods

Study setting

This 18-month prospective, cross-sectional study starting from October 2011 was conducted at 23-bed nephrology ward of an academic referral hospital that was familiar with clinical pharmacist services, Tehran, Iran.

Patient population

All adult patients who were prescribed at least one drug during their hospital stay were included in this study. If there was a readmitted patient during the study, he/she was considered as a new case in each admission and included in the study.

Intervention and data collection

During the study, junior clinical pharmacists visited the patients during afternoon pharmacotherapy rounds conducted by a nephrology ward-based senior clinical pharmacist five days a week. Some medication errors were detected during these pharmacotherapy rounds. The senior clinical pharmacist's-matched interventions were presented at physicians' ward rounds at the next morning. Clinical pharmacists also detected some medication errors during physicians' rounds and proposed their interventions. In this study all clinical pharmacists' recommendations were referred as interventions that might be accepted or rejected by physicians. All medication errors and clinical pharmacists' interventions were collected in designed forms which contained patients' demographic data (age, sex, weight), clinical data including patients' chief complaint, admission diagnosis, past medical and drug history, their medications at nephrology ward (drugs' name, dosage form, dose, frequency and route of administration), findings of physical examination and related laboratory data. Patients were categorized according to the degree of their renal insufficiency based on the classification of National Kidney Foundation.[15] Medication errors were categorized according to the coding system of Pharmaceutical Care Network Europe Foundation[16] to three nodes of prescription, transcription and administration. In prescribing node, the important types of medication errors including inappropriate drug, inappropriate dosage form, inappropriate medication duplication, presence of any contraindication, no clear indication for drug (unauthorized drug), no drug administration in spite of obvious indication (omission drug), low or high drug dose or frequency, too short or long treatment duration, and no control for drug interactions were gathered. To assess medication errors at transcription node, clinical pharmacists evaluated the equivalence of nursery charts and physicians' orders. Clinical pharmacists assessed administration errors through observation of drugs preparation, dilution, storage, and administration by nurses. Direct medication cost was defined as the cost paid by patient and his/her insurance agency only for the drugs and the instruments necessary for drug administration such as syringes and infusion sets. The changes in medications cost after considering clinical pharmacists' interventions were compared with the calculated medications costs if the medication errors would not have been corrected by clinical pharmacist and were continued up to patients discharge time. It's only an estimation of the true cost. Some clinical pharmacists' interventions increased and some decreased medications costs. The mathematical sum of these changes was calculated as the final net effect of clinical pharmacists' intervention on medications costs (1US$ = 12,600 Iranian Rials at the time of the study).

To assess the clinical significance of medication errors, one senior nephrology clinical pharmacist and one nephrologist independently categorized medication errors using guideline of National Council for Medication Error Reporting and Prevention (NCC MERP).[17] To avoid exaggeration of clinical pharmacists' interventions, when there was disagreement between the two clinical raters with lower clinical significance assessment by the nephrologist, the nephrologist opinion on medication error category was considered in the analysis.

Ethics approval

This study was approved by the local Ethics Committee of Tehran University of Medical Sciences.

Data analysis

Data were analyzed using SPSS (version 13.0) software (Statistical Package for the Social Sciences; Chicago, IL). Categorical and continuous variables were presented as percentage and mean ± standard deviation (SD) or median (range) which were appropriate, respectively. Frequency of medication errors and direct related medication costs were calculated using descriptive statistics. The rate of medication errors was calculated by dividing the number of medication errors by the number of patients and the number of ordered drugs. Spearmen test was used to assess the correlations between number of medication errors and age, number of ordered medications, or length of hospital stay. p Value <0.05 was considered as statistically significant.

