Get Smart, Canada: Exploring Smart Pump Implementation, Management, and Compliance with Standards through a Nationwide Survey

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ABSTRACT

Background: Smart pump technology is relatively new, and uncertainty exists regarding best practices for development and management of the drug libraries in these devices. In Canadian hospitals, IV smart pumps and their drug libraries are created and maintained according to recommendations from Accreditation Canada and guidelines from the US Institute for Safe Medication Practices (ISMP). Current compliance with these standards in Canada is unknown. However, neither organization provides specific operational steps detailing how to effectively create and manage a drug library, which leaves significant room for interpretation. Furthermore, the human resources dedicated to creation and management of these libraries in accordance with guidelines and standards are unknown.

Objectives: To describe current compliance with standards and guidelines for smart pump drug libraries; the processes used for drug library set-up, management, training, and support; and the resources currently used for these activities in Canadian hospitals.

Methods: A 43-question online survey was made available in spring 2021 to multidisciplinary team members involved in implementation of IV smart pumps and/or management of drug libraries in Canadian hospitals.

Results: A total of 55 complete or partial responses were received. Most responses indicated that standards set by Accreditation Canada and ISMP were not being met, with only 30% (14/47) updating their libraries at least quarterly and 47% (20/43) performing quality reviews at least every 6 months. Although the majority of respondents reported regular monitoring of compliance, 30% (11/37) did not perform such monitoring. Results further indicated variation across Canadian hospitals in set-up, management, training, and support related to drug libraries, as well as variation in the human resources available for these activities.

Conclusions: Canadian health authorities and organizations are not meeting current ISMP and Accreditation Canada standards for smart pumps. Variation exists in terms of strategies for creating and managing drug libraries, as well as in the training and resources needed to support these initiatives. Canadian health authorities and organizations should prioritize meeting these standards and should closely review the resources required to do so.

Keywords: smart pumps, drug library, dose error reduction system, health technology

RÉSUMÉ

Contexte : La technologie des pompes « intelligentes » est relativement nouvelle et des zones d'ombre subsistent quant aux meilleures pratiques de développement et de gestion des bibliothèques de médicaments intégrées à ces appareils. Dans les hôpitaux canadiens, les pompes IV intelligentes et leurs bibliothèques sont créées et maintenues conformément aux recommandations d'Agrément Canada et aux lignes directrices de l'Institute for Safe Medication Practices (ISMP; États-Unis). Le respect actuel de ces normes au Canada est inconnu. Cependant, aucune des organisations ne fournit de mesures opérationnelles particulières détaillant comment créer et gérer efficacement une bibliothèque de médicaments, ce qui laisse une grande marge d'interprétation. De plus, on ne connaît pas les ressources humaines consacrées à la création et à la gestion de ces bibliothèques conformément aux lignes directrices et aux normes.

Objectifs : Décrire, dans un premier temps, dans quelle mesure les lignes directrices et les normes régissant les bibliothèques de pompes « intelligentes » sont respectées; ensuite, les processus utilisés pour mettre en place la bibliothèque de médicaments, la gérer, former et soutenir le personnel; et, finalement, les ressources actuellement utilisées pour ces activités dans les hôpitaux canadiens.

Méthodes : Au printemps 2021, un sondage en ligne comportant 43 questions a été mis à la disposition des membres d'équipes multidisciplinaires impliquées dans la mise en œuvre des pompes intelligentes IV et/ou la gestion des bibliothèques de médicaments dans les hôpitaux canadiens.

Résultats : Au total, 55 réponses complètes ou partielles ont été reçues. La plupart des réponses ont signalé que les normes établies par Agrément Canada et l'ISMP n'étaient pas respectées. En effet, seulement 30 % (14/47) actualisaient leur bibliothèque au moins tous les trimestres et 47 % (20/43) effectuaient des examens qualitatifs au moins tous les 6 mois. Bien que la majorité des répondants aient fait état d'un contrôle régulier de la conformité, 30 % (11/37) n'effectuaient pas un tel contrôle. Les résultats ont en outre indiqué des variations entre les hôpitaux canadiens en matière de configuration, de gestion, de formation et de soutien liés aux bibliothèques de médicaments, ainsi que des variations dans les ressources humaines disponibles pour ces activités.

Conclusions : Les autorités et organismes de santé canadiens ne respectent pas les normes actuelles de l'ISMP et d'Agrément Canada pour les pompes intelligentes. On observe des variations en termes de stratégies de création et de gestion de bibliothèques de médicaments, ainsi que de formation et de ressources nécessaires pour soutenir ces initiatives. Les autorités et les organismes de santé canadiens devraient accorder la priorité au respect de ces normes et devraient examiner de près les ressources nécessaires pour y parvenir.

