Impact of pharmacist interventions on drug-related problems in general surgery patients: a randomised controlled trial

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ABSTRACT

Objectives The inappropriate use of medications is harmful and is a common issue in hospitalised patients. Patients hospitalised in general surgery wards are usually at high risk for drug-related problems (DRPs). This randomised controlled trial aimed to explore the value of a pharmaceutical care service conducted in general surgery wards in the identification and reduction of DRPs in comparison with standard medical care.

Methods This study was conducted in general surgery wards including abdominal, cardiovascular, vascular, endocrine, orthopaedic and oncological surgeries at one of the largest teaching hospitals in Jordan over a period of 6 months. Recruited patients were randomised into intervention or control groups. Clinical pharmacists assessed patients' DRPs and submitted recommendations to resolve the identified DRPs in the intervention group.

Results Patients in the intervention group (n=63) and the control group (n=60) had a mean age of 55±14.4 years, with 52.0% being women. A total of 1062 DRPs were identified, with a mean of 8.6±3.6 per patient (intervention group, 8.65±4.2; control group, 8.62±2.6; p=0.56). The commonly identified DRPs included safety (20.2%) and efficacy (19.0%) issues. The acceptance rate for pharmacists' recommendations by physicians was very high (90%) with a good DRP correction rate of 58.9% during patients' hospital stay. The value of pharmaceutical care was significantly reflected in the achievement of the therapeutic outcomes and prevention of morbidity (resolved/improved or prevented) of 68.2% (24.2%+44%) in the intervention group compared with 19.2% (12.4%+6.8%) in the control group (p<0.001).

Conclusions This study shows that DRPs are common among general surgery patients in Jordan, especially those related to drug safety and efficacy. Pharmacists' recommendations contributed substantially to resolving most of the identified DRPs and had a significant impact on improving medications used in general surgery patients.

INTRODUCTION

The inappropriate use of medications is harmful and is a common issue in hospitalised patients. Many studies have found that an extensive range of drug-related problems (DRPs) can be identified in hospitalised patients, and are mainly related to the efficacy or safety of medications.[1–4]

Patients hospitalised in general surgery wards are usually at high risk for DRPs due to polypharmacy related to comorbidities; requirements for perioperative medication adjustments and use of high-risk medications such as anticoagulants present further risk.[5–8]

The active participation of clinical pharmacists in inpatient care can have a significant impact on identifying and reducing DRPs, in addition to improving patient outcomes during the hospital stay and afterwards.[1 2 9–11] Clinical pharmacists' duties may include medication assessment throughout patient hospitalisation, participation in clinical rounds and discharge counselling.[12 13] The role of clinical pharmacists in improving therapeutic outcomes, achieving treatment goals, lowering side effects and assuring cost effectiveness in many acute and chronic disorders in internal medicine patients such as those with hypertension, heart failure, dyslipidaemia and diabetes mellitus has been demonstrated in several studies using different designs.[14–19] However, few studies worldwide have investigated the value of pharmaceutical care in general surgery patients.[20–22] Most of these studies investigated specific pharmacist activities such as appropriate antibiotic prophylaxis,[23 24] thromboprophylactic optimisation,[25] pre-admission clinics[26] and prevention of adverse drug events.[27] Many studies have been conducted on specific patient groups such as cardiac,[28] neurosurgical,[29] orthopaedic,[30] bariatric[31] and patients undergoing visceral surgeries.[32] A recent review by Guérin *et al* concluded that "there are few data on the impact of pharmacists in surgery".[33] A need to conduct a comparative study on surgical patients to support their important findings on the potential significant role of pharmacist in surgical settings was also called for.[20]

The present study aimed to explore the value of a pharmaceutical care service in identifying and resolving DRPs in a sample of general surgery patients through the active participation of clinical pharmacists in general surgery wards compared with standard medical care. The secondary aim was to explore the clinical benefits of physician–clinical pharmacist collaboration in achieving better therapeutic outcomes for general surgery patients.

