ORIGINAL RESEARCH

Hospital Pharmacists' Perceptions and Decision-Making Related to Drug-Drug Interactions

Harkaryn Bagri, Karen Dahri, and Michael Legal

ABSTRACT

Background: Pharmacists often overlook drug interaction alerts because of limitations in clinical decision support (CDS) software systems intended to detect evidence-based, clinically significant drug-drug interactions (DDIs). Alert fatigue, which occurs when pharmacists become desensitized to an overload of DDIs, may also contribute.

Objectives: To gain a better understanding of how pharmacists assess common DDIs and the extent to which computerized drug alerts affect their decision-making, as background for initiatives to overcome alert fatigue and improve detection of DDIs.

Methods: This qualitative study used focus group methodology. A structured focus group was planned at each of 3 large tertiary hospitals. Pharmacists were invited to participate if their jobs included patient care and/or dispensary responsibilities. The focus group discussions were audio-recorded and subsequently transcribed, analyzed, and coded into themes using NVivo software. Four main categories of themes were identified: perceived challenges, pharmacists' assessment of DDIs, barriers to responding to alerts, and proposed solutions.

Results: The participants (n = 24) described a large discrepancy among CDS software systems in terms of the severity of specific DDIs, which made it difficult to view these systems as reliable sources. The participants agreed that alert fatigue is present and contributes to DDIs being overlooked. However, lack of patient information to make an initial assessment, as well as the constant need for multitasking, prevents pharmacists from focusing on the evaluation of DDIs.

Conclusions: Although alert fatigue was reported to be a common factor responsible for pharmacists missing DDIs, other barriers also exist. Participants suggested ways to limit DDI alerts to those that are clinically relevant. Having a collaborative team of pharmacists periodically review the DDIs embedded in the CDS system, incorporating a colour-code system, and removing duplicate entries were discussed as ways to improve system efficiency.

Keywords: alert fatigue, drug-drug interactions, pharmacists

RÉSUMÉ

Contexte : Les pharmaciens ignorent souvent les alertes d'interactions médicamenteuses à cause des limites des logiciels d'aide à la décision clinique (ADC) conçus pour détecter les interactions médicamenteuses (IM) factuelles et significatives d'un point de vue clinique. La fatigue liée aux alarmes (alert fatigue), qui survient lorsque les pharmaciens sont désensibilisés à cause d'une surcharge d'IM, peut aussi contribuer à cette situation.

Objectifs : Mieux comprendre comment les pharmaciens évaluent les IM courantes et dans quelle mesure les alertes médicamenteuses affectent leur prise de décision, dans le cadre de la mise en œuvre d'initiatives visant à surmonter la fatigue liée aux alarmes et à mieux détecter les IM.

Méthodes : La méthodologie de cette étude qualitative se basait sur les groupes de discussion. Un groupe de discussion structuré était prévu dans chacun des trois grands hôpitaux tertiaires. Les pharmaciens étaient invités à participer si leur travail comprenait des soins offerts aux patients ou des responsabilités dans la distribution de médicaments. Les discussions dans les groupes ont fait l'objet d'un enregistrement audio avant d'être retranscrites, analysées et codées selon les thèmes à l'aide du logiciel NVivo. Quatre catégories de thèmes principaux ont été établies : les défis perçus, l'évaluation des IM par les pharmaciens, les obstacles à lever pour répondre aux alertes et les solutions proposées.

Résultats : Les participants (n = 24) ont mentionné un écart important dans les définitions de la gravité [severity] d'IM spécifiques données par les logiciels d'ADC, de sorte qu'il était difficile de se fier à ces systèmes. Les participants ont indiqué que la fatigue liée aux alarmes existait bel et bien et qu'elle contribuait au manque de prise en compte des IM. Cependant, le manque d'information sur les patients pour faire l'évaluation initiale, ainsi que le besoin constant d'effectuer plusieurs tâches à la fois, empêche les pharmaciens de se concentrer sur l'évaluation des IM.

