ARTICLE ORIGINAL / ORIGINAL ARTICLE

MEDICATION PRESCRIBING ERRORS: DATA FROM SEVEN LEBANESE HOSPITALS

http://www.lebanesemedicaljournal.org/articles/60-1/original6.pdf

Amal AL-HAJJE, Sanaa AWADA, Samar RACHIDI, Nazih BOU CHAHINE, Rania AZAR, Salam ZEIN
Anna-Maria. HNEINE, Nadia DALLOUL, Georges SILI, Pascale SALAMEH*

Al-Hajje A, Awada S, Rachidi S, Bou Chahine N, Azar R, Zein S, Hneine AM, Dalloul N, Sili G, Salameh P. Medication prescribing errors : data from seven Lebanese hospitals. J Med Liban 2012 ; 60 (1) : 37-44.

ABSTRACT • INTRODUCTION : Medication prescribing errors are made all over the world. However, exact data about them are lacking in Lebanon. Our objective was to describe medication errors, including drug-drug interactions in medication orders given to patients admitted to Lebanese hospitals.

METHODS : A prospective study was carried out on 313 patients taken from seven Lebanese hospitals ; 1826 medication orders were assessed for errors and 456 drug-drug interactions were found. Data was entered and analyzed on SPSS.

RESULTS : Around 40% of medication orders were judged to comprise at least one prescribing error, mainly no ordering of parameters monitoring (20%), unnecessary medication (9%), and no indication (7%). Errors occurred mainly in the pediatrics (50%) and internal medicine wards (40%). Having an infectious or gastrointestinal problem almost doubled the risk of medication prescribing error. Antiulcer agents, NSAIDs, antibiotics and steroidal agents were the medications mainly involved. Meanwhile, 12 adverse medication events were reported, with an odds ratio of association to a medication error of 7.4 (p = 0.004). As for drug-drug interaction (DDI), prescriptions comprised zero to 29 interactions, involving medications with low margin of safety such as acenocoumarol, amiodarone and valproate. Pharmacodynamic interactions were mainly found (60%). The majority of DDI were of high clinical significance and well documented (80%), with moderate (59%) to major (17%) severity.

CONCLUSION : These results highlight the urgency of an intervention to improve patients' outcomes and avoid deleterious impact of inadequate medication use in Lebanon. The presence of a clinical pharmacist, the inclusion of computerized systems and the application of drug management policies are suggested to decrease medication prescribing errors and enhance the physician attention to DDI.

*Lebanese University, Faculty of Pharmacy, Clinical Pharmacy Department, Hadath Campus, Beirut, Lebanon.

Correspondence: *Pascale Salameh, Pharm D, MPH, PhD. Jdeidet El Meten. Chalet Suisse St. Ramza Azzam Bldg. Beirut. Lebanon.*

e-mail: *psalameh@ul.edu.lb*
pascalesalameh1@hotmail.com

Tel. : *+961 3 385 542*

Fax: *+ 961 1 696 600*

Al-Hajje A, Awada S, Rachidi S, Bou Chahine N, Azar R, Zein S, Hneine AM, Dalloul N, Sili G, Salameh P. Les erreurs de prescription médicamenteuse : données de sept hôpitaux libanais. J Med Liban 2012 ; 60 (1) : 37-44.

RÉSUMÉ • INTRODUCTION : Les erreurs de prescription médicamenteuse sont fréquentes mondialement ; les données au Liban sont inexistantes. Notre objectif était de décrire les erreurs de prescription, interactions médicamenteuses incluses, dans les ordres médicamenteux de patients hospitalisés au Liban.

MÉTHODES : Etude prospective menée sur 313 patients dans 7 hôpitaux libanais ; 1826 prescriptions médicamenteuses ont été évaluées, et 456 interactions y ont été trouvées. Les données ont été saisies et analysées sur SPSS.

RÉSULTATS : 40% des prescriptions évaluées comprenaient au moins une erreur de prescription : la non demande de surveillance des paramètres adéquats (20%), le médicament non nécessaire (9%), ou non indiqué (7%). Ces erreurs étaient surtout retrouvées dans les départements de pédiatrie (50%) et de médecine interne (40%). Le fait d'avoir un problème infectieux ou gastro-intestinal doublait le risque d'erreur. Les agents antiulcéreux, les AINS, les antibiotiques et les corticoïdes étaient surtout impliqués. Douze évènements indésirables liés aux médicaments étaient rapportés, avec une forte association aux erreurs de prescription (OR = 7,4 ; p = 0,004). Les prescriptions évaluées pouvaient contenir de zéro à 29 interactions médicamenteuses, où des substances à marge thérapeutique étroite telles qu'acénocoumarol, amiodarone, et valproate étaient impliquées. Ces interactions étaient surtout pharmacodynamiques (60%) ; les interactions retrouvées étaient souvent cliniquement significatives et bien documentées dans la littérature (80%), avec une sévérité modérée (59%) à majeure (17%).

CONCLUSION : Ces résultats démontrent l'urgence d'une intervention pour diminuer les erreurs de prescriptions et sensibiliser les médecins aux interactions médicamenteuses. La collaboration entre pharmaciens cliniciens et médecins, l'introduction de systèmes informatisés et l'application des recommandations internationales de traitements médicamenteux pourraient améliorer l'état du patient et éviter l'impact de l'utilisation inadéquate de médicaments.