Results

During this 18-month study, 406 patients (129 females and 277 males) with the mean age of 50.9 ± 17.9 years were admitted to the nephrology ward of our hospital. The total number of ordered medications in these patients was 7762. A total number of 1373 medication errors on 350 patients were detected by clinical pharmacists. This means that 86.2% of the admitted patients experienced at least one medication error (Table 1). This is equal to a median of 3.5 errors per patient or a mean of 0.18 errors per ordered drug. Most medication errors happened during prescribing by physicians (96.1% of errors) and the remaining by nurses during transcription or drug administration (3.9% of errors).

Table 1. Demographic and clinical characteristics of patients.

Age (mean ± SD)	50.9 ± 17.9 years old
Sex (female/male) [number (percent)]	(129) (31.8%)/277 (68.2%)
Number (percent) of CKD stage 2 patients	88 (21.7%)
Number (percent) of CKD stage 3 patients	111 (27.3%)
Number (percent) of CKD stage 4 patients	38 (9.4%)
Number (percent) of hemodialysis patients	116 (28.6%)
Number (percent) of peritoneal dialysis patients	6 (1.4%)
Number (percent) of patients with functioning kidney transplant	23 (5.7%)
Number (percent) of non-CKD patients	24 (5.9%)
Duration of hospital stays (days) [median (range)]	12.5 (1–66)
Total number of ordered drugs	7762
Number of co-morbidities per patient [median (range)]	4 (1–6)
Number of ordered drugs per patient [median (range)]	18 (4–25)
Number of patients who experienced at least one medication error	350
Total number of medication errors	1373
Number of medication errors per patient [median (range)]	3.5 (1–16)

Table 2. Medication error nodes, types, and frequency, changes in direct medication cost.

Medication error types	Number	Percent
Prescription errors		
Inappropriate drug (not most appropriate for indication)	107	7.8%
Inappropriate dosage form (not most appropriate for indication)	24	1.7%
Inappropriate duplication of therapeutic group or active ingredient	54	3.9%
Contraindication for drug	4	0.3%
No clear indication for drug use	251	18.3%
No prescribe drug but clear indication	369	26.9%
Low drug dosage or frequency	237	17.3%
High drug dosage or frequency	175	12.7%
Too short treatment duration	0	0%
Too long treatment duration	58	4.2%
No control of drug interaction	41	3%
Transcription errors	43	3.1%
Administration errors		
Drug not administered	1	0.1%
Wrong drug administered	9	0.7%

The frequency of different types of medication errors have been shown in Table 2. Clinical pharmacists provided interventions to correct medication errors upon their detection. Treating physicians accepted 1161 out of these 1373 (84.6%) clinical pharmacists' interventions. Main reasons for rejecting the remaining interventions of clinical pharmacists were expressed as lack of relevant information for immediate pharmacotherapy decision-making or missing laboratory or imaging data.

As seen in Table 3, most of the medication errors happened on cardiovascular drugs (24%) followed by vitamins, minerals, and electrolytes (22.1%) and antimicrobial agents (18.5%). Total number of medication errors in each patient significantly correlated with the total number of ordered medications for the patient ($r = 0.437$; $p < 0.0001$) and patient's length of hospital stay ($r = 0.41$; $p < 0.0001$) but not with patient's age ($r = -0.04$; $p = 0.39$) or glomerular filtration rates ($r = 0.12$; $p = 0.11$). The median number of medication errors did not differ between males and females [3 (1–12) vs. 3 (1–17); $p = 0.29$] or among patients with different stages of renal dysfunction ($p = 0.17$).

Medication errors categorizations have been presented in Table 4. There were only three errors that have been categorized differently by senior clinical pharmacist and the nephrologist. These three errors were categorized based on the nephrologists' opinion. As seen, about 22% of medication errors resulted in harm to the patients. Fortunately, none of the medication errors were life-threatening.

Table 3. Drug classes involved in medication errors.