Conclusions : Bien que la fatigue liée aux alarmes empêche fréquemment les pharmaciens de remarquer les IM, il existe d'autres obstacles. Les participants ont proposé de limiter les alertes d'IM à celles pertinentes d'un point de vue clinique. Les solutions examinées pour améliorer l'efficacité du système ont porté sur la formation d'une équipe collaborative de pharmaciens qui examine périodiquement les IM intégrés dans le système ADC, l'incorporation d'un système de codes de couleur et l'élimination des entrées dupliquées.

Mots clés : fatigue liée aux alarmes interactions médicamenteuses, pharmaciens

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INTRODUCTION

A drug-drug interaction (DDI) occurs when one drug affects the pharmacokinetics or pharmacodynamics of another drug, resulting in a qualitative or quantitative change in action.[1,2] An adverse DDI is one that leads to increased drug toxicity.[2] DDIs are preventable occurrences that can result in adverse drug events (ADEs), causing serious harm to patients or reducing the therapeutic efficacy of one or more medications.[1] Up to 11% of patients experience adverse effects due to DDIs, with 2%–3% of these adverse effects being responsible for hospital admission.[3]

Pharmacists are in a unique position to identify DDIs and intervene when necessary to prevent ADEs.[1] When pharmacists review drug regimens manually, 66% of DDIs in 2-drug regimens are correctly detected, with the proportion decreasing as the number of drugs increases.[4] Within hospitals and in the community, clinical decision support (CDS) software systems are available to assist pharmacists in identifying DDIs of clinical importance.[1] However, these drug information software programs can cause pharmacists to become desensitized to an overload of DDI alerts; as a result, they may not spend an appropriate amount of time evaluating each DDI.[1] Evaluating DDIs can be mentally exhausting and time-consuming when there are too many alerts, which may lead pharmacists to ignore both relevant and irrelevant warnings, a phenomenon known as alert fatigue.[1,4] It is reported that pharmacists' override rates can be as high as 71.9% during daily practice.[5] Furthermore, DDI screening software programs are limited in their ability to detect evidence-based, clinically significant DDIs, and they sometimes fail to alert pharmacists about DDIs of real concern.[5,6]

In general, all CDS software systems function in a similar manner; however, in British Columbia, different health authorities work with different CDS software companies. All of the systems are intended to display DDI alerts according to the severity of the interaction; however, severity may be presented in the form of numbers (1, 2, 3) or letters (A, B, C), with the designation 1/A being most severe and 3/C being least severe. It is important to note, however, that not all health authorities were included in this study; therefore, there may be other designations for indicating severity levels.

Studies performed to date have mainly focused on evaluating the performance of DDI screening software programs in identifying select clinically significant DDIs in the hospital setting.[6-9] Many of these studies have concluded that a high number of pharmacy CDS systems perform suboptimally.[6] In addition, customization of drug alerts at various hospital sites allows pharmacists to miss DDIs of higher severity.[10] Software customization involves turning certain interactions on or off at the discretion of pharmacy staff.[7] Such customization can create variation in the system's performance, which can in turn compromise patient care.[7]

The purpose of this study was to investigate how hospital pharmacists assess common DDIs and to evaluate the extent to which computer alerts affect pharmacists' decision-making (in terms of determining which DDIs are clinically significant). Our assessment of how pharmacists deal with DDIs in their daily practice, as well as which information sources they use and wish to have on hand, will help inform initiatives to overcome alert fatigue and improve interaction detection rates. Improving a pharmacist's ability to detect DDIs could reduce the chance of ADEs, preserve patient safety, and prevent medical and legal problems.[4]

METHODS

A qualitative study was conducted using focus group methodology. Three structured focus groups, consisting of 6 to 8 pharmacists each at 3 different sites (Surrey Memorial Hospital, St Paul's Hospital, and Vancouver General Hospital), were planned. An invitation to participate in the focus groups was sent via e-mail by site-specific hospital clerical staff to group e-mail lists for pharmacists. Those interested in participating were asked to contact one of the co-investigators (H.B.). Potential participants were included if they worked in an institutional setting and had dispensary or patient-care responsibilities. Community pharmacists and pharmacy technicians were excluded, because the study's focus was primarily on hospital software systems. However, hospital pharmacists who participated in the study might have been working concurrently or have had past experience in the community. We did not ask participants to report their community experience, and the focus group questions pertained to pharmacists' experiences with CDS software systems in the hospital setting. All participants gave written informed consent. Ethics approval to conduct the study was obtained from the University of British Columbia Behavioural Research Ethics Board.