INTRODUCTION

Medication prescription and administration are delicate tasks, and medication errors are commonly seen in hospitals. They may occur across the entire spectrum of prescribing, dispensing, and administering [1-3]. Reported prescribing error rates vary widely, ranging from 0.3% to

39.1% of written medication orders and from 1% to more than 90% of hospital admissions [4]. Conversely, more than 70% of serious medication errors occur during prescribing [5]; they can be responsible of hospital admissions and complications [6-8], and are costly to the health care system [5].

On the other hand, reported adverse events have a high rate of preventability (57% to 76%), i.e. they are medication errors [5, 9-12]. For example, in children, severe injury or death have been reported by the American Association of Poison Control Centers in children of the United States, due mainly to excessive medication dosing (72%) [13]. Higher rates of medication errors, drug-drug interactions and adverse events are also found in elderly receiving multiple medications for long-term illnesses [14-15]; in this population, a relatively high proportion of adverse drug events may be preventable [16].

In the Middle Eastern region, the situation does not differ from industrialized countries. Prescription writing of physicians was demonstrated to be suboptimal in Bahrain [17], while in Palestine, a wide range of dosing errors was common among patients with renal impairment [18]. In Saudi Arabia, 35% of patients were prescribed medication at a wrong dose, 31% by a wrong route of administration, and 30% with a wrong dosage form. These errors were due to human factors in 47% of cases [19]. In a study over 20 health care centers, 90.5% of infants' prescriptions comprised at least one error (non specification of duration or dose, dosing error, frequency error, and other errors types), mainly related to inadequate information about medications and nonadherence to basic principles of prescribing by physicians [20].

In Lebanon, 22.4% of elderly outpatients had inadequate prescribed medications (according to Beers' criteria) [21]. In Lebanese medical centers, several points have been demonstrated in previous research: the incidence of medication-related illnesses is not different from that in Western nations [22], and medication errors are quite possible since the medication use system in Lebanese hospitals is not well monitored [23]. However, published data is still lacking concerning the importance of clinical pharmacy in Lebanese hospitals, particularly in the field of medication prescribing error prevention. The objective of the study was to describe medication prescribing errors, including drug-drug interactions, in medication orders given to patients admitted to Lebanese private and public hospitals.

METHODS

Study design

This is a prospective descriptive study, carried out between October 15th and November 15th 2008.

Setting and participants

The study took place in a convenient sample of hospitals: Seven hospitals in Lebanon (public and private), where PharmD students of the Lebanese University carry out their practicum. Patients were included if they were admitted to the following wards during the study period: Internal Medicine, Intensive Care, Cardiology and Pediatrics. Every PharmD student was required to collect information for the first 10 patients admitted to his rotation ward. No exclusion criteria were adopted.

Procedure and main outcome measures

Patients' charts were reviewed and physicians were interviewed to fill out a standardized Clinical Research Form (CRF). Collected data included patient medical and medication history, laboratory data (biochemistry, hematology, microbiology, and clinical chemistry data), diagnosis and comorbidities, detailed medication orders and eventual adverse drug events. Data were collected by PharmD students, and CRF were subsequently evaluated by their preceptors (PharmDs & PhDs). No intervention was done in front of physicians to change the prescriptions; CRF were then centrally collected at the department of Clinical Pharmacy.

Only medication prescribing errors were evaluated in this study. The following definition was used: "A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescribing writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective or (2) increase in the risk of harm when compared with generally accepted practice." [24]. Information was assessed using two international references [25-26]. The following medication prescribing errors were considered per medication order: inadequate indication, use in case of a contraindication, duplicate and unnecessary therapy, inappropriate dosing for the patient's condition (dosing outside the recommended range, dosing without adaptation in case of renal of liver failure), inadequate specification of parameters to monitor by the physician (absence of or incomplete specification of required parameters), inadequate route of administration, inadequate frequency of administration, and missing information on the chart (missing dose, frequency or route). We note that the last error may be due to the physician lack of specification or the nurse mistranscription.

Drug-drug interactions (DDI) per prescription were completely assessed according to the Drug Interaction Facts book [27]: DDI were classified as of *major* (life threatening or potentially causing permanent damage), *moderate* (because they would cause deterioration of patient status), and *minor significance* (bothersome or causing little effect). The mechanisms of DDI were recorded (pharmacodynamic or pharmacokinetic, and being on absorption, metabolism, distribution or elimination, or unknown). The eventual onset of DDI was described as rapid (within 24 hours) or delayed (days to weeks). On the other hand, DDI's documentation was found to be as follows: established in the literature (proven in well controlled studies), probable (very likely, but not proven clinically), suspected (may occur; some good data but would need more study), possible (could occur, but data is limit-

ed), or unlikely (doubtful). Finally, the overall clinical significance was divided into clinically significant (if of high to moderate severity, coupled to possible to good documentation), or non clinically significant (otherwise), as described in the Drug Interaction Facts book [27]. Furthermore, interactions were double checked by using the Drug Interaction Checker of the Medscape for Pharmacists [28].