Drug classes	Number of errors	Percent of errors
Cardiovascular drugs	329	24%
Vitamins, electrolytes, minerals	303	22.1%
Antibiotics	254	18.5%
Gastro-intestinal drugs	128	9.3%
Immunosuppressive drugs	62	4.5%
Others (hormonal agents, antigout, analgesics, pulmonary drugs, neurologic and psychiatric drugs, topical agents)	297	21.6%

The total medication costs paid by the patients and their insurances were 76 479.1$. Calculated costs showed that if medication errors were not corrected up to patients' discharge time, the total medications costs would increased by 3288.6$. Thus it was estimated that clinical pharmacists' interventions decreased patients' direct medication costs by 4.3% (8.1$ per patient).

Discussion

Medication errors are highly prevalent among CKD and dialysis patients due to the altered pharmacokinetics of drugs,

Table 4. Categorization of medication errors ($n = 1373$).

Clinical significance	Definition[9]	Number of errors (%)
No error	*Category A*:circumstances for events that have the capacity to cause error	12(0.9%)
Error, No harm	*Category B*: An error occurred but the error did not reach the patient	556(40.5%)
	Category C: An error occurred that reached the patient but did not cause patient harm	483(35.2%)
	Category D: An error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient and/or required intervention to preclude harm	26(1.9%)
Error, Harm	*Category E*: An error occurred that may have contributed to or resulted in temporary harm to the patient and required intervention	233(16.9%)
	Category F: An error occurred that may have contributed to or resulted in temporary harm to the patient and required initial or prolonged hospitalization	63(4.6%)
	Category G: An error occurred that may have contributed to or resulted in permanent patient harm	0
	Category H: An error occurred that required intervention necessary to sustain life	0
Error, Death	An error occurred that may have contributed to or resulted in patient death	0

Notes: Harm: Impairment of the physical, emotional, or psychological function or structure of the body and/or pain resulting therefrom. Monitoring: to observe or record relevant physiological or psychological signs. Intervention: may include change in therapy or active medical/surgical treatment. Intervention necessary to sustain life: includes cardiovascular and respiratory support (e.g. CPR, defibrillation, intubation, etc.) (Based on reference #17).

presence of multiple complex co-morbidities, polypharmacy, and high susceptibility of these patients to drug toxicity.[4–6] In the present study, more than 85% of patients experienced at least one medication error that is comparable to reported medication error rates in CKD patients by other researchers.[7] In our survey, the rates of medication errors were 3.5 errors per patient and 0.18 errors per ordered medication that is more than those reported from the infectious disease ward of the same hospital (0.3 errors per patient and 0.05 errors per ordered drug).[12] These differences may be due to more co-morbidities, polypharmacy, and drug pharmacokinetic changes in CKD patients that predispose physicians, nurse, and patients to more medication errors. In our study, more than 95% of the medication errors occurred at prescription nodes by physicians and the remaining were transcription or administration ones by nurses. Most common prescribing errors were omission or unauthorized drugs and low drug dosage or frequency. Most of the medication errors happened on cardiovascular drugs followed by vitamins, minerals, electrolytes and antimicrobial agents. The latter finding was predictable due to the high rates of cardiovascular co-morbidities, electrolytes disturbances, and infectious diseases among CKD patients that necessitate higher use of these drugs among CKD patients. The total number of medication errors was significantly correlated with the number of ordered medications and length of hospital stay. These correlations have been reported from other study on patients with renal insufficiency as well.[7] The present study estimated that clinical pharmacists' interventions decrease patients' direct medication costs by 4.3%. In this study, despite the high prevalence of omission drug as medication errors that resulted in increased medication cost following clinical pharmacists' interventions, the direct medication cost even decreased by clinical pharmacists' contributions.