The target sample size for each focus group was 6 to 8 participants. If an insufficient number of pharmacists responded to the initial e-mail invitation, the investigators approached individual pharmacists from a cross-section of positions. The focus groups were planned to last about 1 hour and were scheduled during the participants' lunch hour, with lunch being provided by the unrestricted start-up research fund of one of the coauthors. No other honorarium or incentive was offered to participants, and no other funding was involved in any other aspect of the study.

One of the co-investigators (H.B.) conducted all of the focus groups, with a designated research assistant also present to observe and take notes. The sessions were audio-recorded for subsequent transcription and analysis.

A comprehensive literature search was performed to determine the questions that would be used in the focus groups. A panel of pharmacists reviewed the preliminary questions with a view to further improvement. The focus group questions could be categorized as seeking the resources that pharmacists use when reviewing DDIs and their thought processes when assessing DDIs

of potential concern (see Appendix 1, available at https://www.cjhp-online.ca/index.php/cjhp/issue/view/191/ showToc).

The audio-recordings were transcribed by the research assistants and reviewed for accuracy by the focus group moderator. One of the investigators (H.B.) then coded the transcripts and organized the content into common themes using NVivo software (https://www.qsrinternational.com/nvivo/what-is-nvivo).

This was a qualitative study, so there was no primary outcome. The 2 primary objectives of this qualitative evaluation were to learn more about how pharmacists perceive DDI alerts and to determine the extent to which computer alerts affect pharmacists' decision-making when dispensing a medication.

RESULTS

A total of 24 participants were recruited: 9 from Surrey Memorial Hospital, 8 from St Paul's Hospital, and 7 from Vancouver General Hospital. Fifteen (62%) of the participants had been working at their respective hospital sites for no more than 5 years, and 15 (62%) had both clinical and dispensary duties (Table 1). Only 1 pharmacist had dispensary duties only.

The qualitative analysis revealed themes, which were organized into the following 4 main categories: perceived challenges, pharmacists' assessment of DDIs, barriers to responding to alerts, and proposed solutions.

Perceived Challenges

One theme mentioned frequently in the focus groups was that the CDS systems can be overwhelming in terms of the information they provide about DDIs (Box 1). Furthermore, some pharmacists felt that the CDS systems were not a reliable source when it came to assessing more severe or unusual DDIs. As a result, they found themselves referring to other resources to determine whether a particular DDI was clinically significant.

Many pharmacists agreed that there is a large discrepancy in the severity of specific DDIs among the various CDS software systems.

> "It feels like 95% of the interactions are maybe completely useless … I wouldn't do anything about them."
> —Participant

For example, a DDI flagged in the CDS software system as having severity 1 or severity X, meaning that the drug combination should be avoided, might not be categorized as having the same severity by the pharmacist reviewing the DDI, who might consider it as having severity 3 or severity C, meaning that the drug therapy should be monitored. Furthermore, participants in all 3 focus groups frequently cited interactions embedded in the CDS systems that were irrelevant or for which they felt they did not have enough information to do an adequate assessment. For example, QT prolongation was commonly mentioned (in all 3 focus groups) as irrelevant or useless, and many participants stated that this is something they would watch out for but not act upon (Box 1). Another interaction mentioned as irrelevant was "same drug, multiple routes". This concern typically referred to opioids,

Box 1. Participants' Opinions Concerning Challenges Associated with CDS Software Systems, Presented as Common Themes*