Adverse drug events were also evaluated; they were rated by using Naranjo probability scale criteria: according to their severity, consequences and objective proofs, they were considered definite, probable, possible or unlikely to be linked to the administered medication [29].

Statistical analysis

Data was entered and analyzed on SPSS, version 13.0. For nominal and ordinal variables, frequencies and percentages were presented; for continuous quantitative variables, the mean and standard deviation (SD) were presented. Statistical analyses included using Chi^2 test and Fisher exact test for nominal and ordinal variables, while Student test was used for continuous variables comparison be-tween two groups, in case of normal distribution and homogeneous variances. In case of non normal distribution or non homogenous variances, Mann-Whitney test was used to compare between two groups. A *p*-value of less than 0.05 was considered significant, and 95% confidence intervals (CI) were calculated for selected parameters, namely odds ratios (OR).

RESULTS

Patients characteristics and medication orders' description

Out of 380 returned CRF, 313 were adequately filled out, corresponding to 313 patients involved in the study, whose charts involved 1826 medication orders (Table I). Patients were almost evenly distributed between hospitals, while the majority of medication orders were taken from the internal medicine ward. Less than 10% of medication orders were taken from the intensive care units.

Fifty-four percent of involved patients were males, while 46% were females. The mean age was 44.6 years, with a standard deviation of 28.4. As for age distribution, 9.2% were infants (neonates to 1 year of age), 15.9% were children (1 to 17 years), 39.4% were adults (18 to 64 years), and 35.2% were elderly (65 years and more). The mean serum creatinin was 1.3 mg/dl (SD = 4.2), and mean creatinin clearance was 90.5 ml/min (SD = 46.7); 16.2% had renal failure. Liver function was normal in the majority of cases; only 1.6% were clinically judged to have liver failure. Four percent were reported to be allergic to at least one medication.

Clinical problems and prescribed medications

Out of 313 patients, 38.1% had a cardiovascular system problem, 38.4% had an infection, 19.7% had a lung problem and 11.1% had a gastrointestinal problem. Other problems were less common. Polypharmacy was found in the great majority of patients; only 1.3% had one prescribed medication on their chart; the rest had at least two medications. Prescribed medications' types were the following mainly antibiotics (18.7%), anticoagulant/antiplatelet agents (13.1%), antihypertensive agents (11.2%) and antiulcer agents (11.2%).

Medication prescribing errors

Out of 313 patients' prescriptions, only 55 (17.5%; 95% CI [13.3%-21.7%]) were found to have no error, while the rest (82.5%; 95% CI [78.3%-86.7%]) had at least one prescribing error. Per medication order, 60.7% of medication orders were considered with zero error (95% CI [58.5%-62.9%]), while 39.3% of orders had one error or more (95% CI [37.1%-41.5%]): 21.7% of orders had one error, 10.4% had two errors, 3.4% had three errors, and 1.8% had four errors or more per medication order.

Thus, among 1826 medication orders, 1103 errors of various types were found: 20.3% had no adequate specification of parameters to be monitored, 9.3% were unnecessary, 7.1% were non-indicated medications, 4% were prescribed at a lower dose than adequate, 2.8% at an inadequate frequency, 2.8% had missing information from file, 2.7% were prescribed for a too short duration, 2% were prescribed at a higher dose than necessary, and 0.8% for a too long duration. There were a relative contraindication in 1.2%, an absolute contraindication in 0.3%, and an inadequate route of administration in 0.9%.

Here are some examples of the prescribing errors that were found:

- Proton pump inhibitors and intravenous ranitidine were used in many patients outside the Intensive Care Unit without any compelling indication.
- Enoxaparin was used at a low dose of 20 mg once daily for deep venous thrombosis prophylaxis with no obvious reason for dose lowering.

TABLE I
PATIENTS AND MEDICATION ORDERS' DISTRIBUTION

Characteristics	Patients N (%)	Medication orders N (%)
Hospital (H)		
Zahraa H. - *Beirut*	34 (10.8)	169 (9.3)
Notre-Dame des Secours H. - Jbeil	46 (14.6)	311 (17.0)
Makassed General H. - Beirut	35 (11.1)	219 (12.0)
Military H. - Beirut	34 (10.8)	159 (8.7)
Rafik Hariri University H. - Beirut	94 (29.8)	491 (26.9)
Sacré-Cœur H. - Hazmieh	41 (13.0)	315 (17.3)
Sahel General H. - Beirut	29 (9.2)	152 (8.3)
Ward		
Internal Medicine	148 (47.0)	841 (46.1)
Intensive Care Unit	24 (7.6)	171 (9.4)
Pediatrics	81 (25.7)	347 (19.0)
Cardiology	60 (19.0)	456 (25.0)
Total	**313 (100)**	**1826 (100)**

– For some patients, antibiotics were given without stating the duration; this caused some patients to receive the antibiotics for periods longer than necessary.

Subgroups' comparison of medication prescribing errors

In table I, we present medication prescribing error percentages per ward and type of problem. There is a significant ($p < 0.001$) difference in medication prescribing errors occurrence between wards, with pediatric ward having the highest (49.4%) and cardiology ward the lowest (27.2%) percentage of errors.