METHODS

Design and setting

This unblinded randomised controlled trial was conducted in the general surgery wards in one of the largest teaching hospitals in Amman, Jordan. This large general hospital provides services to a large and wide variety of the Jordanian population. The 300-bed general surgery wards (out of a total of 544 beds) at the hospital cover the following

specialties: abdominal surgery, cardiovascular surgery, vascular surgery, endocrine surgery, orthopaedic surgery and oncological surgery. The study protocol met the Declaration of Helsinki and Good Clinical Practices principles and was approved by the institutional review board of the hospital.

Sample size

The findings from the initial 15 study subjects were used for sample size calculation. The mean difference in DRPs on discharge between the intervention and control groups was 2 (SDs 2.1 and 4.0). Setting alpha at 0.05 and using a power of 80%, a minimal sample size of 41 subjects per group (intervention vs control group) was needed to obtain a significant difference. Assuming that 20% of subjects may be lost to follow-up, the total required sample size was determined to be at least 99 patients (50 patients per group).

Study subjects

Patients who were hospitalised in the general surgery wards with an expected duration of stay of more than 2 days were asked to participate in the study. Data collection and follow-up were conducted during weekdays over a 6-month period. Patients were provided with information about the study and were invited to be interviewed by the qualified clinical pharmacists.

Patients older than 18 years diagnosed with one or more chronic or acute medical conditions and taking ≥2 medications on admission were eligible for study entry. Patients with any of the following conditions documented in the medical record were excluded: pregnancy, dementia or cognitive impairment and patients who were unable to provide informed consent. Written informed consent was obtained from all study participants in both study groups.

Definition and classification of DRPs

The definition used for DRPs was 'any drug-related issue that may actually or potentially interfere with the patients' optimal clinical outcomes'. DRPs were classified in accordance with AbuRuz *et al*.[34] DRPs are classified into seven main categories: unnecessary drug therapy, untreated conditions that require drug therapy, efficacy, safety, inappropriate knowledge, inappropriate adherence and need for additional/more frequent drug monitoring.

Data collection

During the process of obtaining patient consent, the recruited patients were informed that they would be assigned randomly to either the intervention group (physician–pharmacist collaborative practice) or control group (usual care; physician-only team). At the time of recruitment, patients were randomised into the intervention group or control group. Randomisation was according to a computer-generated randomisation table. The process was simple randomisation and the sequence was generated using the website www.randomization.com. Data were collected by three trained and qualified clinical pharmacists with at least 3 years experience in general surgery. Once recruited, patients' medications were evaluated by the pharmacists on a daily basis to identify DRPs. A previously described systematic evidence-based approach was used to assess patients' medications for DRP and to optimise treatment in patients in the intervention group.[35] A validated pharmaceutical care tool[34] was used for the collection of patients' data, which consisted of general patient information (demographic and administrative information), current acute and chronic medical problems, current drugs, history of previous diseases and drugs, family history, lifestyle, social history, allergies, vital signs, physical examination data, laboratory data, drug serum concentration and diagnostic test results. This tool was used to collect data for all patients at baseline and at follow-up through patient interview and by using the patients' medical records.

Description of the intervention versus 'usual care'

The clinical pharmacists initially interviewed patients in both study groups to collect information about their medications, medical conditions, lifestyle and to explore and assess the DRPs.

The patients in the intervention group received usual care (table 1) by their physicians, nurses plus pharmaceutical care services provided by clinical pharmacists. Pharmacists followed up patients and assessed medications for efficacy and safety on a daily basis, recommended optimal medication therapy for each medical condition, provided medication counselling, answered

Table 1 Standardised procedure followed in data collection clarifying the differences between the intervention and control groups