Challenges

- Current CDS systems are not a reliable source to assess drug interaction alerts (*n* = 24)
- The information provided by CDS systems can be overwhelming (*n* = 7)
- More severe or unusual interactions will prompt pharmacists to look to other resources to determine if the interaction is clinically relevant (*n* = 5)
- A discrepancy in severity exists among the different CDS systems (*n* = 4)
- The CDS systems are outdated (*n* = 2)

Interactions perceived as irrelevant or "useless"†

- QT prolongation (*n* = 3)
- Insulin and β-blockers (*n* = 2)
- Same drug, multiple routes (*n* = 2)
- Bleeding risk (*n* = 2)
- PRN opioid sedation (*n* = 2)
- Dimenhydrinate interactions (*n* = 1)

CDS = clinical decision support, PRN = administration as needed.

*The common themes presented here were mentioned during some or all of the focus groups. The *n* value for each theme represents the total number of times the theme was mentioned over the course of the 3 focus groups

†Refers to interactions embedded in the CDS software system that pharmacists perceived as irrelevant or for which they would not have the necessary information to act.

Table 1. Demographic Characteristics of Participants (*n* = 24)

Characteristic	Hospital Site; No. of Participants		
	Surrey Memorial Hospital (*n* = 9)	St Paul's Hospital (*n* = 8)	Vancouver General Hospital (*n* = 7)
Years at hospital site			
≤ 5	7	4	4
> 5	2	4	3
Primary work area			
Dispensary only	0	1	0
Clinical only	3	2	3
Clinical + dispensary	6	5	4

which can be administered by different routes (e.g., hydromorphone oral or IV). The possibility of multiple routes for a single drug can also contribute to alert fatigue, which can result in pharmacists missing both irrelevant and relevant DDIs.

Pharmacists' Assessment of DDI

When participants were asked how they assessed whether a potential DDI is of concern, they commonly reported asking themselves, "What are the ramifications of dispensing the medications that could cause the DDI?" (Box 2). Only those with the potential for an immediate effect would be considered clinically significant.

> "The first step I would think is what is the extreme things that could happen if I don't act on this. Are we either going to compromise therapy or reduce efficacy of something? Are we going to cause patient harm?" —Participant

Participants also described a series of questions they often ask themselves before acting upon a DDI alert: Is the consequence of the DDI reversible or irreversible? What is the indication for the medication? What are the patient's own risk factors for experiencing this DDI? What is the reported incidence of the interaction? How likely is the DDI to occur in my patient?

An additional theme was that a pharmacist's familiarity with the particular DDI plays a role in determining whether it is deemed to be clinically relevant. Recent pharmacy graduates often flagged a DDI because they lacked of experience and did not want to cause patient harm. Participants indicated that although they frequently turned to the Lexicomp database as their initial resource for assessing the clinical significance of a DDI, they often had to use other references, including Micromedex and the *Compendium of Pharmaceuticals and Specialties* (Box 3).

Box 2. Factors Leading Pharmacists to Assess DDIs as Clinically Significant*

DDIs with immediate, severe ramifications are considered clinically significant (*n* = 9)
Recent pharmacy graduates are more likely to flag a DDI because of lack of experience (*n* = 2)

DDI = drug-drug interaction.

*The *n* value for each factor represents the total number of times the factor was mentioned over the course of the 3 focus groups

Box 3. Drug Information Resources* Preferred by Pharmacists†

University of Liverpool HIV Drug Interaction Checker (*n* = 3)
Natural Medicine (*n* = 3)
Case reports (*n* = 2)
Compendium of Pharmaceuticals and Specialties (*n* = 2)
Micromedex (*n* = 1)
Credible Meds QT (*n* = 1)

*Tertiary drug information resources used by pharmacists when clinical significance of a drug-drug interaction could not be determined from the Lexicomp database.

†The *n* value for each resource represents the total number of times the resource was mentioned over the course of the 3 focus groups.