Having an infectious or a gastrointestinal disease are both associated with higher rates of medication prescribing errors, while having a cardiovascular, endocrinology or renal disease are inversely associated with medication prescribing errors ($p < 0.05$). For other specified problems, no significant differences in percentage of medication prescribing errors were found.

As for types of medications, significantly different rates were found with the lowest prescribing errors for antidiabetic, antianginal and antispasmodic/muscle relaxing agents and the highest for antiulcer agents, non steroidal anti-inflammatory medications and antibiotics (Table II).

TABLE II
MEDICATION PRESCRIBING ERROR PERCENTAGE PER WARD, PROBLEM AND MEDICATION TYPES

	Orders N	Medication errors	*p value*	OR [95% CI]
WARD				
Internal Medicine	822	40.3%	*< 0.001*	1.80 [1.40-2.31]
Intensive Care Units	167	34.7%		1.42 [0.97-2.08]
Pediatrics	340	49.4%		2.61 [1.94-3.51]
Cardiology	448	27.2%		1.00
PROBLEM TYPE*				
Cardiovascular	850	30.5%	*< 0.001*	0.54 [0.44-0.65]
Other problems	938	44.9%		
Infectious	585	47.9%	*< 0.001*	1.84 [1.51-2.26]
Other problems	1203	33.3%		
Gastrointestinal	164	47.0%	*0.014*	1.50 [1.09-2.07]
Other problems	1624	37.1%		
Endocrinology	136	27.9%	*0.012*	0.61 [0.41-0.90]
Other problems	1652	38.9%		
Renal	92	28.3%	*0.047*	0.63 [0.40-0.99]
Other problems	1696	38.6%		
MEDICATION TYPE				
Antiulcer agents	201	59.7%	*< 0.001*	4.95 [0.06-0.41]
NSAIDs	26	50.0%		2.08 [1.03-4.20]
Antibiotics	334	48.8%		3.60 [1.51-8.55]
Steroids	65	44.6%		2.39 [1.09-5.26]
Antipyretics	48	39.6%		1.93 [0.91-4.10]
Bronchodilators	101	39.6%		2.23 [0.99-5.04]
Hypolipemic agents	67	38.6%		1.35 [0.63-2.90]
Neuropsychiatric medications	56	37.5%		1.88 [0.87-4.04]
Laxatives	11	36.4%		1.30 [0.76-2.23]
Thyroid medications	6	33.3%		1.15 [0.75-1.76]
Supplements	27	33.3%		1.45 [0.41-2.84]
Analgesics	60	31.7%		1.58 [0.74-3.39]
Anticoagulants/ antiplatelet agents	235	25.1%		1.35 [0.58-3.14]
Antihypertensive medications	203	23.2%		1.22 [0.53-2.82]
Antispasmodics/ muscle relaxants	14	21.4%		1.09 [0.63-1.74]
Antianginal agents	38	21.1%		1.06 [0.54-2.07]
Antidiabetic agents	31	19.4%		1.00

*For other problems, no significant differences in percentage of medication prescribing errors were found.

Adverse drug events

As for adverse drug events (ADE), 12 (0.7%) were reported. Complete data was available for 11 of them: 4 medications were discontinued, 6 were changed, 2 required dose modification, 3 prolonged hospital stay, and 3 necessitated supportive therapy. As for severity, 1 resulted in a serious harm, 3 were considered mild, 7 moderate, and 1 severe. There were conclusive reports in the literature for 10. ADE disappeared after the medication was stopped for 7; it was dose-dependent for 4, and the patient already presented a similar AE for 4. Objective proof was available for 9. Globally, according to Naranjo probability scale, ADE was considered probable for 6, possible for 4 and doubtful for 1.

In orders with medication prescribing errors, there was a significantly higher risk of reporting an adverse events (OR = 7.40 [1.59-34.45]; $p = 0.004$) (Figure 1); in other words, the adverse event was avoidable.

Here are some examples of some adverse events that were judged avoidable (related to medication prescribing errors):

– Gout crisis that needed medication treatment after high doses of bumetanide, administered without adequate monitoring of uric acid blood levels;
– Extra-pyramidal syndrome after administration of very high doses and for a long duration of metoclopramide to a patient with intractable vomiting;
– Amiodarone was administered to a patient who was already suffering from hypothyroidism, which exacerbated her thyroid status.

Drug-drug interactions' description

Out of 1822 medication orders in prescriptions of more than two medications, a total of 456 potential DDI were found, present in 46.6% of prescriptions. 165 out of 313 (52.7%) of prescriptions were free of DDI, while the rest had at least one DDI. As expected, DDI increased along with the number of prescribed medications: r = 0.63; $p < 0.001$.

In 37.5% of cases, the DDI involved a toxic or narrow therapeutic window medication. Examples of interactions include: antihypertensives (involved in 46.5% of DDI), non steroidal anti-inflammatory medications (31.8%),

anticoagulant and antiplatelet agents (30.7%), neuropsychiatric medications (20.9%), antibiotics (20.9%), and gastrointestinal tract medications (16.9%). For severity, 19.5% of DDI were classified as major, 60.7% were considered moderate, and 19.7% were of minor severity according to the Drug Interactions Facts book [27].