	Procedure step	Intervention group	Control group
1.	Demographic and clinical data were collected on admission using patient interview, active participation in clinical rounds and medication records. Medication reconciliation was also conducted on admission	Implemented	Implemented
2.	Patients' medications were evaluated daily for DRPs. The present study adopted the up-to-date guidelines and drug information to assess efficacy and safety parameters of the used medications in order to identify any issues related to the optimal selection, efficacy and safety or dosing regimens of medications. Daily evaluation of patients' symptoms and laboratory data was carried out to assess effectiveness of medications and to identify adverse drug reactions and possible drug interactions. Patients' knowledge and adherence to their medications were assessed through the use of previously validated scales.[34] Kidney and liver function were evaluated regularly to help in assessing the appropriateness of the dosing regimen and in recommending correct medication doses.[45]	Implemented prospectively	Implemented retrospectively
3.	The clinical pharmacists discussed most of their findings, identified DRPs and recommendations during the clinical rounds with the responsible physician to allow for immediate implementation and actions. Some recommendations or DRPs were addressed in the physician's office due to time limitation or due to the need for more time to assess patient response or to conduct further literature search. A treatment care plan including all pharmacists' recommendations was developed for all intervention group patients and submitted to the physician	Implemented	Not implemented
4.	The pharmacist followed up the patients daily to resolve actual and prevent potential DRPs	Implemented	Not implemented
5.	The pharmacist conducted discharge medication counselling	Implemented	Not implemented

DRPs, drug-related problems.

questions asked by patients or physicians, assessed and encouraged adherence to medications and recommended laboratory data monitoring.

Patients in the control group received the usual care as provided by the physicians and nurses. The clinical pharmacist did not provide any recommendations and did not offer any educational advice or counselling. For control patients, medications were assessed for DRPs at discharge and retrospectively during the hospital stay to asses outcomes for DRPs and compare with the intervention group. DRPs were not assessed on a daily basis in the control group to allow appropriate comparison with the intervention group and to better assess the impact of clinical pharmacists on patients. On the other hand, identifying DRPs in the control group without intervention could raise ethical issues and impact the study outcomes if resolved or withdrawn. All identified DRPs, recommendations and therapeutic outcome classifications were recommended by the study pharmacists and reviewed by two of the study investigators for discussion and approval.

Outcome measures

The following outcomes were measured in this study:

1. Process outcomes which include:
   a. Prevalence of DRPs
   b. Types of identified DRPs
   c. Degree of physicians' acceptance of pharmacists' recommendations.
2. Clinical outcomes: the intervention and control groups were compared with regard to:
   a. Therapeutic outcomes of DRPs during hospital stay (see below for details): Patients were followed up to investigate the outcome of each DRP during the hospital stay. This included assessment of vital signs, physical examination data, laboratory data, diagnostic test results, patients' symptoms and medical file notes. The intervention and control groups were compared with regard to the number of DRPs that were resolved, improved, prevented, not changed or worsened.
   b. To further assess the impact of pharmacists' interventions during the hospital stay, we assessed and compared the number of DRPs at discharge medication between the intervention and control groups.

Definition of therapeutic outcomes of DRPs

Therapeutic outcomes of DRPs were classified into the following categories[9]:

- *Resolved/improved*: Therapeutic outcome was achieved or improved. This term was also used to describe outcomes for DRPs that required addition of a drug to improve the long-term therapeutic outcome. Resolving actual adverse drug reactions or actual drug–drug interactions was also considered as 'resolved/improved'.
  Example 1: Blood pressure readings were improved and became at goal when given the optimal individualised treatment.
  Example 2: The clinical signs and symptoms of infection were improved or resolved when a proper empirical antibacterial was given to a patient with surgical site infection.
- *Prevented*: Future morbidity was prevented through preventing an adverse drug reaction or drug–drug interaction, education for inappropriate knowledge or adherence, and stopping unnecessary or potentially unsafe drug therapy.
  Example: Osteoporosis could be prevented in patients taking glucocorticoids chronically (eg, prenisolone use in renal transplant patients) by using bisphosphonates, calcium and vitamin D supplements.
- *No change*: The therapeutic outcome was not improved or changed. The term is used in case adding the recommended medication did not improve the clinical outcomes. This term was also used in case of not implementing recommendations related to miscellaneous problems or not adding a drug that affects long-term therapeutic outcomes.
  Example: The patient was given the recommended antihypertensive medication but the blood pressure did not reach the therapeutic goal.
- *Worsened*: The clinical outcome was worsened.
  Example: The patient received the recommended treatment for postoperative pain but his pain worsened.

