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# Multiple Intravenous Infusions Phase 2a: Ontario Survey

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# Abstract

## Background

Research conducted in earlier phases of this study prospectively identified a number of concerns related to the safe administration of multiple intravenous (IV) infusions in Ontario hospitals.

## Objective

To investigate the potential prevalence of practices or policies that may contribute to the patient safety risks identified in Phase 1b of this study.

## Data Sources and Review Methods

Sixty-four survey responses were analyzed from clinical units where multiple IV infusions may occur (e.g., adult intensive care units). Survey questions were organized according to the topics identified in Phase 1b as potential contributors to patient harm (e.g., labelling practices, patient transfer practices, secondary infusion policies).

## Results

Survey results indicated suboptimal practices and policies in some clinical units, and variability in a number of infusion practices. Key areas of concern included the following:

- use of primary IV tubing without back check valves when administering secondary infusions
- administration of secondary infusions with/as high-alert continuous IV medications
- potential confusion about how IV tubing should be labelled to reflect replacement date and time
- interruptions to IV therapy due to IV pump and/or tubing changes when patients are transferred between clinical units
- coadministration of continuous or intermittent infusions on central venous pressure monitoring ports
- variability in respondents' awareness of the infusion pump's bolus capabilities

## Limitations

Due to the limited sample size, survey responses may not be representative of infusion practices across Ontario. Answers to some questions indicated that the intent of the questions might have been misunderstood. Due to a design error, 1 question about bolus administration methods was not shown to as many respondents as appropriate.

## Conclusions

The Ontario survey revealed variability in IV infusion practice across the province and potential opportunities to improve safety.

# Plain Language Summary

Very sick patients in hospital often need several different medications at the same time. Many of these medications are given directly into their veins *(intravenously).* Caregivers use tools called *infusion pumps* to control how much medication patients receive, and how quickly. When more than 1 medication is given this way (called *multiple intravenous infusions*), mistakes can happen that make patients worse.

Health Quality Ontario asked HumanEra, a research team at the University Health Network, to explore what mistakes can happen with multiple intravenous infusions, and what can be done to prevent or reduce them.

This report describes what we found when we asked caregivers in Ontario about multiple intravenous infusions. We picked only caregivers from units that were likely to give multiple intravenous infusions, and we asked only 1 caregiver from each unit to answer our questions.

Our findings showed that there are ways for caregivers to work better or use technology better to prevent mistakes.

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# List of Abbreviations

| | |
|---|---|
| **CCNC** | Critical Care Nurse Certificate |
| **CNCC** | Certified Nurse in Critical Care |
| **CNO** | Chief nursing officer |
| **CVP** | Central venous pressure |
| **DERS** | Dose error reduction system |
| **ICU** | Intensive care unit |
| **IV** | Intravenous |
| **ISMP (United States)** | Institute for Safe Medication Practices (United States) |
| **ISMP Canada** | Institute for Safe Medication Practices Canada |
| **LHIN** | Local Health Integration Network |
| **NGG** | Nursing Graduate Guarantee |
| **OHA** | Ontario Hospital Association |
| **PCA** | Patient-controlled analgesia |

# Background

The Multiple Intravenous Infusions research project is being conducted in several phases. Each phase applies different methods to build on the knowledge gained from the previous phases. Two reports precede this one:

- The Phase 1a study report, *Multiple Intravenous Infusions Phase 1a: Situation Scan Summary Report*, is available at: http://ehealthinnovation.org/wp-content/uploads/Multiple-IV-Infusions_Phase1a_SummaryReport1.pdf
- The Phase 1b study report, *Multiple Intravenous Infusions Phase 1b: Practice and Training Scan*, is available at: http://www.hqontario.ca/en/eds/tech/pdfs/2012/multipleinfusions1b_May.pdf

Recommendations endorsed by the Ontario Health Technology Advisory Committee based on the study findings can be found on the Health Quality Ontario website: http://www.hqontario.ca/evidence/publications-and-ohtac-recommendations/ohtac-recommendations.

# Introduction

### Issue and Research Motivation

Acutely ill patients with life-threatening conditions require constant care, monitoring, and a number of life-sustaining medications. (1-3) Tight control of medication dosing and the need for immediate therapeutic effects make the controlled administration of medication directly into a patient's bloodstream an invaluable tool for patient care. The administration of medication and fluids into a patient's veins is referred to as intravenous (IV) administration, and about 90% of hospitalized patients receive medications this way. (4) Infusion pumps are devices that accurately control the amount of medication patients receive and the rate at which the medication is administered; still, medication errors associated with infusion therapy are well documented. (5-7)

IV administration via a large-volume infusion pump has a number of advantages compared to gravity infusion (in which no pump is used). Infusion pumps offer increased control and accuracy of fluid flow and the ability to detect or prevent other serious errors (e.g., occlusions, air in tubing, free flow). In this way, infusion pumps are the safest way to administer IV therapy. However, infusion pumps have also been associated with a high rate of recalls and adverse events, resulting in patient injuries and deaths. A review of the United States Food and Drug Administration records over a 4-year period revealed that there were 87 infusion pump recalls and 56,000 adverse events (including 710 deaths) associated with infusion pump use. (8;9) Since 2010, organizations such as the Association for the Advancement of Medical Instrumentation and the Food and Drug Administration have made improving the safety of infusion pumps a priority.

While there has been a growing awareness of the factors that lead to errors when programming infusion pumps, minimal research has been conducted into the errors that can result from administering multiple IV infusions to a single patient at 1 time. (10;11) Previous research has highlighted a number of safety risks associated with managing multiple IV infusions. (7;10) For example, secondary (often referred to as *piggyback*) IV infusions are commonly used to deliver single or intermittent doses of IV medication over a safe period of time, followed by an automatic return to a separate, continuous infusion when complete, but previous studies have indicated that there is a high risk of errors related to the setup and administration of secondary infusions. (12) In addition, a recent study found that each additional IV medication increased the likelihood of an adverse drug event by 3%. (13) Further research is needed to

systematically and comprehensively identify the risks and contributing factors associated with multiple IV infusions. There is also a need to investigate the effectiveness of various practice-, technology-, and education-related interventions to mitigate or reduce those risks. To address this research gap, the Ontario Health Technology Advisory Committee commissioned HumanEra (formerly the Health Technology Safety Research Team), with support from Health Quality Ontario and in collaboration with the Institute for Safe Medication Practices Canada (ISMP Canada), to generate evidence-based recommendations to reduce the hazards associated with administering multiple IV infusions to a single patient.

## Project Phases

A challenge to studying the risks associated with multiple IV infusions is that they are not confined to a single controlled element (e.g., an isolated technology issue); instead, a detailed understanding of many system elements (e.g., clinical tasks and processes, infusion pump technology, hospital policies and procedures, individual practices, nursing training) is required. As such, HumanEra aimed to identify and help mitigate the risks associated with multiple IV infusions while accounting for the complex interactions between system elements. Different but complementary human factors methods and tools were used to achieve this objective, and the following multi-phase project was designed (see Figure 1):

- Phase 1: Environmental Scan
  - Phase 1a: Situation Scan
  - Phase 1b: Practice and Training Scan
- Phase 2: Risk Prevalence and Mitigation
  - Phase 2a: Ontario Survey
  - Phase 2b: Laboratory Study
- Phase 3: Knowledge Translation

In addition, a Multiple IV Infusions Expert Panel (henceforth referred to as the *expert panel*) was established as a project advisory group, consisting of representatives from clinical, professional practice, and/or regulatory groups (see the Acknowledgements for a full list of expert panel members).