Box 4. Barriers to Responding to Alerts about DDIs, Presented as Common Themes*

Alert fatigue is a common factor in missing potential DDIs (*n* = 16)
Pharmacists lack the clinical context to assess a DDI in the dispensary (*n* = 5)
Heavy workload and multitasking can contribute to pharmacists not identifying clinically important DDIs (*n* = 4)
Pharmacists working clinical shifts feel they are limited by time available to assess DDIs (*n* = 2)

DDI = drug-drug interaction.

*The *n* value for each theme represents the total number of times the theme was mentioned over the course of the 3 focus groups.

Barriers to Detecting DDIs

Most participants agreed that alert fatigue is a common contributor to the underdetection of DDIs (Box 4). However, other barriers may also impede pharmacists' optimal workflow. Participants felt that there was a lack of resources, such as patient-specific information, rather than a lack of time. Participants reported that, in the dispensary, they were often presented with a DDI alert that they would never act upon, because they do not have enough information about the patient to assess the DDI in the first place. Moreover, participants felt that they had multiple competing duties to which they had to attend throughout the day and thus might not be entirely focused on the orders in front of them, as illustrated by the following quotation:

> "We're dealing with phone calls at the same time, questions are being asked by other pharmacists, by technicians, we may be dealing with shortages, we are not 100% as focused as we can be on the order at any given time of the day …" —Participant

In contrast to pharmacists working in the dispensary, pharmacists working clinical shifts felt limited by time, as opposed to resources, when assessing DDIs. They often have 20 to 40 patients to look after, and it is not possible to spend hours determining whether a DDI is clinically important and requires immediate action.

Proposed Solutions

Throughout the focus groups, participants suggested various ways to improve drug alert detection rates (Box 5). Common suggestions included a periodic review of the DDIs embedded in the hospital's computer systems by a collaborative team of pharmacists, who would decide which of those being flagged were clinically relevant. The purpose would be to limit the alerts to those that are clinically important, in an effort to reduce alert fatigue. Furthermore, the implementation of a colour-coding scheme to differentiate the various severity levels might also help to improve drug alert detection rates. For example, information presented in red would stand out more and be harder to miss; this

Box 5. Participants' Ideas for Overcoming Alert Fatigue, Presented as Common Themes*

Annual review of DDIs in CDS software systems, performed by team of pharmacists (*n* = 8)
Allow colour-coding to differentiate severity levels (*n* = 6)
Limit duplication (*n* = 2)
Customize severities (*n* = 2)

CDS = clinical decision support, DDI = drug-drug interaction.
*The *n* value for each theme represents the total number of times the theme was mentioned over the course of the 3 focus groups.

colour could be implemented for the highest severity of interaction (i.e., the combination of medications should be avoided). Conversely, the colour green could be used to indicate less severe interactions, for which the clinical decision would be to simply monitor therapy.

Another interesting suggestion was to have a way of documenting that a specific DDI had been reviewed by a specific person, who would be different from the person who verified the entire order. For example, the pharmacist would be prompted to enter his or her initials once the DDI had been verified. Limiting duplication (e.g., for cases of the same drug by multiple routes) would also substantially reduce alert fatigue. Finally, customization of severities was commonly mentioned throughout the focus groups. Customization is a feature of the software that allows hospital sites to select certain DDIs to be turned on or off, depending on their frequency of occurrence at the specific hospital site. In contrast to the identification of clinically relevant DDIs by a team of pharmacists, customization may be carried out by nonpharmacist staff members.

DISCUSSION

The findings of this study indicate that pharmacists believe the CDS software systems perform suboptimally when it comes to detecting clinically important DDIs. Discrepancies among the hospital CDS software systems in terms of severity assigned to specific DDIs cause pharmacists to utilize other resources (e.g., Lexicomp database) to thoroughly assess the DDIs, leaving less time to care for their patients. When it came to actually assessing a DDI, participants explained that they often went through a series of questions before they could confidently act upon the DDI. An important question they often ask themselves is "What are the ramifications of dispensing the medications involved in this DDI?" Alert fatigue was determined to be a major contributor to pharmacists missing DDI alerts; however, other barriers, such as lack of resources in the dispensary and lack of time when performing clinical duties, can also prevent pharmacists from fully assessing DDIs. In addition, because pharmacists have multiple duties throughout the day, they may not be entirely focused on the job at hand, with the distractions causing them to miss DDIs. Many of the focus group participants proposed potential solutions to improve drug alert detection rates. Periodic review of the DDIs embedded in the CDS systems was the most common recommendation.