As for involved mechanisms in DDI, 62.1% were pharmacodynamic interactions, while the rest were pharmacokinetic. The onset of DDI would be rapid in 35.3% of cases, and delayed in 64.7% of cases. On the other hand, DDI's documentation was found to be as follows: 21.5% were established in the literature, 15.6% were probable, 29.4% were suspected, 29.6% were possible and 3.9% were unlikely or doubtful [28].

For the overall clinical significance of the potential DDI, more than 80% are clinically significant: 17.8% were severe and well documented, 27.5% were moderate and well documented, 3.9% were minor and well documented, 24.3% were major to moderate and possible, while 16.4% were minor and possible or were unlikely [28]. No statistically significant differences in the rate of clinically important interaction were found between subgroups: $p > 0.05$ between gender, age classes, wards and types of problems. However, there was a trend toward a higher rate of adverse drug events in patients with at least one clinically significant drug interaction in their prescription (5.6% versus 2.4% in patients with no clinically significant interaction in their prescription ($p = 0.15$; OR = 2.38 [0.71-7.97]); moreover, patients with adverse events had a trend towards a higher number of clinically significant DDI in their prescription (0.55 versus 0.34; $p = 0.15$).

DISCUSSION

In this study, we found that around 40% of medication orders comprised at least one medication prescribing error. The most common errors were no specification of adequate parameters to be monitored (20%), unnecessary or duplicate therapy (9%), and the use of non-indicated medication (7%). All over the world, reported prescribing error rates vary widely [4]: in a systematic review, median error rate was 7% (2-14%) of medication orders, 52 (8-22%) errors per 100 admissions in developed countries (US and UK), much lower than our results [30]. Lower results were even found in Germany (57 per thousand of medication orders) [11]. In other studies, almost 28% of the prescriptions evaluated contained one or more errors or potential errors [31]. In Saudi Arabia, all analyzed files contained at least one prescribing error, but the error was classified as serious in only 0.98% of patients' files [19]. These results are closer to ours. We note that prescribing errors variability between studies is partly due to variations in defining and severity evaluation of prescribing errors, methods used to collect error data and settings of the studies [30]. Thus, our study design does not allow for drug error incidence comparison, but mainly the nature and frequency of drug errors.

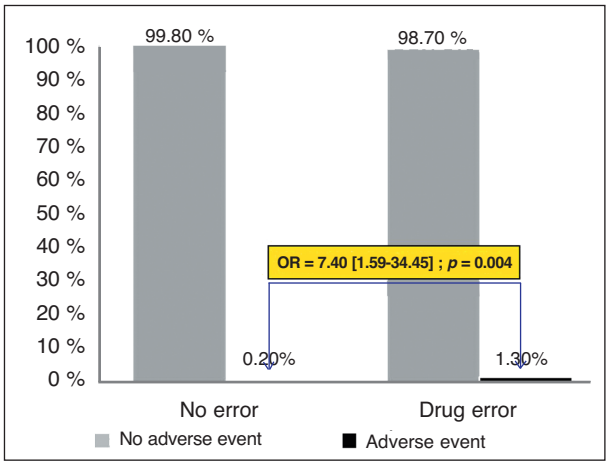

Figure 1. Medication prescribing errors association with reported adverse events. *In medication orders where there was at least one medication prescribing error, there was a significantly higher rate of adverse events compared with medication orders with no prescribing error.*

The most common factors generally associated with medication prescribing errors are related to knowledge regarding medication therapy and patient factors consideration, in addition to nomenclature factors (incorrect medication name, dosage form, or abbreviation) and dosage calculation [31]. Although the most serious errors originate in prescribing decision [32-33], monitoring problems are also reported to cause adverse drug events and even to be preventable causes of hospital admissions for outpatients [12]. This is also similar to what we found, where monitoring specifications were not given and thus, monitoring was not done. Accordingly, health care practitioners and systems must incorporate adequate error reduction, prevention, and detection mechanisms into the routine provision of care [34-35]. High-risk agents should be closely monitored based on patient and medication administration characteristics [36-37].

As for drug-drug interaction (DDI), 46.6% of prescriptions involved at least one interaction; medications with low margin of safety could be involved in one third of DDI, such as acenocoumarol, amiodarone, and valproate; the majority of DDI were of high clinical significance (55%), with moderate (60%) to major (20%) severity. Our results are similar to those of researchers in developing countries: the overall frequency of potential DDI was 49.7% in a Brazilian teaching hospital [3] and 57.8% in the psychiatric department of a Thailand hospital [38]. However, lower rates are found in developed countries, such as in the United States: 0.63% of clinically important DDI [39]. Similar to our findings, patient factors generally found to be associated with increased risk of DDI were high age, a high number of concurrently used medications and of prescribers [15, 40-41].

Interactions can have significant implications due to medication-related morbidity and mortality [39]. The trend for a higher rate of adverse events we found is thus easily explainable. In fact, patients do suffer adverse drug

reactions from major drug-drug interactions [42]. For example, in the Netherlands, the most frequently occurring clinical consequence of DDI was an increased risk of bleeding (22.0%), hypotension (14.9%), nephrotoxicity (12.6%) and electrolyte disturbances (10.5%). Almost half (48.6%) of the DDI could be managed by monitoring laboratory values [43]. However, many physicians may be unaware of DDI [44-45]. In Singapore, specialists were less likely to correctly identify interactions than generalists, while a previous experience with DDI-caused harm predicted better DDI knowledge [46]. Thus, health care professionals' ability to recognize potential DDI is important in reducing the risk of potential DDI and their consequences.