Mots-clés: pompes « intelligentes », bibliothèque de médicaments, système de réduction des erreurs de dose, technologie de la santé

INTRODUCTION

Intravenous (IV) pumps with a dose error reduction system (DERS), also known as smart pumps, represent an advancement in health technology and patient safety.[1] Smart pumps have improved drug delivery accuracy and control, and they also prevent medication infusion errors.[1] As a result, smart pump technology has become a standard of practice, with 89% of Canadian hospitals using this technology.[2] For a glossary of terms used in this article, please refer to Appendix 1 (available at https://www.cjhp-online.ca/index.php/cjhp/issue/view/215).

The US Institute for Safe Medication Practices (ISMP) has published guidelines for "Optimizing Safe Implementation and Use of Smart Infusion Pumps."[1] These guidelines recommend standardization of smart pump drug libraries contained in the DERS across facilities within a health network, interoperability with electronic health record (EHR) and computerized prescriber order entry (CPOE) systems, compliance auditing, interdisciplinary teams for library management, and implementation of a systematic process for review. They also endorse the use of care areas/profiles, hard and soft limits, and standardized management of container overfill and clinical alerts.[1] Specifically ISMP recommends quarterly quality reviews and drug library updates.

Similarly, Accreditation Canada recommends that established dosing limits be reviewed every 6 months (with changes being made as required) and that updates to drug libraries be performed not less than quarterly (unless no updates are required for a given quarter).[3] Currently, compliance of Canadian health care organizations with ISMP guidelines and Accreditation Canada standards is unknown.

Information regarding methods of subcategorizing drug libraries, organization of user interfaces, maximum number of entries for individual drugs (where entries may differ by concentration, as well as by limits on concentration, dosing, and/or rate), the health care professionals responsible for setting limits, strategies to account for overfill, clinical alerts of importance, and use of "keep vein open" rates, is unclear.[1]

There has been little research describing best practices for the creation and maintenance of drug libraries in the Canadian context. Studies on error rate reduction after implementation of IV smart pumps have been reported from the United States, Spain, and Canada.[4-6] However, this work has not described or evaluated methods for creating drug libraries, other than recommending approval of content by a multidisciplinary group of health care professionals.[5,6]

In 2017, ISMP conducted a survey to gather perceptions of US smart pump users; respondents identified many challenges with the implementation and use of these devices. That study provided little information about drug library set-up but did include information on library organization. The results indicated that multiple organizational strategies could be implemented in the same library, including organization based on care area (reported by 89% of respondents), weight (47%), therapeutic drug class (35%), and/or patient age (6%).[7] Information on drug library set-up in the Canadian context is unknown.

Collection and review of continuous quality improvement (CQI) data and regular updates of drug library content are necessary processes for drug library management. Although most Canadian sites report annual updates,[2] no data are available describing compliance with the 2019 Accreditation Canada standards, which specify quarterly drug library updates and biannual drug library quality reviews.[3]

Furthermore, the current processes used for performing updates and quality reviews, including the frequency and method of obtaining feedback and CQI data, are undefined. Lack of a clear process may delay library updates, leading to a risk of harm when IV infusions are administered with outdated drug limit settings.[8] Among 778 multidisciplinary respondents from 5 US health systems, approximately half felt that the process for updates and quality reviews was effective, and only 10% could correctly relay required steps.[9] Knowledge of the current methods used for drug library audits and updates, including how feedback is obtained and how end-users are informed of changes, could help health care organizations develop safer and more effective processes.

Staff education and training on infusion pump use, including use of DERS, can reduce the frequency of infusion errors and severe adverse drug events.[10] Accreditation Canada recommends standardized training and competency assessments biennially[11] but does not describe the type of training to be offered. Studies have indicated that education from a manufacturer may be less effective than hands-on training.[12] In addition, the efficacy of virtual training has been mixed.[13,14] The choice of trainer may be an important factor; for example, one study found that a group led by a nurse-champion was successful in improving pump compliance.[15] Simulation-based training, 24/7 vendor support after implementation, and ongoing clinical support for nursing staff have also been used,[5] but research has been lacking on the efficacy of these approaches. The current frequency of retraining in Canada is unknown.

Although ISMP recommends "dedicated time" for maintenance of pump software,[1] to the authors' knowledge no studies exist evaluating human resource requirements to create and manage drug libraries. At present, the number of full-time equivalents (FTEs) allocated to each profession within a smart pump team is unknown.

Given that IV smart pump technology has reached its 20th anniversary of mainstream use, this study was undertaken to determine rates of compliance with ISMP and Accreditation Canada standards, the processes for implementation and maintenance of smart pumps (including those for drug library set-up, management, training, and support), and the human resources allocated to these efforts.