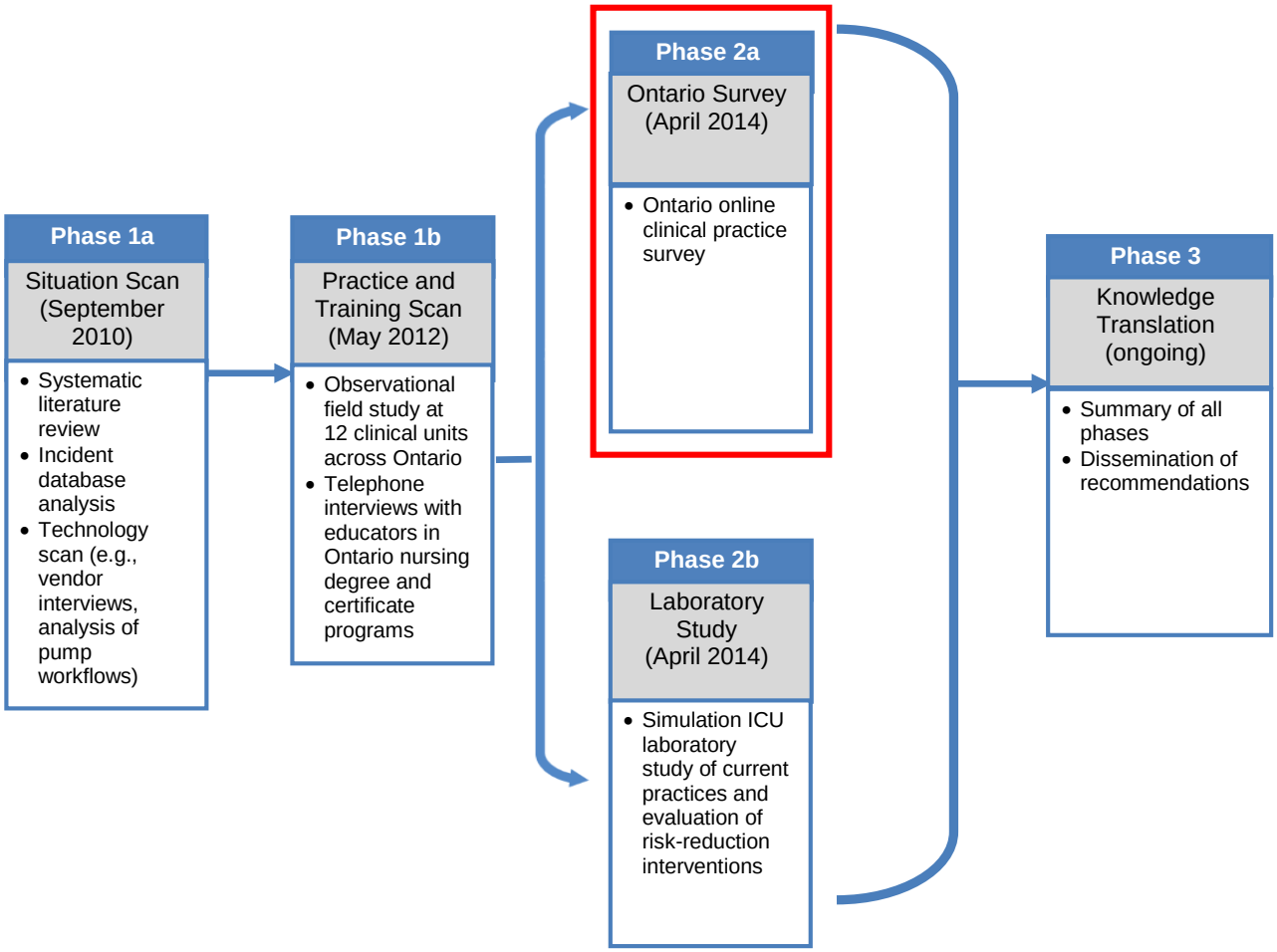


**Figure 1: Multiple IV Infusions Project Phases**

Abbreviations: IV, intravenous; ICU, intensive care unit.

Phase 1a (10) confirmed the lack of research in this area, demonstrated that errors resulting in patient harm do occur in the context of multiple IV infusions, and indicated that further investigation was required.

Phase 1b (14) identified the breadth of practices (e.g., workflows, tasks), infusion setups, technology (e.g., infusion pumps, IV components), and education associated with administering multiple infusions in different clinical environments (e.g., critical care, pediatric care, outpatient chemotherapy). Analysis identified specific safety issues with the potential to cause direct patient harm, along with related contributing factors. These were categorized using the following themes:

- infusion setup and removal
- infusion identification
- dead volume management
- secondary IV infusion setup
- IV pump bolus administration
- pump-specific issues

# Objective of Analysis

The objective of this report (Phase 2a: Ontario Survey) was to investigate the potential prevalence of practices or policies that may contribute to the patient safety risks identified in Phase 1b of this study.

# Scope of Analysis

The current report presents the findings of Phase 2a, an online survey investigating the potential prevalence of factors that contribute to patient harm. (True prevalence could not be established because it was not clear how representative the data were of clinical practice in Ontario; as a result, the term *potential prevalence* is used.)

*Note: Throughout the Multiple Intravenous Infusions reports, the study team generally refers to nurses, because they are the primary group responsible for administering IV infusions in the clinical environments that are in the study scope. However, we recognize that other health care professionals may be involved in the administration of multiple IV infusions (e.g., physicians).*

## Inclusions

The emphasis of the survey was to uncover the potential prevalence of factors that may contribute to patient harm. These factors were physical (e.g., infusion pumps, IV tubing, and other components), policy-oriented, or practice-oriented.

The IV system components under consideration included the following:

- any agents intended to be administered intravenously via bags, bottles, or syringes (e.g., hydration, blood and blood products, total parenteral nutrition, IV medications, IV chemotherapy)
- large-volume IV infusion devices
  - single- and multiple-channel devices
  - devices with and without a dose error reduction system (DERS)
- syringe-based IV infusion devices
  - single- and multiple-channel devices
  - devices with and without a DERS
- IV accessories (e.g., tubing, clamps, poles, connectors, splitters, single- and multiple-lumen catheters, pressure transducers)
- labels used to identify the contents of IV infusions on tubing or pumps

## Exclusions

### *Topics*

The following topics were not considered in this research:

- pharmaceutical interactions and the pharmacokinetics of multiple IV medication therapy (e.g., medication compatibility)
- interaction and/or absorption of IV medications by IV bags, tubing, and connectors
- misconnections between IV tubing and tubing that delivers fluids or gases via other routes (e.g., IV/epidural, IV/intrathecal, or IV/nasogastric)

Several of these topics are being investigated elsewhere. (15-17) Although work done in these areas has immediate applicability to improving patient care and is complementary to the findings presented in this report, it will not be discussed further here.

### *Components*

The following medication therapy components were not considered in this research:

- insulin, elastomeric, patient-controlled analgesia (PCA), and ambulatory pumps
- magnetic resonance imaging–compatible IV pumps
- pumps intended for non-IV routes (e.g., nasogastric, intrathecal, epidural)
- arterial lines
- gravity infusions
- high-pressure infusors (e.g., high-flow-rate fluid resuscitation units, common in trauma settings)

## Clinical Areas Studied

The clinical units targeted in the survey were selected to provide a range of patient populations while maintaining a high likelihood that respondents would administer multiple IV infusions to a single patient. They included the following:

- adult cardiac intensive care unit (ICU)
- adult ICU
- pediatric cardiac ICU
- pediatric ICU
- neonatal ICU
- adult oncology unit
- pediatric oncology unit
- emergency department
- adult inpatient ward (noncritical care) containing acute medical or surgical patients

Responses from some clinical unit types were combined to ensure anonymity. Further details are described in Data Validation and Formatting, below.

# Survey Analysis

## Research Questions

1. What is the potential prevalence of practices recommended in the Phase 1b report?
2. What is the potential prevalence of practices identified in the Phase 1b report that may mitigate or contribute to patient safety issues?
3. What tools, processes, or policies do clinical units in Ontario currently use to implement practices that may mitigate or contribute to patient safety issues?

## Research Methods

### Survey Design

#### *Survey Questions*

Survey questions were designed to identify the number and type of respondents with practices or policies that contributed to patient harm (i.e., contributing factors). The Phase 1b report grouped these practices according to 6 themes:

- secondary infusions
- IV line identification
- IV line setup and removal
- dead volume management
- IV bolus administration
- pump-specific issues

Since pump-specific issues vary by pump used, and infusion pumps in use vary by hospital and clinical unit, pump-specific issues were not discussed in detail in the Phase 1b report, and no explicit attempt was made to collect data on this topic in the Phase 2a survey.

The Phase 1b report also presented the findings of interviews with nurse educators at the baccalaureate and Critical Care Nurse Certificate (CCNC) levels. Survey questions attempted to explore this topic further by investigating the potential prevalence of specific nurse hiring requirements. Responses about training and qualifications in IV administration were expected to provide insight into the experience and knowledge nurses typically possess before they begin work in areas where multiple IV infusions are administered.

A single online survey was developed for all clinical units using Survey Monkey (http://www.surveymonkey.com). The survey consisted of 59 questions on the following topics, presented in the following order:

- hospital and respondent demographics
- nurse hiring requirements
- shift handovers
- IV tubing labels (including plain IV lines)
- IV connectors
- central venous pressure monitoring

- IV pumps (large-volume and syringe)
- secondary infusions
- patient transfers
- IV boluses
- IV pump labelling

Questions were presented in the above order to ensure that respondents would see only questions relevant to them. For example, respondents who did not use infusion pumps would not be shown the latter half of the survey, for which the use of IV pumps was a prerequisite. The number of respondents varied between questions for the following reasons:

- choosing not to answer the question
- not completing the survey (i.e., stopped before reaching the question)
- questions skipped based on respondents' previous answers

The research ethics board at the University Health Network approved the survey questionnaire, consent form, and recruitment process on March 1, 2012 (#11-0680-AE). The full survey questionnaire can be found in Appendix 1.