In settings where pharmacists have been integrated into medication therapy management processes, patient outcomes have improved [47-51]. Combining the presence of a pharmacist and computerized alerting systems is useful [52-55]. Thus, targeted education, collaborative medication selection, and pharmaceutical care are all strongly encouraged [43, 56-57]. The hospital and clinical pharmacists fulfill vital roles in improving medication safety [58-59], as an essential part of the quality improvement process [60]. Going back to Lebanon, physicians and nurses are aware of the importance of clinical pharmacy [61], pharmacists have enough education and are willing to work as clinical pharmacists [62] and hospital official accreditation by the Lebanese Ministry of Health requires the presence of clinical pharmacists [63]. Moreover, clinical pharmacy is known all over the world to be cost effective [47, 64], and was shown to minimize cost of pharmaceutical care in a Lebanese hospital [65]. Despite all this, hospital directors are still reluctant to employ clinical pharmacists: we hope that this study will encourage them to do so.

We are aware of the limitations of this study: a selection bias is possible, since the hospitals that participated may not represent all Lebanese hospitals, and patients' charts that were analyzed may not represent all Lebanese patients. Moreover, having both adults and children in the same analysis may overestimate or underestimate the medication errors results, since medication prescribing errors vary with the age of the patient [37]. An information bias is also possible, since missing data cannot be ruled out due to inadequate filling of patients' charts by nurses. Moreover, the prescribers' characteristics were not taken into account to analyze the occurrence of medication prescribing errors and DDI. Larger scale and specific prescribers' and patients' types oriented studies are expected to improve the precision of the obtained results.

CONCLUSION

In conclusion, we have shown in this work that potential medication prescribing errors and drug-drug interactions are quite common in Lebanese hospitals; we have also shown their strong association with adverse events' occurring. Thus, whatever system is chosen by Lebanese hospitals, reducing medication prescribing errors should be explicitly included in accreditation policy of the Lebanese Ministry of Health. Clinical pharmacy implementation, computerized systems and the application of drug management policies are definitely efficient and cost effective solutions.

CONFLICT OF INTEREST: None to declare.

REFERENCES

1. Miller MR, Robinson KA, Lubomski LH, Rinke ML, Pronovost PJ. Medication errors in paediatric care : a systematic review of epidemiology and an evaluation of evidence supporting reduction strategy recommendations. Qual Saf Health Care 2007 ; 16 (2) : 116-26.
2. van den Bemt PM, Egberts TC, de Jong-van den Berg LT, Brouwers JR. Drug-related problems in hospitalized patients. Drug Saf 2000 ; 22 (4) : 321-33.
3. Cruciol-Souza JM, Thomson JC. Prevalence of potential drug-drug interactions and its associated factors in a Brazilian teaching hospital. J Pharm Pharm Sci 2006 ; 9 (3) : 427-33.
4. Dean Franklin B, Vincent C, Schachter M, Barber N. The incidence of prescribing errors in hospital inpatients : an overview of the research methods. Drug Safety 2005 ; 28 (10) : 891-900.
5. Senst BL, Achusim LE, Genest RP et al. Practical approach to determining costs and frequency of adverse drug events in a health care network. Am J Health Syst Pharm 2001 ; 58 (12) : 1126-32.
6. National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) [online]. Available from URL : www.nccmerp.org. Accessed June 2009.
7. Anderson DJ, Webster CS. A systems approach to the reduction of medication error on the hospital ward. J Adv Nurs 2001 ; 35 (1) : 34-41.
8. Santell JP, Cousins DD. Medication errors involving wrong administration technique. Joint Commission Journal on Quality and Patient Safety 2005 ; 9 : 1-3.
9. Kunac DL, Kennedy J, Austin N, Reith D. Incidence, preventability, and impact of adverse drug events (ADEs) and potential ADEs in hospitalized children in New Zealand : a prospective observational cohort study. Paediatr Drugs 2009 ; 11 (2) : 153-60.
10. Jonville-Béra AP, Saissi H, Bensouda-Grimaldi L, Cissoko H, Giraudeau B, Autret-Leca E. Avoidability of adverse drug reactions spontaneously reported to a French regional drug monitoring centre. Drug Saf 2009 ; 32 (5) : 429-40.
11. von Laue NC, Schwappach DL, Koeck CM. The epidemiology of preventable adverse drug events : a review of the literature. Wien Klin Wochenschr 2003 ; 115 (12) : 407-15.
12. Howard RL, Avery AJ, Howard PD, Partridge M. Investigation into the reasons for preventable drug related admissions to a medical admissions unit : observational study. Qual Saf Health Care 2003 ; 12 (4) : 280-5.
13. Tzimenatos L, Bond GR ; Pediatric Therapeutic Error Study Group. Severe injury or death in young children from therapeutic errors : a summary of 238 cases from the American Association of Poison Control Centers. Clin Toxicol (Phila) 2009 ; 47 (4) : 348-54.