Four main categories of themes were identified in the focus group data: perceived challenges, pharmacists' assessment of DDIs, barriers to responding to alerts, and proposed solutions. Although alert fatigue was identified as a major contributor to the underdetection of DDIs, several other barriers also impeded the optimal workflow of pharmacists.

This study aimed to gain a better understanding of how pharmacists assess common DDIs and the extent to which computer drug alerts affect their decision-making. Similar to previous studies, we found that a discrepancy in severity exists among the DDIs identified by the CDS software systems. In a review of 30 million prescriptions dispensed in a community pharmacy, the pharmacists considered only 5.7% of initially detected DDIs to be clinically relevant.[11] This may be partially due to the absence of a universal policy for organizing the severity of DDIs.[5] The severity rating associated with individual DDIs comes primarily from in vitro studies, case reports, and retrospective reviews, there being no studies that have specifically evaluated the clinical effects of DDIs.[5] Furthermore, the CDS systems do not take into consideration an individual patient's characteristics or the dosing modifications and precautions already taken by health care professionals, leading to the frequent reporting of DDIs that are irrelevant.[11] As a result, health care professionals may not find the CDS software systems to be an accurate source for detecting DDIs. Additionally, there may be differences in the perceptions of hospital versus community pharmacists, dependent upon the practice setting. In the hospital setting, there is more capability to monitor the patient, so a hospital pharmacist may be less likely than a community pharmacist to act upon a DDI. As in previous studies, our study also found that pharmacists were more likely to act upon a DDI that could have an immediate effect resulting in patient harm or the inefficacy of one or more medications.[5]

During initial assessment of a DDI's clinical relevance, pharmacists reported that they most often considered the immediate effects of the interactions if the medications were to be dispensed by them. They might then consider other clinical questions to help determine whether they should act upon the DDI alert. Although pharmacists are typically more concerned with the immediate effects of a DDI, delayed effects are just as important and may be missed if they are not considered with the same priority as immediate effects. In addition, because of the unreliability of the CDS systems, pharmacists often have to utilize additional resources to complete their clinical assessment of a DDI. The process illustrates the thorough job that pharmacists do in assessing DDIs but also alludes to the increased workload and pressures on their time that may result. It was also found that the pharmacists' level of experience affected their decision-making

regarding DDIs, with more recent pharmacy graduates flagging most of the DDIs identified by the system. These practitioners may lack the clinical experience of a pharmacist who has been working for many years and has had the opportunity to witness the clinical result of the interaction in question. Newer pharmacists also expressed concern about liability and did not want to do anything that might jeopardize their newly started career. Given these findings, we suggest that an algorithm be developed as a universal tool for all pharmacists to use in assessing DDIs. Such a tool would alleviate the fears of newly practising pharmacists.

This study revealed that, in addition to alert fatigue, pharmacists felt they were too busy to address all of the DDI alerts. The medicolegal implication of this perception is that a pharmacist would become liable if they dispensed the medications involved in a DDI that resulted in potential harm or inefficacy. Nonetheless, the heavy workload contributes to pharmacists not identifying clinically significant DDIs. As is the case for community pharmacists, hospital pharmacists are often multitasking, and the chances of completing any given task without interruption are low. As a result of interruptions, pharmacists may lose their concentration on the task at hand, which may lead to medical errors and patient harm.[1] Furthermore, interruptions in the thought process may impair a pharmacist's memory to follow up on DDI alerts that were flagged. Alternatively, unexplored reasons for not resolving DDIs may be clinical inertia, lack of knowledge, or lack of skills concerning which DDIs are clinically significant.