### *Question Types*

There were 3 types of survey questions:

- **Compliance questions:** The Phase 1b report made several IV infusion practice recommendations. Compliance questions attempted to establish the proportion of respondents who were in compliance with the recommendations at the time of the survey. It should be noted, however, that the Phase 1b recommendations were not publicly available when the survey was administered. Therefore, it is preferable to view findings in this category as "prospective compliance," rather than expecting that all clinical units would abide by the Phase 1b recommendations.
- **Practice prevalence questions:** These questions attempted to identify the proportion of respondents who used a particular type of IV infusion practice (e.g., IV tubing labelling). Responses identified the potential prevalence of these practices across Ontario, but not the specifics of how they were implemented.
- **Exploratory questions:** These questions attempted to identify how clinical units in Ontario differed in their approach to administering or managing IV infusions. Unlike compliance questions, no established best practice or recommendation was available. Responses showed variability in Ontario practice and may have also showed trends.

These 3 question types helped build on findings from the Phase 1b report while exploring the use of common risk-mitigating strategies (e.g., IV tubing/pump labelling) and the details of their implementation.

### *Definitions of Terms*

Survey respondents were provided with a number of definitions for terms such as *high-alert medication, standard work practice, bolus,* and *plain IV line*. See the Glossary for definitions. See Appendix 1 for how definitions were presented in the survey.

## Recruitment

The study team collaborated with the Ontario Hospital Association (OHA) to recruit survey respondents. OHA membership comprises all publicly funded hospitals in Ontario (personal communication, clinical expert, July 8, 2011). The OHA website listed 149 member hospital corporations at the time the recruitment strategy was designed. (18)

### *Recruitment Process*

The list of survey respondents was acquired via a multi-step process to ensure that survey distribution:

- maximized the response rate among clinical units relevant to the survey
- minimized the chance of receiving responses from clinical units that were not relevant to the survey
- led to a response from only 1 individual per unit

The recruitment process was as follows:

1. The OHA contacted the chief nursing officers (CNOs) of its membership via an email distribution list. The study team did not have direct access to the OHA list. The email asked each CNO to provide the contact information of a nursing leader in the specific clinical units of interest (see Table 1). The email was sent on March 13, 2012.
2. When CNOs responded, the study team entered the contact information into the Survey Monkey website and sent an email invitation to each potential respondent. The invitation had a unique link that would allow respondents to return to the survey if they were unable to complete it in 1 sitting. Once respondents had finished the survey, the link would prevent them from changing their answers. Initial email invitations were sent out starting March 29, 2012. Any contact information received after this date was used to issue additional invitations as quickly as possible to maximize response rate before the end of the data collection period.
3. Potential respondents who were responsible for multiple units received an email directly from the study team asking them to indicate whether they required more than 1 survey invitation. If respondents indicated that several units in their institution were similar in practice, single responses were duplicated (only if respondents indicated this was the case in their survey answers).1 These emails were also sent out on March 29, 2012.
4. An email was sent on April 16, 2012, referencing the upcoming survey close date and reminding respondents to complete the survey.
5. The survey was closed on April 22, 2012.

### *Survey Invitations*

The CNO email list contained 141 recipients, but 13 institutions named 2 recipients (the corporation may have had multiple nursing leaders or multiple hospital sites). Therefore, 128 unique hospital corporations were contacted.[2]

CNOs from 46 unique hospital corporations responded, leading to the distribution of 159 survey invitations and the potential for responses from 189[3] clinical units (see Table 1). Clinical units from 36

[1]In some cases, a single survey response could be duplicated if the respondent indicated that a single clinical unit cared for multiple types of patients (e.g., combined adult ICU and cardiac ICU). The duplicate would then be classified as a different clinical unit than the original. For this reason, the number of units included in the dataset is not representative of the actual number of units of each type that responded (e.g., 13 responses for adult cardiac ICU does not necessarily mean that 13 dedicated adult cardiac ICUs responded).

[2]Some hospital *sites* were identified in the CNO mailing list rather than the larger *corporation* they belonged to; there were other discrepancies as well (e.g., some institutions were on the CNO email list but not on OHA's member list). Therefore, 128 hospital corporations is an approximate number.

[3]Some invitations were exploratory (i.e., the study team was not sure a unit existed based on the CNO response, but sent an invitation to maximize inclusion).

unique hospital sites (30 hospital corporations) responded to the survey. Some hospital sites contained more than 1 clinical unit of interest and provided multiple responses.

In some cases, the CNO identified 2 or more individuals as being responsible for a single clinical unit. To avoid multiple responses from a single unit, the study team randomly selected 1 potential respondent.

In some cases, potential respondents could not use the unique survey link provided in their email invitation[4]; for these respondents, a non-unique survey link was provided.

**Table 1: Number and Type of Invitations per Clinical Unit**

| Clinical Unit | Invitations Sent | | | | Responses Received | |
|---|---|---|---|---|---|---|
| | From Survey Monkey | From Study Coordinator (no Survey Monkey Request) | In Addition to a Survey Monkey Request (if Overseeing Multiple Units) | Total | After Data Validation[a] but Before Duplication | After Duplication[a] |
| Adult cardiac ICU | 11 | — | 9 | 20 | 3 | 3 |
| Adult ICU | 30 | 2 | — | 32 | 9 | 9 |
| Pediatric ICU[b] | 5 | — | 2 | 7 | 3 | 3 |
| Neonatal ICU | 11 | — | 2 | 13 | 5 | 5 |
| Adult oncology unit | 13 | — | 1 | 14 | 5 | 6 |
| Pediatric oncology unit | 4 | — | 3 | 7 | 2 | 2 |
| Emergency department | 40 | — | 5 | 45 | 16 | 17 |
| Adult inpatient ward[c] | 36 | — | 8 | 44 | 16 | 19 |
| Other[d] | 7 | — | — | 7 | 4[e] | 4[e] |
| **Total** | **157** | **2** | **30** | **189** | **59** | **64** |

Abbreviation: ICU, intensive care unit.

[a]See Data Validation and Formatting for an explanation of survey removals and duplications.

[b]Included some specialty pediatric ICUs.

[c]Noncritical care units containing acute medical or surgical patients.

[d]These results were excluded from the survey analysis. This category was listed in the survey for respondents who did not want to classify themselves as any of the other units listed, so no invitations were initially planned for this category. However some clinical units that did not fall under the other categories expressed an interest in participating. In the interest of collecting these data in case they could be used, the study team invited these units to participate, recognizing that they could be removed from the analysis later if needed.

[e]Excluded from the column total.

[4]Some respondents had difficulty accessing their individualized survey link; they were given a general link that anyone could fill out. Since this was not a personalized link, there was no ability to save responses and return to them later. In addition, some potential respondents were on a "do not email" list created by Survey Monkey (prior to this study, they had indicated they did not want any emails from Survey Monkey prior to this study). In such cases, the study coordinator emailed them directly with a nonspecific link.

## Data Validation and Formatting

Of the 189 invitations sent out during the recruitment process, 65 responses were recorded. However, for the purposes of analysis, several data manipulations were required to ensure accuracy and consistency between respondents.

### *Survey Exclusions*

Six surveys were excluded from the dataset.

- Responses from the same unit would compromise data validity, so any responses other than the most recent were excluded (1 survey).
- One survey provided no responses other than giving consent, and was therefore excluded.
- Four surveys categorized as "other" by respondents were excluded to ensure that only units of interest and with similar patient populations were represented. These 4 "other" units described themselves as follows:
  - pediatric cardiac inpatient unit
  - pediatric transplant unit
  - pediatric neuro/trauma
  - pediatrics, birthing, special care nursery, and postpartum

These 6 survey exclusions lowered the dataset from 65 to 59 survey responses, of which 57 were fully completed and 2 were partially completed.

### *Survey Duplications*

Five complete survey responses were duplicated, because respondents indicated they were answering on behalf of multiple units. For example, if a respondent stated that he/she was responsible for both an emergency department and an adult inpatient ward, the survey response was duplicated, classifying 1 as an emergency department and the other as an adult inpatient ward. Exceptions were made to this process for 2 respondents who indicated they were responsible for a combined adult cardiac ICU and adult ICU; these responses were classified only as an adult ICU and not duplicated.

The survey duplications increased the dataset from 59 responses to 64, 2 of which were partially completed. Responses from partially completed surveys were included for the questions that were answered. Even in fully completed surveys, not all respondents answered all questions (question path was dependent on previous answers).

### *Clinical Unit Reclassifications*

Based on respondents' comments, 3 survey responses were reclassified:

- "Medicine cardiology unit" was reclassified as an adult inpatient ward.
- "Chemo unit" was reclassified as an adult oncology unit.
- "Both CCU and ICU" was reclassified as an adult ICU.