METHODS

Survey

A 43-question online survey was distributed to smart pump team members to determine compliance with ISMP guidelines and Accreditation Canada standards and to identify knowledge gaps. The survey was divided into 6 sections: demographic characteristics (3 questions), organization of the drug library–user interface (6 questions), drug library entries (7 questions on naming, number of entries, drug library limits, and overfill), process for implementation and review (8 questions on quality reviews, compliance audits, and pump updates), clinical implications and training (15 questions on clinical alerts, alert fatigue, transfer policies, "keep vein open" rates, and training), and resources (4 questions about FTEs allocated). Six health care professionals familiar with smart infusion pumps reviewed and provided feedback on the survey before circulation.

Participants and Procedure

Given that ISMP recommends the use of multidisciplinary teams in the development and maintenance of smart pump drug libraries, participants from pharmacy, nursing, medicine, and clinical engineering, with experience in building and/or management of smart IV pumps, were eligible to complete the survey.

The survey link was circulated by email to pump team members known to the authors and through a post on several of the Canadian Society of Hospital Pharmacist's Pharmacy Specialty Networks (Parenteral Services, Drug Information, Medication Safety, and Hospital Pharmacy), as well as by email to known drug library team members involved in implementation and maintenance of smart pumps based on contacts provided by the Institute for Safe Medication Practices Canada and pump manufacturers. Participants were encouraged to forward the survey to additional pump team members in an effort to ensure participation of different disciplines. The survey was available from February 23 to April 6, 2021. The LimeSurvey tool (https://www.limesurvey.org/en/) was used to create and distribute the survey and to store the responses.

Data Analysis

All responses were analyzed descriptively, and quantitative data are reported as valid percentages (with exclusion of missing responses). The 2 authors, who are pharmacists working with DERS libraries, reviewed the free-text responses for common themes and summarized them descriptively.

RESULTS

Overall, 55 participants responded. All questions had varying levels of missing data. For clarity, only valid percentages are reported.

The percentage of respondents by province is shown in Figure 1. Most respondents were from Ontario (22/55, 40%). Most were pharmacists (42/54, 78%), followed by clinical engineers (8/54, 15%) and nursing professionals (4/54, 7%). Half of respondents (26/52) reported that a single drug library was used across their organization, while only 19% (9/48) reported a single drug library for their entire province (specifically, Alberta, Manitoba, Northwest Territories, Nova Scotia, Prince Edward Island, and Saskatchewan). Respondents managed an average of 1.6 pump brands. Most managed large-volume pumps (46/50, 92%), and less than half (20/50, 40%) managed multiple pump types (large-volume, syringe, patient-controlled analgesia, epidural). Table 1 presents information on pump standardization, brands, and types.

Compliance with Standards

Compliance with Accreditation Canada's 2019 standards and with ISMP guidelines was generally low (Table 2). Only 47% of respondents reviewed and analyzed smart pump data at least every 6 months, and only 30% updated their drug libraries at least quarterly. Regular monitoring of drug library compliance was reported by 62%. One respondent (2%) reported integration of smart pumps with an EHR, which would allow information to flow from the EHR to the smart pump and thus facilitate auto-programming of orders entered in the EHR and auto-documentation of administration information from the pump into the EHR. Similarly, one respondent (2%) reported integration of smart pumps with a CPOE system, which would allow auto-programming of orders entered by authorized prescribers on the smart pump.

Drug Library Set-up

As shown in Table 3, most drug libraries were categorized by care area (92%) and age (70%). The pump–user interface was most often organized alphabetically, with 29% of respondents reporting that frequently used medications were placed at the top of the list. The maximum number of entries for a specific drug within a particular care area (e.g., by concentration or limits) varied greatly; only 30% (out of 10 respondents) limited the number to 1 or 2 entries. Pharmacists were almost always responsible for setting limits in the pump (92%), although 62% of respondents reported that nursing professionals were also responsible. There was great variation in how overfill was managed within a pump library, and 18% of respondents stated that they did not account for overfill. Most respondents (81%) used the "keep vein open" rate on their pumps. Reasons for not using "keep vein open" rates included inappropriateness of this setting for the clinical setting or pump type and the requirement for a patient-specific order. Most respondents (76%) used some form of clinical alert; the top 3 most effective alerts related to administration/filter requirements