14. Kongkaew C, Noyce PR, Ashcroft DM. Hospital admissions associated with adverse drug reactions : a systematic review of prospective observational studies. Ann Pharmacother 2008 ; 42 (7) : 1017-25.
15. Salazar JA, Poon I, Nair M. Clinical consequences of polypharmacy in elderly : expect the unexpected, think the unthinkable. Expert Opin Drug Saf 2007 ; 6 (6) : 695-704.
16. Cresswell KM, Fernando B, McKinstry B, Sheikh A. Adverse drug events in the elderly. Br Med Bull 2007 ; 83 : 259-74.
17. Al Khaja KA, Sequeira RP, Al-Ansari TM, Damanhori AH. Prescription writing skills of residents in a family practice residency programme in Bahrain. Postgrad Med J 2008 ; 84 (990) : 198-204.
18. Sweileh WM, Janem SA, Sawalha AF et al. Medication dosing errors in hospitalized patients with renal impairment : a study in Palestine. Pharmacoepidemiol Drug Saf 2007 ; 16 (8) : 908-12.
19. Dibbi HM, Al-Abrashy HF, Hussain WA, Fatani MI, Karima TM. Causes and outcome of medication errors in hospitalized patients. Saudi Med J 2006 Oct ; 27 (10) : 1489-92.
20. Al Khaja KA, Al Ansari TM, Damanhori AH, Sequeira RP. Evaluation of drug utilization and prescribing errors in infants : a primary care prescription-based study. Health Policy 2007 ; 81 (2-3) : 350-7.
21. Saab YB, Hachem A, Sinno S, El-Moalem H. Inappropriate medication use in elderly Lebanese outpatients : prevalence and risk factors. Drugs Aging 2006 ; 23 (9) : 743-52.
22. Major S, Badr S, Bahlawan L et al. Drug-related hospitalization at a tertiary teaching center in Lebanon : incidence, associations, and relation to self-medicating behavior. Clinical Pharmacology & Therapeutics 1998 ; 64 (4) : 450-61.
23. Salameh P, Najjar Aad M, Semaan M et al. Le circuit du médicament dans les hôpitaux libanais. Revue d'Epidémiologie et de Santé Publique 2007 ; 55 (4) : 308-13.
24. Dean B, Barber N, Schachter M. What is a prescribing error ? Quality in Health Care 2000 ; 9 : 232-7.
25. Chrisholm-Burns MA : Pharmacotherapy : Principles and Practices, USA : McGraw Hill editions, 2008.
26. Vidal L : L'information de référence sur les médicaments. Base de données médicamenteuses, France : VIDAL, 2008.
27. Tatro DS : Drug Interaction Facts, Saint Louis, Missouri, USA : Walter Kluwer Health, 2006.
28. Medscape for Pharmacist. Drug Interaction Checker. Available on www.medscape.com. Consulted July 2009.
29. Naranjo CA, Busto U, Sellers E et al. A method for estimating the probability of adverse drug reactions. Clin Pharmacol Ther 1981 ; 30 : 239-45.
30. Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, incidence and nature of prescribing errors in hospital inpatients : a systematic review. Drug Safety 2009 ; 32 (5) : 379-89.
31. Devine EB, Wilson-Norton JL, Lawless NM et al. Characterization of prescribing errors in an internal medicine clinic. Am J Health Syst Pharm 2007 ; 64 (10) : 1062-70.
32. Lesar TS, Briceland L, Stein DS. Factors related to errors in medication prescribing. JAMA 1997 ; 277 (4) : 312-17.
33. Dean B, Schachter M, Vincent C, Barber N. Prescribing errors in hospital inpatients : their incidence and clinical significance. Qual Saf Health Care 2002 ; 11 (4) : 340-4.
34. Ghaleb MA, Barber N, Dean Franklin B, Wong IC. What constitutes a prescribing error in paediatrics ? Qual Saf Health Care 2005 ; 14 (5) : 352-7.
35. Rinke ML, Moon M, Clark JS, Mudd S, Miller MR. Prescribing errors in a pediatric emergency department. Pediatr Emerg Care 2008 ; 24 (1) : 1-8.
36. Evans RS, Lloyd JF, Stoddard GJ, Nebeker JR, Samore MH. Risk factors for adverse drug events : a 10-year analysis. Ann Pharmacother 2005 ; 39 (7-8) : 1161-8.
37. O'Mahony D, Gallagher PF. Inappropriate prescribing in the older population : need for new criteria. Age Ageing 2008 ; 37 (2) : 138-41.
38. Janchawee B, Wongpoowarak W, Owatranporn T, Chongsuvivatwong V. Pharmacoepidemiologic study of potential drug interactions in outpatients of a university hospital in Thailand. J Clin Pharm Ther 2005 ; 30 (1) : 13-20.
39. Aparasu R, Baer R, Aparasu A. Clinically important potential drug-drug interactions in outpatient settings. Res Social Adm Pharm 2007 ; 3 (4) : 426-37.
40. Bjerrum L, Gonzalez Lopez-Valcarcel B, Petersen G. Risk factors for potential drug interactions in general practice. Eur J Gen Pract 2008 ; 14 (1) : 23-9.
41. Johnell K, Klarin I. The relationship between number of drugs and potential drug-drug interactions in the elderly : a study of over 600,000 elderly patients from the Swedish Prescribed Drug Register. Drug Saf 2007 ; 30 (10) : 911-18.
42. Preskorn SH. How drug-drug interactions can impact managed care. Am J Manag Care 2004 Jul ; 10 (6 Suppl) : S186-S198.
43. Zwart-van Rijkom JE, Uijtendaal EV, ten Berg MJ, van Solinge WW, Egberts AC. Frequency and nature of drug-drug interactions in a Dutch university hospital. Br J Clin Pharmacol 2009 ; 68 (2) : 187-93.
44. Cruciol-Souza JM, Thomson JC. A pharmacoepidemiologic study of drug interactions in a Brazilian teaching hospital. Clinics 2006 ; 61 (6) : 515-20.
45. Ko Y, Malone DC, Skrepnek GH et al. Prescribers' knowledge of and sources of information for potential drug-drug interactions : a postal survey of US prescribers. Drug Safety 2008 ; 31 (6) : 525-36.
46. Ko Y, Malone DC, D'Agostino JV et al. Potential determinants of prescribers' drug-drug interaction knowledge. Res Social Adm Pharm 2008 ; 4 (4) : 355-66.
47. MacLaren R, Bond CA, Martin SJ, Fike D. Clinical and economic outcomes of involving pharmacists in the direct care of critically ill patients with infections. Crit Care Med 2008 ; 36 (12) : 3184-9.
48. Bond CA, Raehl CL, Franke T. Clinical pharmacy services, hospital pharmacy staffing, and medication errors in United States hospitals. Pharmacotherapy 2002 ; 22 : 134-47.
49. Hanlon JT, Weinberger M, Samsa GP et al. A randomized, controlled trial of a clinical pharmacist intervention to improve inappropriate prescribing in elderly outpatients with polypharmacy. Am J Med 1996 ; 100 (4) : 428-37.
50. Lipton HL, Bero LA, Bird JA, McPhee SJ. The impact of clinical pharmacists' consultations on physicians' geriatric drug prescribing. A randomized controlled trial. Med Care 1992 ; 30 (7) : 646-58.