Several other clinical units were reclassified into a more general category to avoid identification of respondents. Three new unit classifications were constructed:

- *Neonatal or pediatric ICU* included both types of ICUs and any specialty pediatric ICUs that responded.
- *Adult ICU* included all adult ICUs and any specialty adult ICUs that responded.
- *Adult or pediatric oncology unit* included all adult or pediatric oncology units that responded.

### *Respondent Role Reclassifications*

Three survey responses did not include selection of a role/job title, but listed "charge nurse" or "advanced practice nurse" in the comments. For simplicity, these surveys were classified as responses from a "staff nurse."

### *Infusion Pump Reclassifications*

Sixteen respondents reported that they had a second IV pump on their unit, and 3 respondents indicated that they had a third IV pump. However, upon review, some of the additional pumps listed were outside of the requested scope (e.g., epidural, PCA, rapid infusor, subcutaneous pump), or were simply multi-channel versions of the initial pump listed. When out-of-scope pumps and duplicate makes/models were removed, the number of respondents with a second IV pump dropped from 16 to 12; no respondents had a third IV pump.

### *Addition of Hospital Classifications*

To further understand the context of each respondent, the study team retrospectively categorized respondents based on hospital type. A classification scheme devised by the Ontario Ministry of Health and Long-Term Care (19) was used. All survey respondents worked in hospitals that fell into 1 of 3 categories: Group A, Group B, or Group C.

Group A hospitals are defined as follows (19):

> *General hospitals providing facilities for giving instruction to medical students of any university, as evidenced by a written agreement between the hospital and the university with which it is affiliated, and hospitals approved by the Royal College of Physicians and Surgeons for providing post-graduate education leading to certification or fellowship in one or more of the specialties recognized by the Royal College of Physicians and Surgeons.*

Group A hospitals were described in the survey as "academic hospitals."

Group B hospitals were described in the survey as "hospitals with 100 beds or more." There was no overlap between Group B and Group A, so hospitals in Group B were considered to be non-academic hospitals.

Group C hospitals were described in the survey as "hospitals with fewer than 100 beds." Group C hospitals were also considered to be non-academic hospitals.

## General Respondent Demographics

Figure 1 illustrates the distribution of Local Health Integration Networks (LHINs) in Ontario.

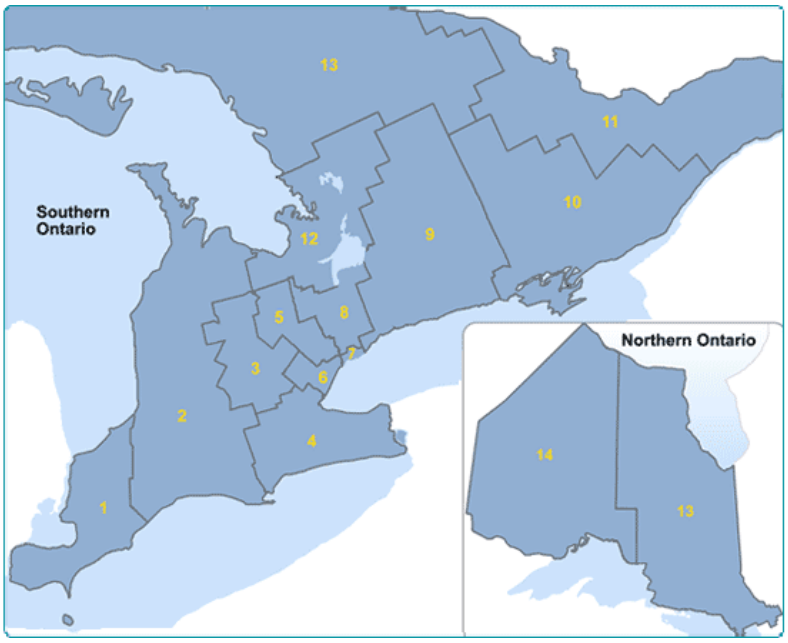


**Figure 2: Geographic Distribution of Respondent Hospital Sites**

*Source: Health Quality Ontario. (20)*

Table 2 outlines the distribution of responses by LHIN, following data validation and formatting.

**Table 2: Distribution of Responses by LHIN**

| LHIN Number | LHIN Name | Number of Responses |
|---|---|---|
| 1 | Erie St. Clair | 1 |
| 2 | South West | 6 |
| 3 | Waterloo Wellington | 6 |
| 4 | Hamilton Niagara Haldimand Brant | 10 |
| 5 | Central West | 4 |
| 6 | Mississauga Halton | 4 |
| 7 | Toronto Central | 9 |
| 8 | Central | 0 |
| 9 | Central East | 1 |
| 10 | South East | 1 |
| 11 | Champlain | 9 |
| 12 | North Simcoe Muskoka | 1 |
| 13 | North East | 9 |
| 14 | North West | 3 |

Abbreviation: LHIN, Local Health Integration Network.

Table 3 summarizes the distribution of the final dataset used for analysis.

**Table 3: Distribution of Survey Responses by Hospital Type, Clinical Unit, and Respondent Role**

| Hospital Type and Clinical Unit | Nurse Manager | Nurse Educator | Staff Nurse | Other[a] | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **18 (86%)** | **—** | **1 (5%)** | **2 (10%)** | **21** |
| Adult ICU | 1 | — | 1 | — | 2 |
| Adult or pediatric oncology unit | 2 | — | — | — | 2 |
| Emergency department | 6 | — | — | — | 6 |
| Adult inpatient ward | 9 | — | — | 2 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **4 (18%)** | **16 (73%)** | **1 (5%)** | **1 (5%)** | **22** |
| Adult ICU | 1 | 4 | — | 1 | 6 |
| Pediatric or neonatal ICU | — | 3 | — | — | 3 |
| Adult or pediatric oncology unit | — | — | 1 | — | 1 |
| Emergency department | 2 | 4 | — | — | 6 |
| Adult inpatient ward | 1 | 5 | — | — | 6 |
| **Academic Hospitals** | **5 (24%)** | **8 (38%)** | **4 (19%)** | **4 (19%)** | **21** |
| Adult ICU | 3 | 1 | — | — | 4 |
| Pediatric or neonatal ICU | — | 1 | 1 | 3 | 5 |
| Adult or pediatric oncology unit | — | 2 | 2 | 1 | 5 |
| Emergency department | — | 4 | 1 | — | 5 |
| Adult inpatient ward | 2 | — | — | — | 2 |
| **Total** | **27 (42%)** | **24 (38%)** | **6 (9%)** | **7 (11%)** | **64** |

Abbreviation: ICU, intensive care unit.

[a]Survey respondents who indicated an "other" role tended to be high-level administrators (e.g., director of critical care or patient care) or have a specialized role.

## Analysis Strategy

### *Descriptive Statistics*

At first, descriptive statistics for all survey questions were analyzed (e.g., number and percentage of respondents who selected each answer), with a focus on noting any trends that suggested increased patient safety risk, particularly with respect to small sample sizes that may not have been amenable to statistical tests.

### *Inferential Statistics*

The second stage of analysis focused on the use of inferential statistical tests. These tests were performed only on compliance and practice prevalence questions; no exploratory questions were included. The objective of this stage was to help substantiate any trends or associations presented in the descriptive statistics (e.g., were respondents significantly more likely to answer "Yes" for a given question?). Statistical tests were also used to compare respondent answers as a function of hospital type or clinical unit (e.g., were respondents from non-academic hospitals with fewer than 100 beds likely to answer "Yes" to a question than those from other types of hospitals?). These tests provided insight into whether specific subpopulations were more likely to experience infusion risks.

Some testing was not possible, due to insufficient sample size. Not all 64 respondents answered every question, and in questions with multiple answer categories, the power of the statistical tests rapidly decreased.

When sample sizes were sufficient, compliance or practice prevalence questions were analyzed using 1 or more of the following tests:

- A Chi-square goodness-of-fit test was used to determine if 1 answer type (e.g., Yes) was selected more frequently than the others (e.g., No or Not sure); post hoc testing was performed with additional Chi-square goodness-of-fit tests.
- A Pearson Chi-square for association test was used to determine whether the answers varied as a function of hospital type (i.e., academic hospitals, non-academic hospitals with 100 beds or more, non-academic hospitals with fewer than 100 beds).
- A Pearson Chi-square for association test was used to determine whether the answers varied as a function of clinical unit (e.g., emergency department, adult ICU, adult or pediatric oncology unit).

Statistics were analyzed using SPSS Statistics 17.0 (SPSS Inc., Chicago, Illinois).

Respondents' answers to each survey question are presented in Appendix 2, with an explicit breakdown by respondent clinical unit and hospital type.

# Results and Analysis

Building on the work done in Phase 1b, the survey findings were organized according to 7 themes:

1. secondary infusions
2. IV line identification
3. IV line setup and removal
4. dead volume management
5. IV bolus administration
6. nurse hiring requirements
7. final comments from respondents

The first 5 themes match those from the Phase 1b report. The sixth theme builds on the interviews and analysis related to nurse education from the Phase 1b report. The seventh theme contains respondents' general thoughts and concerns beyond the boundaries set by the other themes, and is a unique aspect of this survey.