Data analysis

SPSS Version 21 (SPSS Inc, Cary, North Carolina, USA) was used for data entry and analysis. A χ^2 test was used to evaluate the association between categorical variables, while an independent sample t-test was used to evaluate differences between continuous variables. Relative risk reduction (RRR) and numbers needed to treat (NNT) were also calculated for the therapeutic outcomes of DRPs. NNT is defined as the number of patients who should receive pharmaceutical care service to see a positive

Table 2 Demographic and clinical characteristics of the study sample*†‡

Parameter	Intervention group (n=63)	Control group (n=60)
Age	54.13 (±15.47)	55.97 (±13.24)
Gender, female, n (%)	35 (55.60)	29 (48.3)
Weight (kg)	79.44 (±18.0)	74.73 (±14.0)
BMI	9.45 (±6.76)	27.23 (±4.46)
Employment, n (%)		
Yes	17 (27.0)	16 (26.7)
No	39 (61.9)	38 (63.3)
Retired	7 (11.1)	6 (10.0)
Marital status, n (%)		
Single	7 (11.1)	3 (5.0)
Married	53 (84.1)	52 (86.7)
Divorced/widow	1 (1.6)	5 (8.3)
Smoking status, n (%)		
Non-smoker	37 (58.7)	44 (73.3)
Ex-smoker (quit >6 months)	10 (15.9)	5 (8.3)
Smoker	16 (25.4)	11 (18.3)
Length of hospital stay	9.78 (±7.58)	9.46 (±7.70)
Acute and chronic medical problems	5.90 (±3.07)	6.30 (±3.16)
Prior to admission (PTA) medications	25 (±3.20)	3.86 (±2.73)
Current medications (during hospital stay)	10.40 (±4.43)	9.95 (±3.90)
General surgery specialty, n (%)		
Abdominal	28 (44.4)	26 (43.3)
Endocrine	13 (20.6)	14 (23.3)
Oncology	11 (17.5)	7 (11.7)
Cardiovascular/vascular	11 (17.5)	13 (21.7)

*Parameter described as mean (SD) unless stated otherwise.
†All differences were not statistically significant (p>0.05).
‡Some data were missing, so totals do not always add up to the final number.
BMI, body mass index.

Table 3 Drug-related problems identified during hospitalisation*

Parameter	No (%) of patients with DRPs	DRPs in intervention group (n=63) N (%)	DRPs in control group (n=60) N (%)
Total DRPs	123 (100)	545 (100)	517 (100)
Unnecessary drug therapy	62 (50.0)	42 (7.7)	58 (11.2)
Untreated condition	62 (50.0)	59 (10.8)	42 (8.1)
Efficacy-related issues	100 (81.3)	116 (21.3)	86 (16.6)
More effective drug recommended	54 (43.9)	33 (6.1)	36 (6.9)
Need for additional/combination therapy	71 (57.7)	56 (10.3)	37 (7.2)
Low dose	23 (18.7)	22 (4.0)	8 (1.5)
Efficacy drug interaction issue	4 (3.3)	5 (0.9)	5 (1)
Safety-related issues	86 (70)	109 (20.0)	106 (20.5)
High dose	46 (37.4)	36 (6.6)	37 (7.2)
Drug is contraindicated	15 (12.2)	8 (1.5)	11 (2.1)
The patient is at high risk for developing adverse drug reaction and requires prophylaxis or intervention	36 (29.3)	29 (5.3)	18 (3.5)
Allergic reaction or undesirable effect	7 (5.7)	5 (0.9)	3 (0.6)
Safety drug interaction issue	28 (22.8)	31 (5.7)	37 (7.2)
Inappropriate knowledge about medications or diseases	91 (74.0)	72 (13.21)	76 (14.7)
Inappropriate adherence to medications	83 (67.5)	41 (7.52)	42 (8.1)
Need for additional/more frequent drug monitoring	96 (78.0)	106 (19.45)	107 (20.7)

DRP classification according to AbuRuz *et al*, 2006.[34]
*All differences in mean DRP for each DRP category between the intervention and control groups were not statistically significant (independent sample t-test, p>0.05).
DRP, drug-related problem.

outcome in one patient. A p value <0.05 was considered to be statistically significant.