51. De Rijdt T, Willems L, Simoens S. Economic effects of clinical pharmacy interventions : A literature review. Am J Health-Syst Pharm 2008 ; 65 : 1161-72.
52. van Rosse F, Maat B, Rademaker CM, van Vught AJ, Egberts AC, Bollen CW. The effect of computerized physician order entry on medication prescription errors and clinical outcome in pediatric and intensive care : a systematic review. Pediatrics 2009 ; 123 (4) : 1184-90.
53. Jayawardena S, Eisdorfer J, Indulkar S, Pal SA, Sooriabalan D, Cucco R. Prescription errors and the impact of computerized prescription order entry system in a community-based hospital. Am J Ther 2007 ; 14 (4) : 336-40.
54. Conroy S, Sweis D, Planner C et al. Interventions to reduce dosing errors in children : a systematic review of the literature. Drug Saf 2007 ; 30 (12) : 1111-25.
55. Kirk RC, Li-Meng Goh D, Packia J, Min Kam H, Ong BK. Computer calculated dose in paediatric prescribing. Drug Safety 2005 ; 28 (9) : 817-24.
56. Hidle U. Implementing technology to improve medication safety in healthcare facilities : a literature review. JNY State Nurses Assoc 2007 Fall-2008 Winter ; 38 (2) : 4-9.
57. Larson KA, Wiggins EF, Goldfarb MA. Reducing medication errors in a surgical residency training program. Am Surg 2004 ; 70 (5) : 467-71.
58. Guchelaar HJ, Colen HB, Kalmeijer MD, Hudson PT, Teepe-Twiss IM. Medication errors : hospital pharmacist perspective. Drugs 2005 ; 65 (13) : 1735-46.
59. Venkatraman R, Durai R. Errors in medicine administration : how can they be minimized ? J Perioper Pract 2008 ; 18 (6) : 249-53.
60. Benjamin DM. Reducing medication errors and increasing patient safety : case studies in clinical pharmacology. J Clin Pharmacol 2003 ; 43 (7) : 768-83.
61. Salameh P, Bou Chahine N, Bou Antoun R. La pharmacie clinique au Liban : une étude pilote concernant l'opinion du personnel hospitalier. Lebanese Medical Journal 2006 ; 54 (1) : 2-8.
62. Bou Antoun R, Salameh P. La satisfaction des pharmaciens au Liban et la perspective de la pharmacie clinique. East Mediterranean Health Journal 2009 ; 15 (6) : 1553-63.
63. Lebanese Ministry of Public Health. Hospital Accreditatiom Standards, Lebanon, 2003 [Accessed May 2009]. URL: http://www.public-health.gov.lb
64. Gandhi PJ, Smith PS, Tetaronis GR, Maas B. Impact of pharmacists on drug costs in coronary care unit. Am J Health Syst Pharm 2001 ; 58 : 497-503.
65. Salameh P. Cost minimization due to clinical pharmacist intervention in Rizk hospital. Presented in Rizk Hospital, May 2002.