Each theme section contains the following:

- a background section describing the importance of the theme
- an overview of the sub-themes and objectives
- a summary of the results for each sub-theme and a related discussion
- a summary of findings for the theme as a whole, and considerations for future work

## Theme 1: Secondary Infusions

### *Background*

Secondary infusions are a means of administering an IV medication—typically a periodic or 1-time IV medication—by attaching it to an existing IV infusion. The attachment is made above the infusion pump so that the pump can control either the primary infusion or the secondary infusion. This method of administration has several advantages, such as avoiding additional IV access (thereby lowering infection risks), and minimizing the nurse's workload (because the primary infusion automatically resumes when the secondary infusion is complete).

Critical to the accurate administration of a secondary IV infusion is the presence of a back check valve on the primary infusion tubing. The back check valve is a component of the primary IV tubing that sits above the secondary infusion port, where the secondary IV tubing is attached. It prevents fluid from the secondary IV bag from flowing "backwards" into the primary IV bag, ensuring that only the secondary medication is infused, rather than an indeterminate mix of fluids from both IV bags. Pump tubing is often unique and proprietary to the specific IV infusion pump in use.

The Phase 1b report provided a comprehensive definition of secondary infusions and described 8 related issues that could lead to patient harm. (14) The report made 3 recommendations, 2 of which were specifically investigated in the survey: (14)

> *Secondary infusions should be attached to primary infusion sets that have a back check valve. If infusion sets without back check valves are also available, multiple strategies should be employed to ensure that the types of tubing available are easily differentiated, and that the likelihood of a mix-up is minimized.*
>
> Continuous *high-alert medications should be administered as primary infusions.* Continuous *high-alert medications should not be administered as secondary infusions. No secondary medications should be connected to high-alert primary continuous infusions.*

The survey attempted to identify whether units had a policy or standard work practice that adhered to these recommendations (direct observation would have been required to investigate nurses' actual adherence to such policies).

### *Sub-Themes and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **Back Check Valves**
  - Compliance: Identify the potential prevalence of back check valve use on primary infusions when secondary infusions are administered.
- **High-Alert Continuous IV Medications and Secondary Infusions**
  - Compliance: Identify the potential prevalence of secondary infusions attached to primary infusions administering a high-alert continuous medication.
  - Compliance: Identify the potential prevalence of high-alert continuous medications administered as secondary infusions.
- **Secondary Infusion Usage and Alternatives**
  - Practice prevalence: Identify the potential prevalence of secondary infusions as a means of administering IV medications, and what alternatives are used.

### *Back Check Valves*

**Summary of Results**

Table 4 summarizes respondent answers to the question about back check valves.

**Table 4: Back Check Valves—Compliance Question[a]**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[b] | |
| **Does the large-volume IV pump tubing used in your unit have a back check (i.e., 1-way) valve to prevent fluid from a secondary infusion from travelling backwards up the primary tubing?** | **n = 56** | | **$\chi^2 = 35.000$ *P* < 0.001** |
| Secondary infusions not given on this pump | 6 | 11 | Pairwise comparisons found only that "Yes" was selected significantly more often than all other answer categories |
| Yes | 33 | 59 | |
| No | 7 | 13 | |
| Not sure | 10 | 18 | |

Abbreviation: IV, intravenous.
[a]Only respondents who answered "Yes" to the practice prevalence question were shown this question. Seven of the 49 respondents had a second infusion pump used to administer secondary infusions, so this table reflects the number of responses rather than the number of respondents.
[b]Percentages may appear inexact due to rounding.

While the majority of respondents did have IV tubing with a back check valve when administering secondary infusions, up to 31% may not have had a back check valve.

There was insufficient power to test for differences across hospital types or clinical units. However, when respondents who answered "Secondary infusions not given on this pump" were removed and respondents answering "No" and "Not sure" were grouped, a Pearson Chi-square test for association was possible to evaluate differences across hospital type; no significant differences were found ($\chi^2 = 0.125$; $P = 0.94$). For a detailed breakdown of respondent answers, please see Table A1. One notable finding was that 5 of the 7 respondents who indicated they did not have a back check valve on their primary IV tubing were from emergency departments.

**Discussion**

Three key observations were made based on the data above:

- A significant proportion of survey responses (17 out of 56; 31%) indicated that respondents did not have a back check valve or were uncertain if they had a back check valve on the primary IV tubing used to administer secondary infusions. This represented a significant population that could benefit from review and implementation of the Phase 1b recommendation concerning back check valves.
- Among the units that were uncertain about the presence of back check valves were several adult ICUs, as well as pediatric and neonatal ICUs (where fluid volume and dosing accuracy is particularly sensitive to small patient weights). All of these units indicated that they administered secondary infusions on large-volume IV infusion pumps.
- Emergency departments were the most likely to use IV tubing without a back check valve when secondary infusions were administered.

With respect to the first observation above, 31% is presented as the worst-case scenario, as it treats respondents who answered "Not sure" as not having a back check valve. As well, 3 of the 7 units

indicating no use of back check valves were from the same institution (1 respondent answered on behalf of an oncology unit, an inpatient ward, and an emergency department). This may have artificially increased the appearance of this practice, given the small sample sizes. If duplicate responses were excluded and it was assumed that that those who answered "Not sure" *did* have a back check valve, the proportion of clinical units at risk would drop considerably, to 5 out of 54 respondents (9%). Still, even this conservative estimate represents an unacceptable risk for an issue that could be easily remedied by selecting the correct type of IV tubing.

Given the risks associated with administering secondary infusions without back check valves (discussed in Phase 1b) and the recommendation supporting the use of back check valves, there is room for improvement among clinical units in Ontario. It is worth noting that the letter alerting hospitals to the Phase 1b report and its recommendations was released in June 2012, but the data collection period for the survey ended in April 2012. Clinical units may have made adjustments to their practice since the survey data were collected.

Back check valves are unlikely to affect the administration of primary IV infusions when secondary IV infusions are not required. However, there may be select cases when the presence of a back check valve is not advisable for a primary infusion. One case is when required flow rates are in excess of the limit of most large-volume IV infusion pumps: typically 999 mL/h. Due to their design, back check valves are known to reduce the speed of infusions with high flow rates. (21;22) In some situations (e.g., trauma and resuscitation), the demand for IV fluid may be immediate and life-saving, and the back check valve may endanger patient safety. To generate flow rates in excess of 999 mL/h, IV infusions tend to be removed from typical large-volume IV infusion pumps and pressure applied to the IV bag, usually with a high-pressure infusor system or a pressure cuff. Such circumstances were not investigated as part of this study, because gravity infusions and high-pressure infusors were excluded; they are mentioned here only because they should be considered in evaluations of when back check valves should be available, and by extension, when secondary IV infusions are allowable.

Back check valves may also be undesirable in other situations. For example, some primary IV infusions are commonly infused alone (e.g., blood or blood products, total parenteral nutrition). Some hospitals may opt to provide IV tubing without a secondary IV connection port for these infusions to prevent the addition of a secondary infusion. If a secondary port is not available, a back check valve is unnecessary, given that secondary infusions and back flow would not be possible.

While back check valves protect against back flow in typical secondary infusions, hospitals should be aware that back check valves address only 1 aspect of safety for secondary infusions. For example, when secondary infusions are programmed with high flow rates (e.g., over 500 mL/h), the speed of the infusion may reduce back pressure enough to open the back check valve, allowing concurrent flow. Anecdotally, some hospitals have reported upstream "no flow" alarms when the primary infusion is programmed to run at 500 to 999 mL/h, particularly when the primary IV bag has been lowered to facilitate a secondary infusion. This issue may be more common with infusion pumps that rely on gravity to fill the pumping mechanism from the primary IV bag; lowered IV bags have less gravity-induced flow, and the pumping mechanism may not receive fluid quickly enough to maintain the intended flow rate. Secondary IV infusion setup issues will be discussed further in the Phase 2b report.

Hospitals may consider 2 options for improving the use of the back check valve:

1. Ensuring that back check valves are present when a secondary IV infusion port is available on IV tubing. Primary IV tubing without a back check valve should not have a secondary IV infusion port.
2. Improving the clarity of primary IV tubing packaging (both individual tubing packets and the boxes they arrive in) to clearly indicate whether or not tubing is appropriate for secondary IV

infusions. In combination with the point above, if incorrect IV tubing is selected, nurses will not be able to use it to administer secondary infusions (unless they inappropriately attempt to connect the secondary IV bag to the lower injection port).

Continued dissemination of Phase 1b recommendations through both research- and practice-oriented channels (e.g., journal articles, ISMP Canada bulletins, practice-oriented safety alerts through nursing organizations) may assist in generating awareness of secondary infusion risks.