RESULTS

Study sample

The number of patients who were admitted to the surgical wards at the study site during the study period was 221 patients. One hundred and thirty-five patients (61.1%) fulfilled the inclusion criteria and 132 patients (59.7%) gave consent for participation and were randomised into the intervention and control groups. Nine patients were discharged earlier than expected (less than 48 hours) and were removed from the study (3 intervention group and 6 control group). The remaining 123 patients (93.2%) completed the study (63 in the intervention group and 60 in the control group) (online supplementary figure 1).

Table 4 Physicians' acceptance of pharmaceutical care recommendations

Parameter	Intervention group N (%)	Control group N (%)
Number of DRPs during hospitalisation	545	517
Number of recommendations submitted to physician*	358 (65.7)	NA
Number of recommendations accepted by physicians	324 (90.5) †	NA
Number of implemented recommendations	208 (64.2) ‡	NA
Number of DRPs corrected by physicians/nurses without pharmacist intervention	0	75 (14.5)
Number of recommendations at patient level	113 (20.7)	NA

*The rest of the recommendations were not submitted as the patient was discharged early or the physician was not available or were only at patient level.
†Percentage of submitted.
‡Percentage of accepted.
DRP, drug-related problem; NA, not available.

The demographic and clinical characteristics were similar in both groups, with no statistical significant differences shown (p>0.05, table 2). Patients were admitted mainly for abdominal (43.9%), endocrine (21.9%) and oncological surgeries (14.6%).

DRPs during hospitalisation

A general description of DRPs identified during hospitalisation is shown in table 3. A total of 1062 (range 2–19) DRPs with a mean of 8.6±3.6 (intervention group: 8.65±4.2; control group: 8.62±2.6; p=0.56) were identified during the study period in both groups. All of the study patients had at least one DRP. There were no statistically significant differences in the number of identified DRPs in any of the DRP categories or in the total number of DRPs between the intervention and control groups during hospitalisation (table 3).

The main commonly identified DRPs (in both groups) were efficacy-related DRPs (19.0%), safety-related DRPs (20.2%) and need for additional monitoring (20.0%). With regard to the efficacy-related DRPs, the need for combination therapy (8.8%) and a more effective drug (6.5%) were the most frequent DRPs. For safety-related DRPs, high dose (6.9%) and safety drug interactions (6.4%) were the most frequent DRPs in the study sample.

Physicians' acceptance of pharmaceutical care recommendations

Only pharmacists' recommendations for patients in the intervention group were submitted and discussed with physicians. The acceptance rate for pharmaceutical care implementation by physicians was very high (90%, table 4). The majority of the identified DRPs (58.9%) during hospitalisation were corrected (321 recommendations, 208 with physicians and 113 at patient level). The 321 DRP recommendations were accepted and implemented in the intervention group compared with 75 DRPs (14.5%) in the control group identified and corrected by physicians and/or nurses.

Table 5 Therapeutic outcomes of drug-related problems during hospitalisation

Therapeutic outcome	Intervention group		Control group		P value	RRR or RBI (95% CI)	NNT (95% CI)
	No of DRPs N (%)	No of patients N (%)	No of DRPs N (%)	No of patients N (%)			
Number of DRPs during hospitalisation	545	63	517	60		NA	NA
Resolved or improved	132 (24.2)	30 (47.6)	64 (12.4)	14 (23.3)	0.01	104.3% (RBI) (20.5% to 245.6%)	4.1 (2.5 to 12.7)
Prevented	240 (44.0)	42 (66.7)	35 (6.8)	6 (10.0)	<0.0001	567% (RBI) (205.9% to 1352.8%)	1.8 (1.4 to 2.5)
Not changed	161 (29.5)	23 (36.5)	403 (77.9)	56 (93.3)	<0.0001	60.9% (RRR) (55.5% to 71.9%)	1.8 (1.4 to 2.3)
Worsened	12 (2.2)	6 (9.5)	15 (2.9)	12 (20.0)	0.71	52.5% (RRR) (−18.8% to 80.9%)	9.5 (4.4 to 53.1)

DRP, drug-related problem; NNT, number needed to treat; RBI, relative benefit increase; RRR, relative risk reduction.