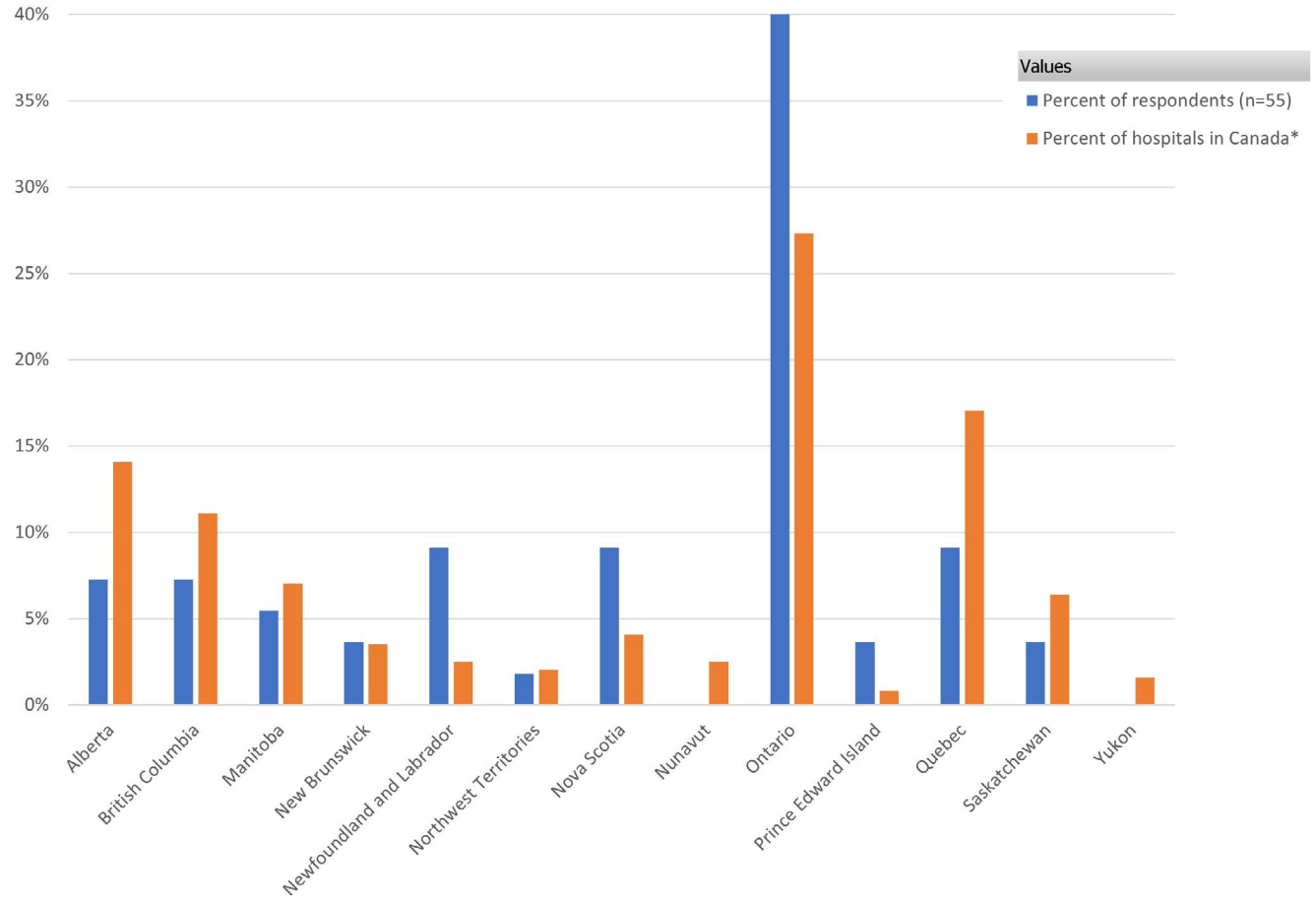

FIGURE 1. Percentage of respondents in each province or territory compared with percentage of all Canadian hospitals in each province or territory in 2021 (n = 1080). *Percentage of hospitals in Canada based on Government of Canada data, using hospitals listed as "employers".[16]

(50%), high-alert medications (43%), and weight, dose, or infusion time (36%).

Drug Library Management

Methods for drug library management, including common strategies to obtain user feedback, are shown in Table 4. Use of proactive feedback methods, such as CQI data, formulary changes, and direct communication with end-users were relatively uncommon. Email (80%), memos/newsletters (55%), and huddles/meetings (41%) were the most commonly used methods to inform end-users of updates to the drug library. Most respondents reported using data downloaded from the pump for compliance audits (72%).

To reduce alert fatigue (overuse of alarms, leading users to ignore them), 58% of respondents reported actively re-evaluating clinical alerts and minimizing the clinical alert list, 42% reported updating limits using CQI data, and 11% reported optimizing pump settings.

Training and Support

Most respondents (84%) reported training of personnel at the time of drug library implementation (Table 5). In terms

TABLE 1. Pump Standardization, Brands, and Types

Characteristic	No. (%) of Respondents[a]
Single drug library used across health authority/ organization	n = 52
Yes	26 (50)
No	26 (50)
Single drug library for province/territory	n = 48
Yes	9 (19)
No	39 (81)
Smart pump brands in a single organization	n = 53
Multiple brands	21 (40)
Mean no. of brands	1.6
Median no. of brands	1
Smart pumps managed	n = 50
Multiple pump types	20 (40)
Large-volume pump	46 (92)
Syringe pump	18 (36)
Patient-controlled analgesia or epidural pump	17 (34)

[a]Except where indicated otherwise. Percentages are based on the number of responses (missing responses excluded).

of training methods, most respondents reported that nursing staff had hands-on training (83%) and live information sessions (68%), whereas webinars were less commonly used (45%). Methods to train clinical pharmacy staff were most likely to include live information sessions (57%), followed equally by webinars (30%) and hands-on training (30%).