Table 5 summarizes the factors hospitals may wish to consider when evaluating back check valve availability on IV tubing.

**Table 5: Considerations for Back Check Valve Use**

| Consideration | Use Tubing With Back Check Valve and Secondary Port | Use Tubing With no Back Check Valve and no Secondary Port[a] | Discussion |
|---|---|---|---|
| **Large-Volume IV Infusion Pump[b]** | | | |
| Secondary IV infusions will be administered on this infusion | ✓ | — | It is recommended that tubing with back check valves be standard issue for IV administration with an infusion pump. Infusion pumps regulate flow rate accurately, so back check valves should not affect flow rate accuracy (except for high-pressure infusions used to administer fluid boluses in excess of 999 mL/h; see Discussion) |
| It is possible secondary IV infusions may need to be administered on this infusion at a later time | ✓ | — | |
| Secondary IV infusions will never be administered on this infusion | ✓ | ✓ | Providing only tubing with back check valves can simplify the storage and stocking of IV tubing on clinical units. This may prevent errors in tubing selection and medication incidents involving the wrong tubing. This information should be taken into account when considering whether there are cost savings to purchasing and providing tubing without back check valves<br>If tubing without back check valves must be provided for IV administration, it is recommended that tubing without a secondary port[a] be used. This would provide a clear prompt to the user if the wrong tubing were selected for use with a secondary IV infusion. It is important that storage areas clearly differentiate between infusion sets (e.g., separate storage and clear labelling). Manufacturers should ensure that these 2 types of tubing are labelled/packaged distinctly (e.g., clear packaging so the back check valve is visible, or warnings indicating when tubing is inappropriate for secondary infusion use) |

Abbreviations: DERS, dose error reduction system; IV, intravenous.

[a]*Secondary port* refers to an injection port on the primary IV tubing that is relatively close to the spike used to connect the primary IV tubing to an IV bag. On primary IV tubing intended for use with IV infusion pumps, the secondary port would be located above the infusion pump after the tubing is loaded into the pump. Injection ports closer to the patient end of the IV tubing (i.e., not intended for secondary infusions) may continue to be used (i.e., for emergency syringe injections of medication), because a back check valve is less critical in these instances. However, non-secondary injection ports are not mandatory; hospitals may elect to use primary IV tubing with no injection ports whatsoever (e.g., similar to IV syringe pump tubing), in which case back check valves are not required.

[b]Gravity infusions were out of scope in this study, but the use of tubing with a back check valve is equally important when secondary infusions are administered via gravity-based infusions (i.e., without an infusion pump). Infusion pumps may be preferred for secondary IV infusions because of their safety benefits (e.g., increased flow rate accuracy, occlusion sensing, DERS), but may not be appropriate or possible in all circumstances. In cases where a pump is not used, nurses must monitor and manage the secondary IV infusion manually, which will likely require drip rate calculations.

### *High-Alert Continuous IV Medications and Secondary Infusions*

**Summary of Results**

Table 6 summarizes respondent answers to questions about high-alert continuous IV medications and secondary infusions.

**Table 6: High-Alert Continuous IV Medications and Secondary Infusions—Compliance Questions[a]**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | %[b] | |
| **Does your unit allow secondary infusions to be attached to a high-alert medication delivered on a primary infusion?** | **n = 48** | | **$\chi^2 = 37.167$, $P < 0.001$** |
| Yes | 8 | 17 | Pairwise comparisons found only that "No" was significantly more likely to be selected than all other answer categories |
| No | 30 | 63 | |
| Only if absolutely necessary | 7 | 15 | |
| Not sure | 3 | 6 | |
| **On your unit, are continuous high-alert medications ever administered as secondary infusions?** | **n = 49** | | **$\chi^2 = 44.633$, $P < 0.001$** |
| Yes | 1 | 2 | Pairwise comparisons found that "No" was significantly more likely to be selected than all other answer categories<br>Comparisons also found that "Only if absolutely necessary" was significantly more likely to be selected than "Not sure" or "Yes" |
| No | 31 | 63 | |
| Only if absolutely necessary | 13 | 27 | |
| Not sure | 4 | 8 | |

Abbreviation: IV, intravenous.

[a]Only respondents who answered "Yes" to the practice prevalence question were shown these questions.

[b]Percentages may appear inexact due to rounding.

There was insufficient power to test for differences across hospital types or clinical units. After grouping respondents who answered "No" and "Not sure," as well as those who answered "Only if absolutely necessary" and "Yes," the 2 tests were repeated, but sample sizes were still too small to test for differences across hospital types or clinical units for either question. For a detailed breakdown of respondent answers, please see Tables A2 and A3 (Appendix 2).

Table 7 shows the relationship between hospital types and respondents' answers.

**Table 7: Response to High-Alert Medication Question[a] by Hospital Type[b,c]**

| Hospital Type | Yes | No | Only if Absolutely Necessary | Not Sure | Total |
|---|---|---|---|---|---|
| Non-academic hospitals with < 100 beds, n (%) | 5 (33%) | 8 (53%) | 1 (7%) | 1 (7%) | 15 |
| Non-academic hospitals with ≥ 100 beds or more, n (%) | 3 (17%) | 12 (67%) | 2 (11%) | 1 (6%) | 18 |
| Academic hospitals, n (%) | 0 (0%) | 10 (67%) | 4 (27%) | 1 (7%) | 15 |
| **Total, n (%)** | **8 (17%)** | **30 (63%)** | **7 (15%)** | **3 (6%)** | **48** |

[a]Does your unit allow secondary infusions to be attached to a high-alert medication delivered on a primary infusion?
[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.
[c]Percentages may appear inexact due to rounding.

Nine respondents provided comments about what drugs might be used when secondary infusions were added to high-alert continuous primary infusions. However, it was sometimes unclear whether respondents were describing the primary or secondary infusion, or how medications were being coadministered. For example, 2 comments were worded in such a way that they may have been referring to the coadministration of 2 primary infusions, rather than to a secondary infusion. Some drugs mentioned in respondents' comments included the following:

- heparin and lasix, morphine, and total parenteral nutrition
- potassium chloride
- IV fluid boluses
- antiarrhythmics and inotropes

Nineteen respondents provided comments about what drugs might be used when high-alert medications were administered as secondary infusions. Respondents suggested that a variety of electrolytes might be administered as secondary infusions, but also morphine, amiodarone, insulin, and others. Significant patient harm could occur with any of these drugs if there was pump programming confusion between primary and secondary infusion modes, or if physical setup errors occurred during the initiation of the secondary infusion.

**Discussion**

Notable observations related to this sub-theme included the following:

- The Phase 1b recommendation regarding high-alert medications and secondary infusions is likely to benefit approximately 30% of clinical units in Ontario if the survey population is representative (Table 6).
- Respondents were more cautious (i.e., answering "only if absolutely necessary") about administering high-alert continuous medications as secondary infusions than about interrupting a high-alert continuous primary infusion with a secondary infusion.
- Based on descriptive statistics, non-academic hospitals with fewer than 100 beds appeared to allow the administration of secondary infusions along with high-alert continuous primary infusions more often than other hospital types (Table 7).
- Pediatric or neonatal ICUs never administered high-alert medications with or as secondary infusions. However, sample sizes were small, and generalizability to the larger Ontario context was also affected by respondents' preference to avoid using secondary infusions (see Secondary Infusion Usage and Alternatives).

One limitation of the data involved a lack of clarity about what constituted a "high-alert" medication. The full list of high-alert medications was not included in the survey to save space, but a web link to the ISMP (United States) high-alert medication list (23) was provided. Respondents may not have visited the link, and their own understanding of high-alert medications may not have been fully congruent with the ISMP (United States) list. For example, in a comment 1 respondent referenced a plain IV line that contained potassium, implying that this was a high-alert medication. The ISMP (United States) high-alert medication list makes reference only to "potassium chloride for injection concentrate," suggesting that lower concentrations of potassium are not necessarily high-alert. If the respondent used low concentrations of potassium for a continuous primary infusion (Figure 3)—a common and often required practice—the addition of a secondary infusion to this would not constitute an interruption of a "high-alert" primary infusion. Confusion such as this may have artificially increased the proportion of respondents who indicated that high-alert primary infusions were being interrupted by secondary infusions.


**Figure 3: Example of Potassium Chloride in IV Fluid Replacement Form**

*Source: Hospira. (24)*

Academic hospitals seemed to be less willing to administer secondary infusions along with high-alert primary infusions (Table 7), because more respondents from academic hospitals stated that this would be done "only if absolutely necessary." However, given the potential for confusion related to the list of high-alert medications (above), respondents from non-academic hospitals may have been as conservative as academic hospitals in restricting the administration of secondary infusions with high-alert primary medications. For this reason, Table 7 can be interpreted 2 ways, depending on how well respondents understood ISMP (United States)'s definition of *high-alert:*

- Respondents from non-academic hospitals treated potassium chloride or other medications as high-alert, and respondents from academic hospitals did not, making comparisons between hospital types inconclusive.
- Respondents from all hospital types interpreted the question correctly, and clear differences in the prevalence of this practice can be observed between hospital types.