Therapeutic outcomes of DRPs

The value of pharmaceutical care was significantly reflected in the achievement of the therapeutic outcomes and prevention of morbidity (resolved/improved or prevented), which was 68.2% (24.2%+44%) in the intervention group compared with 19.2% (12.4%+6.8%) in the control group (p<0.001, table 5). NNT data indicated that pharmaceutical care should be provided to at least 2 (~1.8) patients (for prevention) or to 4.1 patients (for resolving or improving) to achieve benefit in one patient.

Statistical comparison of DRPs upon discharge

Potential DRPs on discharge in the intervention group were 47% (2.34/4.94) of those in the control group (table 6). The reduction in the number of DRPs in the intervention group at discharge was significantly higher than in the control group (p<0.0001).

DISCUSSION

This randomised controlled trial was conducted successfully to assess the incidence of DRPs at an educational hospital in Amman, Jordan, highlighting the impact of pharmaceutical care services on therapeutic outcomes following identifying and resolving DRPs for patients in the surgical ward compared with standard medical practice. The results of this study contribute to the body of literature on the impact of pharmacists in surgery patients, as highlighted previously.[33] It is one of the few comparative studies conducted on surgical patients,[20] and no previous similar study has been conducted on general surgery patients. The role of pharmacists in Jordan and developing countries is rapidly moving towards providing more clinical services.[36]

Patients hospitalised in general surgery were found to suffer from numerous DRPs (1062 DRPs for study participants). The extent of the problem can be demonstrated by the high mean number of DRPs in the study sample (8.6 per patient) and the fact that all patients had at least one DRP. The high number of identified DRPs can in part be related to the high number of medications taken by the patients (10.4 and 9.9 in the intervention and control groups, respectively) and the numerous diseases (5.9 and 6.3 in the intervention and control groups, respectively). Similar findings were observed in other studies where patients were receiving high numbers of medications and the average number of DRPs was 9.4 in the internal medicine settings.[1] However, this may not reflect the actual situation in general surgery patients, where many patients do not usually suffer from chronic diseases and receive no or few medications.[37] In the current study, only patients with chronic diseases and only those who were receiving at least two medications were included. The average number of DRPs reported in the current study was much higher than those reported in studies investigating pharmaceutical care in specialised surgery settings (compared with the general surgery setting).[38–41]

DRPs related to safety (using high-dose and safety drug interactions), efficacy (appropriate choice of effective medications and using lower than recommended dose) and lack of monitoring were those most commonly identified in this study. These categories may specify an issue in selecting appropriate doses and medications for patients admitted to surgery wards in Jordan. These findings strongly support the need for the integration of pharmaceutical care services in general surgery wards in the country. Other sites around the world share, to some extent, this issue, and hence the same recommendation stands. In a study conducted in a cardiac surgery intensive care unit in Saudi Arabia, untreated medical conditions, inappropriate dosing regimen (safety issue) and no indication for drug use were the most common DRPs.[39] In hospitalised paediatric patients in Spain, DRPs related to dosing (safety issue) were the most common.[42] Another study conducted in Jordan in an internal medicine ward found that DRPs related to efficacy were the most common DRP category, followed by safety and no indication.[1] Hence, although differences between the studies exist, the issues of safety and efficacy seems to be a common issue regardless of the study setting (surgery, internal medicine, paediatrics, etc).

Surgeons who participated in the current study accepted more than 90% of the pharmacists' recommendations; this is an indicator of the value and need for pharmaceutical care services in general surgery wards. This finding coincides with a study from Jordan in which physicians strongly supported expanding the

Table 6 Number of drug-related problems on discharge*

Group	Intervention	Control	P value	Mean difference (SE)	Confidence interval for the difference
Mean (±SD) DRPs at discharge medications	2.34 (±2.1)	4.94 (2.44)	<0.0001	−2.6 (±0.46)	−1.7 to −3.53
Mean (±SD) change in DRPs from baseline	−6.31 (±3.45)	−3.68 (±2.79)	<0.0001	−2.63 (±0.67)	−1.31 to −3.94

*Independent sample t-test.

role of pharmacists and the clinical services they can offer.[43] A similar acceptance rate was identified previously for hospitalised patients, for both adults[20] and paediatrics.[42] Surgeons' acceptance rate of pharmacists' recommendations was found to be higher than that reported in the literature for the community pharmacy setting (57%).[44] This further highlights the high need for the role of pharmacists in this setting.