Open-ended responses described on-site support, provided by the vendor or manufacturer, for the pump "go-live" date. Other common support personnel included "superusers", clinical educators, and, less commonly, clinical engineers, information services professionals, and pump team members. Additional support was provided by pharmacy and extra floor staff (profession unspecified). One respondent reported the unique approach of having superusers wear distinctive t-shirts during the implementation period. On-site support for clinical staff, covering pump use and troubleshooting, was the most frequently described support type for the "go-live" date.

Two-thirds (67%) of respondents reported that training was provided for drug library maintenance. According to open-text responses, vendor-provided training was the most common type of maintenance training, and the training itself was same as that provided for implementation. Less commonly reported training included programs created by pump team members and provided by other staff.

The most common frequency for competency assessment and retraining of end-users was every 2 years (21% of respondents) or annually (17%). Notably, 15% of respondents reported no competency assessment or retraining.

Human Resources

As shown in Table 6, most respondents reported that pharmacists (98%) and nursing professionals (94%) were involved in implementation of the drug library, whereas for drug library maintenance, nursing involvement was reported less often than pharmacist involvement (56% versus 98%).

TABLE 2. Compliance with ISMP Recommendations and Accreditation Canada Standards

Survey Question	No. (%) of Respondents	ISMP Recommendation	Accreditation Canada Standard	% Meeting Recommendation or Requirement
Do your IV smart pumps communicate with the electronic health record (EHR)?	*n* = 52	5.1 Implement bi-directional (i.e., auto-programming and auto-documentation) smart infusion pump **interoperability with the EHR**.	Not a requirement	2%
Yes	1 (2)		NA	
No	51 (98)		NA	
Are your IV smart pumps linked to drug order entry?	*n* = 51	5.1 Implement bi-directional (i.e., **auto-programming** and auto-documentation) smart infusion pump interoperability with the EHR.	Not a requirement	2%
Yes	1 (2)		NA	
No	50 (98)		NA	
Frequency of drug library quality reviews	*n* = 43	3.1 Provide dedicated time and resources for regular review and analysis of smart infusion pump data, at least on a quarterly basis.	12.5 Established dosing limits are reviewed every six months and changes are made as required.	% reviewing dosing limits at least every 6 months: 47% (20/43)
Never	13 (30)			
Annually or less	6 (14)			
Biannually	8 (19)			
Quarterly or more often	12 (28)			
As needed	4 (9)			
Frequency of drug library amendments or updates	*n* = 47	2.1 …update the library at least quarterly.	12.3 Updates to the medication libraries are performed… not less than quarterly unless no updates for that quarter.	% updating library at least quarterly: 30% (14/47)
Never	1 (2)			
Annually or less	15 (32)			
Biannually	11 (23)			
Quarterly or more often	14 (30)			
As needed	6 (13)			
Frequency of drug library compliance audits	*n* = 37	3.3 Regularly monitor … to assess drug library compliance and identify barriers to use: facility compliance rate with DERS, compliance rate with DERS by care area/profile.	Not a requirement.	% regularly monitoring compliance (excluding never or as needed): 62% (23/37)
Never	11 (30)		NA	
Annually or less	10 (27)		NA	
Biannually	2 (5)		NA	
Quarterly or more often	11 (30)		NA	
As needed	3 (8)			

DERS = dose error reduction system, NA = not applicable.

TABLE 3 (Part 1 of 2). Organization and Design of IV Smart Pump Drug Libraries

Survey Question	No. (%) of Respondents[a]
Categorization of drug library[b]	*n* = 53
By care area	49 (92)
By patient weight	10 (19)
By age (e.g., adult or pediatric)	37 (70)
By therapeutic drug class	8 (15)
Organization of user interface[b]	*n* = 49
Alphabetical	48 (98)
By therapeutic drug class	3 (6)
By frequency of use (most frequently used at top of list)	14 (29)
Maximum number of entries used for a given drug	*n* = 39
Yes	12 (31)
No	27 (69)
If yes, maximum no. of entries used	*n* = 10
1	1 (10)
2	2 (20)
3 or 4	3 (30)
Limited by pump capabilities	4 (40)
Health care professional responsible for setting limits for each drug entry[b]	*n* = 50
Nursing professional	31 (62)
Pharmacist	46 (92)
Physician	24 (48)
Collaborative approach	35 (70)
Strategies to account for overfill when setting limits[b]	*n* = 38
Use estimated overfill of 10% of the total drug volume	11 (29)
Use estimated overfill of 15% of the total drug volume	1 (3)
Use average overfill volume from the manufacturer	10 (26)
Use maximum overfill volume from the manufacturer	5 (13)
Use 50% overfill volume from the manufacturer	1 (3)
Do not account for overfill	7 (18)
Not applicable (no overfill or use of syringe pumps)	4 (11)
Use of clinical alerts	*n* = 37
Yes	28 (76)
No	9 (24)
If yes, clinical alerts found to be most effective[b]	*n* = 14
Administration/filter requirements	7 (50)
High-alert medication	6 (43)
Weight, dose, infusion time alerts	5 (36)
Monitoring requirements	3 (21)
Central line only	2 (14)
Clarify drug name	2 (14)
Hazardous labelling	1 (7)
Mixing instructions	1 (7)
Premedication requirements	1 (7)