Several suggestions for improvement have been described to overcome alert fatigue. The findings in our study were similar to those of Australian research, which evaluated the design of CDS alerts, to increase the effectiveness of DDI alerts.[12,13] However, those studies focused on computerized physician order entry, whereas our research focused on pharmacists. Periodic review of the DDIs embedded in the CDS systems by a team of pharmacists might help to identify which DDIs are clinically relevant. Having at least one member of the review panel with a pharmacy background would be vital to help ensure that only those DDIs that are relevant pop up, to reduce alert fatigue. Having someone who is familiar with the issue of duplication (e.g., same drug by multiple routes) would also help to decrease the number of alerts. In addition, customization has the advantage of allowing a focus on those alerts that are clinically significant at the particular hospital site.[10] Although customization would solve some of the issues associated with alert fatigue, there are also concerns. For example, turning certain DDI alerts on or off at the discretion of any pharmacy staff member might cause interactions of higher severity to be missed, as different pharmacists will have different perceptions of what DDIs are irrelevant. The practicality of determining which DDIs should be allowed and which should be blocked may have medicolegal implications. The tailoring of DDI alerts to be turned off according to the preference of individual hospital sites may result in the manufacturer of the CDS system being absolved of liability, should adverse events occur. Site-specific customization may also cause variability in the performance of the CDS systems. One disadvantage of removing DDI alerts pertaining to "same drug, multiple routes" would be that patients who receive 2 similar medications may be at increased risk of harm. For example, if a patient had prescriptions for 2 different nonsteroidal anti-inflammatory medications and the DDI alert was overlooked, the patient might experience serious consequences from the duplication of therapy, such as acute renal failure. Although a colour-coding scheme might help to differentiate the various severity levels, this idea has limitations. Pharmacists might interpret "green" to mean that no action is required and might not implement an appropriate monitoring plan for the patient. Yellow alerts might be considered less critical and thus might be overlooked, but in fact this designation might reflect a potential delayed interaction that does require action. Also, alert fatigue can occur with any system that has multiple flags (such as a system of colour coding), and difficulties may be encountered in assigning the appropriate colour to each DDI.

This study had several limitations. The focus groups were held at 3 large tertiary hospitals. Pharmacists working at smaller sites or in different settings may use different computer systems and may have different experiences. Only 1 dispensary-only pharmacist was able to participate in the study. Pharmacists whose duties are limited to the dispensary may have different perceptions of DDIs than pharmacists with dual job duties (dispensary and clinical). One of the major limitations in developing a system that alerts the most clinically relevant DDIs is its subjectivity, as there is little evidence to guide practice and variability in terms of how pharmacists would act upon DDIs, depending on level of experience and prior knowledge. To overcome this limitation, higher-quality overall monitoring of the clinical effects of the DDIs themselves are needed, to guide what should be done in practice. At some sites, the study investigators had to independently encourage pharmacist participation to reach the target size of the focus groups, which might have introduced selection bias. Because this was a qualitative study using focus group methodology, the analysis and interpretation of the results were subjective. Lastly, the number of times that a theme was mentioned may not necessarily depict the "truth" and may not indicate the strength of agreement among participants. Rather, the intent of qualitative research is to explain the underlying reasons for certain observations.

CONCLUSION

The pharmacists who participated in this study believed that definitions of interaction severity differed among the various CDS software systems, which meant they had to look to secondary and tertiary resources to determine whether a DDI was clinically significant. When assessing DDIs, the pharmacists' first step was to assess whether the DDI would have an immediate effect and

what the implications of that effect would be for patients. Alert fatigue was a major problem in DDI alerts being overlooked; however, other barriers do exist, which result in pharmacists being unable to completely focus on evaluating the DDIs. This study did not specifically reveal the benefits of CDS systems; however, there are apparent benefits to having a more efficient CDS system. In addition, a more reliable CDS software system, which detects only those DDIs with clinical relevance, would allow pharmacists to improve their drug alert detection rates, thus reducing the amount of time spent consulting secondary references and increasing the time allocated to patient care. Future research should explore whether the DDIs that pharmacists prioritize and those that the CDS software system flags are in agreement and of clinical importance.

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