The lower rate of actual implementation of pharmacists' recommendations in this study was mainly related to the delay in communicating DRPs between the healthcare professionals and early discharge of patients before implementation of the recommendations by physicians. These issues can be resolved in the future once the pharmaceutical care service trialled in this study becomes an official service at the study site.

Identifying and resolving DRPs during hospitalisation indicated the substantial value of the pharmaceutical care service in surgical wards. Outcomes achieved in the intervention group (DRPs resolved, improved, prevented) for the majority of identified DRPs (68.2%) compared with the control group (19.2%) were valuable. This was also reflected in the NNT data where 1.8 patients (for prevention) and 4.1 patients (to resolve or improve) were needed to achieve benefit from the pharmaceutical care service in one patient.

In the design of this study, limitations encountered in the related published literature were avoided. For example, we used a randomised controlled study design; the clinical pharmacists participated daily in the clinical rounds; data collection from medical files for the intervention group were collected prospectively rather than retrospectively; and the clinical pharmacists involved monitored and followed up the patients on a daily basis until discharge.

The current study is limited, however, by the small sample size and for being a single-centre study. In addition, the recruited patients suffered from several chronic diseases and were prescribed a high number of medications; therefore, the findings may not be applicable to all general surgery settings in Jordan and abroad. In this study, patients were divided equally between the three study pharmacists. We avoided using a specific pharmacist for control group patients as the possible differences in knowledge and skills between the pharmacists could impact the identification of DRPs. On the other hand, assessment of DRPs was done retrospectively in the control group patients due to ethical issues. Also, it was not possible to blind the pharmacists as they have to recommend therapy mortifications for intervention group patients. Retrospective assessment in the control group, the unblinded study design and using the same pharmacists to assess DRPs in intervention and control group patients could introduce bias issues. However, the pharmacists were well trained in the study protocol and the similar number of DRPs identified during hospitalisation between intervention and control patients (average of 8.6 per each group, $p=0.56$) indicates that bias was probably avoided.

Another possible limitation is that physicians could learn from the pharmacists' recommendations in the intervention group and apply it in the control group without pharmacist intervention, which could impact the study results (ie, contamination). However, in surgical patients, where patients receive many medication for perioperative and postoperative care and also suffer from various acute and chronic medical conditions, treatment should be individualised and this requires daily follow-up with regard to efficacy and safety of medication and daily assessment of the patient's response and laboratory data. Each patient is different, therefore the impact of contamination should be minimal. Therapeutic outcomes were much improved in the intervention group, which confirms the minimal impact of contamination.

CONCLUSIONS

This study shows that DRPs are common among general surgery patients in Jordan. The DRPs related to safety, such as using high doses and drug interactions, were the most common, in addition to DRPs related to patient monitoring and drug efficacy. Pharmacists' recommendations contributed substantially to resolving most of the identified DRPs and had a significant impact on improving the efficacy and safety of the medications used in general surgery patients. Accordingly, the results from this study support previous findings and assure the importance of clinical pharmacy cooperation in both general and specialised surgery wards.

What this paper adds

What is already known on this subject

- Inappropriate use of medications is harmful and is a common issue in hospitalised patients
- General surgical patients can benefit greatly from clinical pharmacists' role

What this study adds

- This randomised controlled trial highlighted the impact and importance of pharmaceutical care services on therapeutic outcomes in general surgery patients
- The study indicated that drug-related problems are very common among general surgery patients
- Pharmaceutical care contributed substantially to identifying and resolving drug-related problems in general surgery patients
- Pharmacists' interventions in this setting have a significant impact on improving the efficacy and safety of medication

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