TABLE 3 (Part 2 of 2). Organization and Design of IV Smart Pump Drug Libraries

Survey Question	No. (%) of Respondents[a]
Clinical alerts removed to reduce alert fatigue[b]	*n* = 9
None	5 (56)
Infusion time	2 (22)
Mixing instructions	2 (22)
Adverse effects	1 (11)
Filter requirements	1 (11)
Use of "keep vein open" rates	*n* = 37
Yes	30 (81)
No	7 (19)

[a]Parenthetical values refer to valid percentages, excluding missing responses.
[b]Multiple responses were allowed.

Trends were similar, with greater levels of participation during implementation than for maintenance, for clinical engineers (65% versus 33%), information services professionals (48% versus 12%), and physicians (42% versus 12%).

Dedicated FTEs for smart pump team members also appeared to be higher for implementation than for maintenance. Of note, 46% of respondents reported less than 1 pharmacist FTE dedicated to creation of a new drug library, and 68% reported less than 1 pharmacist FTE for library maintenance (including 28% who reported no dedicated pharmacist hours for maintenance). For nursing professionals, the rates were similar: 39% of respondents reported less than 1 FTE for implementation and 70% reported less than 1 FTE for maintenance.

Of the 9 respondents who reported a provincially standardized drug library, 5 reported some number of pharmacist FTEs for maintenance of the library: 0.5 FTE reported by 1 respondent, 1 FTE reported by 2 respondents, 2 FTEs reported by 1 respondent, and 2.5 FTEs reported by 1 respondent. One respondent reported 1 FTE pharmacist position that had been approved but not yet implemented; this FTE is included in the data reported in Table 6.

DISCUSSION

This study describes the current landscape in Canadian hospitals with regard to compliance with smart pump standards and guidelines, the characteristics of smart pumps in use (including drug libraries), and the health care professionals managing them. Most respondents (40%) were from Ontario, the province with the greatest proportion of hospitals in Canada (27%)[16] (Figure 1). Although the second and third highest proportions of Canadian hospitals are in Quebec (17%) and Alberta (14%),[16] only 9% and 7% of respondents, respectively, were from those provinces. For Alberta, this result may have been due to the existence of a standardized provincial drug library, which may have

reduced the number of pump teams required. For Quebec, the limited number of responses may have been related to availability of the survey only in English.

Compliance with Standards

This study showed low rates of compliance with standards and guidelines. Less than half of respondents reported biannual quality reviews of their drug library, as required by Accreditation Canada, and only 30% updated their library at least quarterly, as recommended by both ISMP and Accreditation Canada. We did not explore the reasons why standards were not being met; however, given the limited number of FTEs that most respondents reported for drug library maintenance, human resources may play a role. Furthermore, the ISMP guidelines were published in February 2020, shortly before the World Health Organization declared COVID-19 a pandemic. With the demands created by the pandemic, organizations may not have had resources available to implement the recommended changes. Further research is needed to understand potential contributing factors.

Most respondents in this study reported that drug libraries had not been standardized across their province/territory. Half of the respondents reported standardization within their health authority or organization, a practice recommended by ISMP.[1] Large-scale standardization presents many challenges, including attaining agreement

TABLE 4. Methods for Managing IV Smart Pump Drug Libraries

Survey Question	No. (%) of Respondents[a]
Method used to obtain drug library feedback from end-users[b]	*n* = 43
Email	17 (40)
Committee/meetings	15 (35)
Request form	13 (30)
Informal verbal request	10 (23)
Website/portal	6 (14)
Continuous quality improvement data	7 (16)
Formulary changes	5 (12)
Direct communication to end-users for feedback	3 (7)
No process developed	2 (5)
Method used to inform end-users of updates to the drug library[b]	*n* = 51
Email	41 (80)
Memo/newsletter	28 (55)
Huddles/meetings	21 (41)
Website/portal	2 (4)
End-users not notified	1 (2)
Data reviewed during drug library compliance audits[b]	*n* = 50
Data downloaded from the pumps	36 (72)
Floor audits	9 (18)
Data retrieved from electronic health record	2 (4)
User-submitted reports	3 (6)
Direct communication with end-users	1 (2)
No compliance audits performed	6 (12)
Designation of person(s) responsible for conducting drug library compliance audits[b]	*n* = 48
Staff member (nonmanagerial)	26 (54)
Manager	16 (33)
Interdisciplinary committee	1 (2)
Strategies used to reduce alert fatigue[b]	*n* = 19
Actively reassess and minimize clinical alert list	11 (58)
Continuous quality review of library entries/limits	8 (42)
Optimize pump settings (e.g., occlusion pressure)	2 (11)
Add clinical alerts to certain medications only (e.g., high-risk medications)	2 (11)
Minimize wording of clinical alerts	1 (5)
Combine clinical alerts	1 (5)
None	3 (16)

[a]Parenthetical values refer to valid percentages, excluding missing responses.
[b]Multiple responses were allowed.