The reality likely lies somewhere in between these 2 extremes, as some respondent comments did mention potassium chloride, but the concentration they were referring to was unclear. It was also unclear how many others provided similar answers without leaving a comment.

However, we should not allow such potential misinterpretation to obscure the issues previously discussed in Phase 1b and elsewhere; there are risks inherent in administering high-alert medications with—or as—secondary infusions. For example, ISMP Canada published a recommendation in 2005 stating, "Do not piggyback a secondary infusion into a high-alert (e.g., insulin) primary drug infusion." (25) In an incident described in ISMP Canada's safety bulletin, a potassium chloride minibag was added as a secondary infusion to a primary infusion of insulin, but the secondary IV clamp was not opened, resulting in the unintended administration of insulin at a flow rate intended for the potassium chloride. Dilute potassium chloride was involved in this case, and while it was not the high-alert medication, the error still had the potential to cause serious harm.

ISMP Canada's recommendation has been available for several years, but its dissemination and/or uptake has not been optimal (see Table 7). It may be advantageous for hospitals to devote staff time to regularly reviewing and comparing hospital practices with safety information as it becomes available. Table 8 provides a summary of resources that may be helpful in this regard.

**Table 8: Safety Information Resources for Hospitals**

| Safety Information Resource | Web Address |
|---|---|
| **Highly Recommended for Regular Review** | |
| Health Canada Advisories, Warnings and Recalls | www.hc-sc.gc.ca/cps-spc/advisories-avis/index-eng.php?cat=5 |
| Health Quality Ontario e-Bulletins | www.hqontario.ca/evidence/publications-and-ohtac-recommendations/e-bulletins |
| ISMP Canada Safety Bulletins | www.ismp-canada.org/ISMPCSafetyBulletins.htm |
| **Additional Canadian Resources** | |
| Accreditation Canada | www.accreditation.ca |
| Canadian Patient Safety Institute | www.patientsafetyinstitute.ca |
| Health Insurance Reciprocal of Canada | www.hiroc.com |
| Ontario Hospital Association | www.oha.com |
| Quality Improvement Resources and Tools | www.hqontario.ca/quality-improvement/tools-and-resources |
| **Additional United States Resources** | |
| ECRI Institute (subscription-based) | www.ecri.org |
| Health Technology Safety Institute | www.aami.org/htsi |
| ISMP (United States) newsletters | www.ismp.org/newsletters |

Abbreviation: ISMP Canada, Institute for Safe Medication Practices Canada; ISMP (United States), Institute for Safe Medication Practices (United States).

Findings related to the efficacy of educational methods will be presented as part of Phase 2b, and may contribute additional ways to enhance awareness of secondary infusion risks.

### *Secondary Infusion Usage and Alternatives*

**Summary of Results**

Table 9 summarizes respondent answers to the question about secondary infusion usage and alternatives.

**Table 9: Secondary Infusion Usage—Practice Prevalence Question**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Does your unit administer medications via secondary infusions?** | **n = 56** | | **$\chi^2 = 79.000$**<br>***P* < 0.001** |
| Yes | 50 | 89 | Pairwise comparisons found that "Yes" was significantly more likely to be selected than all other answer categories |
| No | 4 | 7 | |
| Unit uses only syringe pumps | 2 | 4 | |

[a]Percentages may appear inexact due to rounding.

There was insufficient power to test for differences across hospital types or clinical units. For a detailed breakdown of respondent answers, please see Table A4.

Six units did not use secondary infusions; all cared for pediatric or neonatal populations. Three of the 6 were from the same academic hospital corporation; the same corporation contained 2 units that were restricted to the use of a syringe pump only. The survey was not designed to investigate why some units preferred to use syringe pumps or did not administer secondary infusions.

Four comments were received from units where secondary infusions were not used. The comments suggested that intermittent infusions were still administered, but as a primary infusion on a separate pump (e.g., a syringe pump) or as an IV syringe injection (i.e., IV push), rather than as a secondary infusion. Both of these administration techniques were likely performed by connecting the intermittent infusion to an existing infusion line at a port close to the patient.

Comments from respondents received at the end of the questions related to secondary infusions did not introduce any unexpected findings. Respondents touched on the following:

- handling of high-alert medications (e.g., 1 unit never administered them as secondary infusions)
- the need for improvisation in the emergency department (e.g., violating some guidelines to do so)
- practices that were dependent on, or affected by, the infusion pump
  - the infusion pump drug library was more comprehensive in some clinical areas than others
  - infusion pumps such as the Hospira Plum A+ do not depend on gravity to pull IV fluid from IV bags (see the Phase 1b report (14) for a more detailed discussion of the Hospira Plum A+)
- lack of understanding of secondary infusions by staff, affecting troubleshooting and the management of IV bag overfill

**Discussion**

The data suggest that staff in pediatric or neonatal units recognize that secondary infusions may not be ideal for their patient population. Based on Phase 1b observations, pediatric or neonatal ICUs are likely to require tight control of fluid volume and dosing. The use of secondary infusions in these environments is often suboptimal because the fluid required to mix a small IV bag and administer it along the priming volume of the primary IV tubing may be in excess of what the patient requires. Often, these units prefer IV syringe pumps for their ability to administer small volumes of precisely compounded medications, and

for their highly accurate administration at slow flow rates. Respondents' comments confirmed that separate infusion pumps (i.e., large-volume or syringe pumps) or IV syringe injections were used to administer intermittent medications.

Because 1 institution contained 3 of the 6 units that did not use secondary infusions, the percentage of respondents not administering secondary infusions may have been artificially inflated. Readers should be aware that the proportion of units across Ontario that do not administer secondary infusions may be smaller than is suggested by the data.

Further research may be required to understand whether all pediatric and neonatal units would benefit from avoiding secondary infusions. Given the concerns about secondary infusion setup issues highlighted in the Phase 1b report and the total amount of fluid volume that needs to be administered as part of this method, it is likely that there would be benefits to restricting the use of secondary IV infusions in neonatal and pediatric ICU settings.

It is unclear whether it would be beneficial to standardize infusion methods in adult populations to match those of pediatric units. Given the convenience of secondary infusions (described previously in the Phase 1b report), it is likely that staff in adult units would resist attempts to remove this practice without clear evidence that alternative administration methods are as time-saving and as safe. Attempting to change existing secondary infusion practices in adult environments and follow a pediatric model would be a major change and could raise new issues regarding drug ordering and preparation.

Phase 2b of this study will report findings related to alternative ways of administering intermittent medications and enhancing the safety of secondary infusion administration.

### *Summary of Findings and Future Work*

This theme highlights 2 major concerns related to secondary infusion practices and policies in Ontario.

First, 9% to 31% of respondents (from a total of 56) indicated that secondary IV infusions may be administered using IV tubing that does not have a back check valve. This may lead to unintended mixing of primary and secondary IV fluids, and an inappropriate flow rate for some medications. One potential strategy for addressing this gap is for hospitals to limit the IV tubing available for secondary infusions to tubing with a back check valve. IV tubing without a secondary port could remain available to prevent the addition of secondary infusions in cases when back check valves are not appropriate. There is a clear need for these 2 types of tubing to be distinguishable, however, and it is likely that clear labelling and packaging by manufacturers may benefit both hospitals and clinical staff in properly stocking and separating these products. If it is unlikely that a care area would require IV tubing without a back check valve, hospitals should strive to ensure that only IV tubing with a back check valve is available.

Second, survey data revealed that a 2005 recommendation made by ISMP Canada advising against the administration of secondary infusions on high-alert continuous primary infusions may not be followed by about 30% of survey respondents (from a total of 48). This risk was discussed in detail in Phase 1b and may increase the risk of medication overdose, inappropriate administration flow rate, and/or delay of medication administration. The data were limited in that some respondents may have considered dilute potassium chloride a high-alert medication, which does not fall within the scope of ISMP Canada's recommendation, potentially inflating the proportion of respondents that are at risk of this practice. Hospitals may benefit from efforts to regularly review and implement new safety information and/or recommendations as they become available (e.g., recommendations regarding the avoidance of secondary infusions with high-alert primary infusions). Further research is required to understand why adherence to these recommendations is not higher.

## Theme 2: IV Line Identification

### *Background*

IV line identification refers to the process of identifying the characteristics of each IV line (e.g., drug name and concentration, path to access site on patient, and infusion pump parameters). Misidentifying an infusion could lead to a number of issues, including manipulating an unintended infusion and failing to manipulate the intended infusion. This could lead to under- or overdosing of a medication, and/or a delay in the administration of a potentially life-sustaining medication.