In another report by a nephrology ward-based clinical pharmacist from Iran, about 60% of the nephrology patients experienced at least one medication error. Medication error rates were 0.11 error per ordered medications and 1.13 errors per patient. As seen, the medication error rates are lower in this study compared with our survey. The most common types of errors in that study were wrong drug frequency, wrong drug selection, overdose, too long treatment, and omission drug. Physicians' acceptance rate was 96.5%. The author reported that about 89% of medication errors caused no harm to the patients and 4.7% of errors increased the length of hospital stay or resulted in permanent harm to the patients.[13] Although not seriously, 22% of medication errors in our study resulted in harm to the patient, that is higher than that reported by Vessal et al.[13] This finding, in parallel with higher rate of medication errors in our study, might be due to different types of settings, medication errors definition and classification, and methods and sources of medication errors detection.

Reports from other countries regarding medication errors in nephrology patients have been presented here. A pooled analysis on medication errors reports from different hemodialysis wards of United States showed inappropriate monitoring (23.5%), dosing error (about 21%) and untreated indications (about 17%) as the most prevalent types of medication errors among hemodialysis patients.[5] Except for the error rates of therapeutic drug monitoring, other findings of our study are compatible with this US report.[5] Hug et al. evaluated medication charts of 900 CKD patients from six community hospitals from United States. They showed high rate of adverse drug events (10 per 100 admissions) among these patients. In their study, a majority of adverse drug events were classified as serious or significant and about 5% of them have the potential to cause permanent harm to the patient. More than 90% of errors were preventable, all by checking drug dosage and frequency in renal insufficiency. Errors were more prevalent for antibiotics (37%) followed by analgesics (31.5%) and cardiovascular drugs (16.5%).[8] Similarly, in our study most medication errors also happened on cardiovascular and antimicrobial agents.

A 6-month prospective study in a French ambulatory nephrology clinic showed that about 85% of the patients underwent at least one medication error. Medication error rate was 2.1 errors per patient. The most common type of medication errors were untreated indication and incorrect dosage. Nephrologists accepted 82.6% of clinical pharmacists' recommendations. Most medication errors occurred for cardiovascular drugs. Medication errors were correlated with older age and number of ordered medications.[7] Parallel results on the types of medication errors, clinical pharmacists' interventions, and drug classes with most errors were reported from a survey in an Austrian nephrology ward.[18] As seen, our findings are consistent with these results.

This suggests that medication errors in similar medical wards of different countries may show similar pattern.

Some differences in reported medication error rates among nephrology patients may be related to different types of study design, settings, medication errors definition and classification, and methods and sources of medication errors detection and reporting. High rate of prescription errors in Iranian studies may be due to ever using traditional paper-based prescription system instead of computerized physician order entry that eliminates errors related to illegible handwriting and also give alarm upon occurrence of major drug interactions or dosage errors. However, almost all studies on CKD patients in different countries showed incorrect drug dosage and untreated indications as the most prevalent types of medication errors. Due to the high rate of infectious diseases and cardiovascular co-morbidities among CKD patients, it is not surprising that most reported medication errors have been happened on antimicrobial and cardiovascular drugs.

As seen in above studies and some other reports on medication errors in CKD patients, clinical pharmacists-led medication review of patients with CKD assist identification and resolution of medication errors in these patients and exert clinical and economic impact on patients' health outcome and health-related quality of life.[4–8,13,17–20]

There major limitations of the present study that should be addressed include cross-sectional nature of this study and lack of including hospitals which are deprived clinical pharmacy services as a control group and assessing medication errors only in nephrology wards of one hospital that makes it difficult to extrapolate the findings to other wards or the same ward of other institutions. The other limitation is the estimation, but not the exact evaluation of direct medication cost in this study. We also did not include the fee for clinical pharmacist services in this cost analysis.

Conclusion

Most patients admitted to nephrology wards experienced medication errors possibly due to complex co-morbidities that necessitate polypharmacy. Most frequent errors were prescribing ones including untreated indications, unauthorized drugs and wrong drug dosage. Clinical pharmacists' contributions in nephrology wards were of value to prevent medication errors and to reduce medications cost.

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Declaration of interest

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All authors declare no conflict of interest.

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