TABLE 5. Support and Training of IV Smart Pump End-Users

Survey Question	No. (%) of Respondents[a]
Training provided to drug library implementation team members during implementation	*n* = 37
Yes	31 (84)
No	6 (16)
Type of training provided to nursing staff during implementation[b]	*n* = 47
Hands-on training	39 (83)
Live information sessions	32 (68)
Webinar	21 (45)
Online training modules	3 (6)
Type of training provided to clinical pharmacy staff during implementation[b]	*n* = 47
Live information sessions	27 (57)
Webinar	14 (30)
Hands-on training	14 (30)
None	4 (9)
Training completed by pump team members for pump maintenance	*n* = 33
Yes	22 (67)
No	11 (33)
Frequency of end-user competency assessment and retraining	*n* = 47
Never	7 (15)
Annually	8 (17)
Every 2 years	10 (21)
After any extended leave	5 (11)
As needed	4 (9)
Unsure/unknown	13 (28)

[a]Parenthetical values refer to valid percentages, excluding missing responses.
[b]Multiple responses were allowed.

TABLE 6. Resources Allocated for IV Smart Pump Drug Libraries

Resource	Stage; No. (%) of Respondents[a] Implementation	Maintenance
Team members involved in drug library[b]	*n* = 52	*n* = 52
Pharmacist	51 (98)	51 (98)
Nursing professional	49 (94)	29 (56)
Clinical engineer	34 (65)	17 (33)
Information services professional	25 (48)	6 (12)
Physician	22 (42)	6 (12)
Full-time equivalents		
Pharmacist	*n* = 26	*n* = 25
0	5 (19)	7 (28)
> 0 to < 1	7 (27)	10 (40)
1.0 to 1.9	11 (42)	5 (20)
≥ 2	3 (12)	3 (12)
Nursing professional	*n* = 18	*n* = 10
0	4 (22)	4 (40)
> 0 to < 1	3 (17)	3 (30)
1.0 to 1.9	8 (44)	2 (20)
≥ 2	3 (17)	1 (10)
Clinical engineer	*n* = 7	*n* = 3
0	2 (29)	1 (33)
> 0 to < 1	3 (43)	1 (33)
1.0–1.9	2 (29)	1 (33)
≥ 2	0	0
Information services professional	*n* = 9	*n* = 1
0	2 (22)	0
> 0 to < 1	4 (44)	0
1.0–1.9	2 (22)	1 (100)
≥ 2	1 (11)	0
Physician/medical student	*n* = 4	*n* = 5
0	2 (50)	3 (60)
> 0 to < 1	2 (50)	1 (20)
1	0	1 (20)

[a]Parenthetical values refer to valid percentages, excluding missing responses.
[b]Multiple responses were allowed.

among practitioners about medication concentration, dosing units, medication dose range, administration rate, and/or time of administration. Because of these complexities, it was not surprising that few pump team members were working with a provincially standardized drug library.

Standardization of drug libraries is considered a crucial step in realizing interoperability,[1] which may help to improve compliance, thus leading to increased patient safety.[17] Consistent with data from Ontario,[18] the current study revealed that Canadian hospitals have not integrated smart infusion pumps with EHR or CPOE systems, as recommended by ISMP. Interoperability has been found to improve dose administration, monitoring, accuracy of clinical data, documentation, and efficiency of systems, leading to overall improvement in patient safety.[19-21] However, given that implementation and maintenance of smart pump interoperability is complex, difficult, and costly,[22] achieving such interoperability may be challenging for some organizations. For these reasons, it should be a goal for health care organizations to connect smart infusion pumps to an EHR system.

Drug Library Set-up

Categorization of libraries by care area, organizing the user interface alphabetically, and direct involvement of a pharmacist in setting dosing limits were reportedly employed by most facilities, but other topics exhibited less consensus. Although 70% of respondents reported categorization by age, the responses were not analyzed separately for hospitals serving adults, pediatric patients, and/or neonates. Presumably organizations that do not serve pediatric/neonatal populations would be less likely to arrange their drug library by age.

The use of smart pump drug library programming to support an organization's strategy for overfill management presents a significant opportunity to improve patient care. Failing to account for overfill when administering intermittent infusions can result in significant underdosing of medication, which can affect patient outcomes.[23,24] Reported strategies to manage overfill varied among respondents; surprisingly, 18% of respondents had no strategy for this situation. Therefore, the use of drug library programming to improve overfill management may be an underutilized tool that organizations could consider to improve patient safety.

Patient safety can also be improved by using clinical alerts.[17] Such alerts intentionally interrupt the administration of drugs and must be acknowledged by the user,[1] which increases programming time. To avoid alert fatigue, they should only provide information that is essential to the safe administration of the drug. Surprisingly, the use of alerts for "high-alert medication" was reported with a high frequency of almost 43%. The literature indicates that alerts for "high-alert medications" may be a source of alert fatigue, especially in a critical care setting where most drugs are high alert[25]; as such, this specific alert should not be included. However, the current study did not separate clinical alerts by care area, so the frequency of alerts in the intensive care setting is unknown. Only 50% of respondents reported alerts for administration/filter requirements; this type of alert is believed to be effective in reducing medication administration errors.[25] Canadian hospitals should consider implementing strategies to optimize use of clinical alerts during smart pump programming.

Drug Library Management

Respondents reported predominantly reactive strategies for obtaining feedback from users, which suggests that reporting typically does not occur until a problem arises. Proactive strategies, such as use of CQI data, formulary changes, and direct communication, may increase patient safety and provide additional data that would be valuable for improving drug libraries over time; these strategies should be considered by Canadian health care organizations.

Support and Training

Organizations should recognize the value of providing staffing resources for training and recertification related to smart pump technology. Most respondents in the current study reported hands-on training for nurses during implementation, a method that has been demonstrated as effective in increasing compliance.[26] To the authors' knowledge, however, there is no literature on the best method of training other pump team members. This situation could benefit from future research.

Despite the Joint Commission's recommendations to perform initial and yearly recertification[21] and Accreditation Canada's requirement to perform reassessment every 2 years,[3] many participants reported no retraining or retraining only after an extended leave or as needed. Given the risk of medication administration errors, ensuring that staff maintain competence in smart pump use is essential. Canadian hospitals should work toward the Accreditation Canada standard.

Human Resources

According to this survey study, few full-time staff are dedicated to the implementation and management of drug libraries, despite accreditation requirements and the effects on patient safety. Almost 40% of participants were managing multiple pump brands within a single organization; the need for a separate drug library for each brand of pump adds to the pump team's workload. Depending on the size and complexity of a drug library and the frequency of updates, clinician time to review and update the drug library could be substantial. Although most IV pump teams include pharmacy and nursing personnel, this study showed that not all other disciplines are involved. Even where other disciplines are involved, only limited resources are dedicated to this work, despite guideline recommendations for the use of interdisciplinary teams to develop, test, and update drug libaries.[1] Many pump team members who responded to our survey mentioned, in open-text responses, that they were managing drug libraries alongside other regular responsibilities, which could potentially affect the quality of their work. However, most respondents who reported provincially standardized drug libraries also reported 1 or more pharmacist FTEs; this finding indicates that organizations recognize the need for pharmacist positions to support larger, more complex libraries. More data are needed on the human resources required to manage a drug library, according to size or complexity, to help guide health care organizations in properly supporting these initiatives.

Limitations

Given that the numbers of pump teams and pump team members across Canada are unknown, the response rate in this study could not be determined. Because the perspectives of various health care professionals were desired, the survey was open to any health care professional managing smart pumps, and multiple members of the same team may have participated. This might have led to overrepresentation of larger pump teams or inconsistent reporting of actual practices from single sites.

Pharmacists are generally involved in building drug libraries because of their understanding of drug dosing, pharmacokinetics, drug stability, and proper administration; as such, they were purposely targeted as participants. The organizations used to recruit survey respondents were pharmacy-based, and referral by pharmacists was the main source of recruitment for nonpharmacist participants. This approach likely led to underrepresentation of nonpharmacist team members.

In terms of FTEs, only 3 respondents indicated that more than 2 pharmacist FTEs were dedicated to drug library maintenance. Although 2 of these respondents stated that their province had a provincial drug library (which would likely require more resources to manage), it is possible that the question was misinterpreted; as such, reports of more than 2 pharmacist FTEs may be an overrepresentation.

Finally, although respondents from all Canadian provinces participated, the survey was available only in English, which may have presented a barrier to non–English-speaking pump team members.

CONCLUSION

Variation exists in methods for the implementation and maintenance of IV smart pumps across Canadian hospitals. Although slight variations in process are expected in each unique setting, consensus on best practices for drug library management would benefit the teams responsible for optimizing use of smart pump technology. Determining the impact on medication administration errors of processes related to drug library set-up, management, training, and support, as well as required resources, could benefit from further study. While many pump teams are moving toward meeting available guidelines and standards, it is apparent that Canadian hospitals do not currently meet these standards, and additional human resources may be required to maximize the patient safety benefits offered by smart infusion pumps.

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