The Phase 1b report identified several factors contributing to line-identification errors, including the following:

- physical complexity at the bedside
- lack of standardization in setup procedures
- error-prone methods for line tracing
- suboptimal drug tubing and pump labels
- lack of guidance on shift handovers

The survey focused on the last 2 factors above: labelling and shift handovers.

The survey questions addressed 1 Phase 1b recommendation related to labelling: (14)

> *If an "emergency medication line" controlled by an infusion pump is set up, it is strongly suggested that the associated primary IV tubing be labelled as the emergency medication line at the injection port closest to the patient. The label should be prominent and visually distinct from all other labels in the environment.*

Emergency medication lines were referred to as *plain IV lines* in the survey and defined as follows (see Appendix 1):

> *A plain IV line refers to an IV line continuously infusing a fluid that is compatible with most IV medications, and is not joined with other infusions. It is often kept available in the event that IV drugs are required immediately, and in some institutions, may also be used to deliver intermittent medications.*

The survey was designed to determine adherence to the above Phase 1b recommendation across the province, as well as the potential prevalence of tubing labelling, pump labelling, and formal shift handover processes. It was also designed to provide insight into how those practices were performed.

### *Sub-Themes and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **Labels Applied to IV Tubing**
  - Practice prevalence: Identify the potential prevalence of standard work practices that require the contents of IV tubing to be labelled.
  - Exploratory: Identify where, when, and with what materials IV tubing labels are applied.
- **Differences in Labelling for Plain IV Line Tubing**
  - Compliance: Identify the potential prevalence of labelling practices that distinguish plain IV lines from other IV tubing.
  - Exploratory: Identify how plain IV tubing labels distinguish them from other IV drug tubing.

- **Labels Applied to the Exterior of IV Infusion Pumps**
  - Practice prevalence: Identify the potential prevalence of IV infusion pump labelling.
  - Exploratory: Identify what information is included on IV infusion pump labels, and whether policies specify when pump labels should be removed.
- **Shift Handover Practices**
  - Practice prevalence: Identify the potential prevalence of formal shift handover processes.
  - Exploratory: Identify the details of shift handover practices (e.g., whether a tool is used to assist handover, whether handover occurs at patient's bedside during handover, what information is transferred).

### *Labels Applied to IV Tubing*

**Summary of Results**

Table 10 summarizes respondent answers to the question about labelling IV tubing contents (e.g., drug name).

**Table 10: Labels Applied to IV Tubing—Practice Prevalence Question**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Is there a standard work practice in your unit that requires the contents of the IV tubing to be labelled?** | **n = 64** | | **$\chi^2 = 3.219$ Not significant ($P = 0.20$)** |
| Yes, all | 28 | 44 | No pairwise comparisons performed, as the Chi-square goodness-of-fit was not significant |
| Yes, some drugs/fluids | 17 | 27 | |
| No | 19 | 30 | |

Abbreviation: IV, intravenous.
[a]Percentages may appear inexact due to rounding.

A Pearson Chi-square test for association was conducted to evaluate differences across hospital types and found to be not significant ($\chi^2 = 4.046$; $P = 0.40$). There was insufficient power to evaluate differences across clinical units.

To increase the power of the statistical tests, answers were regrouped, combining "Yes, all" and "Yes, some drugs/fluids." The test for differences across hospital types remained nonsignificant ($\chi^2 = 1.742$; $P = 0.42$), and the test for differences across clinical units continued to be invalid due to insufficient sample size. For a detailed breakdown of respondent answers, please see Table A5.

There was significant variability in how respondents interpreted the question. Numerous comments referred to labels such as the date or time to change tubing, or labels to indicate a medication had been added to the IV bag. Other comments described practices specific to a respondent's unit, which may have limited labelling according to the discretion of nurses, for only specific medications (e.g., high-alert, cytotoxic), to the IV infusion pump only, or only when a high number of IV infusions were required.

Table 11 summarizes respondent answers to the exploratory questions for this sub-theme.

**Table 11: Labels Applied to IV Tubing—Exploratory Questions[a]**

| Survey Questions | Respondents | |
|---|---|---|
| | n | %[b] |
| **Does the standard work practice in your unit specify when labels should be applied to IV tubing?** | **n = 44** | |
| Yes, as part of infusion setup | 35 | 80 |
| Yes, as soon as is reasonable given other work demands | 2 | 5 |
| Yes, within a specified period of time after the infusion has been set up (e.g., within an hour of infusion start) | 1 | 2 |
| No | 6 | 14 |
| **Does the standard work practice in your unit specify the label location?** | **n = 44** | |
| Yes | 26 | 59 |
| No | 18 | 41 |
| **Does the standard work practice in your unit specify what materials should be used to label IV tubing?** | **n = 43** | |
| Yes | 32 | 74 |
| No | 11 | 26 |
| **What materials do nurses use to label IV tubing in your unit? Please select all that apply[c]** | **n = 45** | |
| Tape (handwritten) | 13 | 29 |
| Preprinted stickers | 23 | 51 |
| IV bag labels (commonly used on RN-prepared IV bags) | 27 | 60 |
| Blank stickers (handwritten) | 23 | 51 |
| Other (please specify)[d] | 3 | 7 |

Abbreviations: IV, intravenous; RN, registered nurse.
[a]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown these questions.
[b]Percentages may appear inexact due to rounding.
[c]Respondents could select more than 1 answer, so percentages do not total 100.
[d]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. Any comments in this field were counted as a response.

For a detailed breakdown of respondent answers, please see Tables A6 to A9 (Appendix 2).

Comments from respondents described the specific implementation of labelling practices:

- restricting the use of preprinted stickers to certain medications
- explaining where labels are placed
- mentioning the need to add information to the labels they were using (e.g., preprinted labels may have fields to be filled out)
- indicating when each type of sticker was used, if more than 1 type was available

This series of questions ended with respondents being offered an opportunity to provide general comments about standard work practices for labelling IV tubing. Comments addressed the following:

- There were issues with compliance, because none of the standard work practices were explicitly documented.
- Labels currently in use were too small.

- Some suggested that coloured labels be used for high-alert medications.
- Several commented on what information must be written on preprinted stickers, or how to improve nurse compliance when filling out information. However, respondents appeared to be referring to IV bag labels instead of tubing labels.
- There was staff confusion about whether the date and time applied to IV tubing should refer to the date and time tubing was initiated or when it should be replaced.

**Discussion**

There was considerable variability with respect to standard work practices for IV tubing labels. While 45 out of 64 respondents (70%) indicated that a standard work practice required some or all IV tubing to be labelled, the specifics varied as to where those labels were applied, when they were applied, and what materials were used.

One limitation of the data was potential confusion about how to interpret the questions, as suggested by the comments of several respondents. The survey specifically indicated that the questions referred to labels that "identif[ied] the contents of IV tubing (e.g., drug name)," but at least 9 respondents made reference to labelling date and time—a common practice used to indicate when IV tubing should be replaced to minimize risk of infection. In addition, some comments referred to labelling the drug name, but at locations other than the IV tubing, such as the IV pump. While IV pump labelling was also of interest (and explored later in the survey), it was not the focus of this series of questions and indicated that that the questions may not have been interpreted as intended. It was often unclear whether the comments were provided as complementary information, or whether they represented a fundamental misunderstanding of the questions. It was also unclear whether other respondents also misinterpreted the question but did not provide a comment that might have shown this.

Based on these findings, it was not possible to describe an optimal labelling strategy; multiple factors require further research. In particular, longitudinal testing approaches are needed to determine the following:

- required bedside proximity and stocking strategies to help ensure accessibility for nurses
- risks for confusion with other labels in the environment
- the likelihood of long-term adherence to the use of labels
- whether suboptimal usage presents any unique potential for error (e.g., how robust is the labelling system when it is applied improperly)
- how different labels could be used in unanticipated ways for other purposes, potentially increasing certain types of risks
- how different labelling strategies may be required in different clinical unit types to take into account unique constraints and workflow

Regardless of all these factors, the labelling of IV tubing with a date and time should be consistent. One respondent specifically described the confusion of staff related to whether IV tubing should be labelled with the date and time it was started, or the date and time it should be changed. Other comments mentioned that the date/time label was sometimes not applied at all, particularly with patients being received from other units; labelled with a marker directly on the IV tubing or drip chamber; or applied to tubing that was "pre-primed" for use later, to indicate it was ready.

These comments mirrored some of the variability observed in Phase 1b of the study (Figure 4). It is important for nurses to agree on how the date and time of IV tubing replacements are communicated; confusion may lead to IV tubing being unnecessarily changed or not changed on time, either of which may increase the risk of infection.


**Figure 4: Variations in Date and Time Labels Observed During Phase 1b**

### *Differences in Labelling for Plain IV Line Tubing*

**Summary of Results**

Table 12 summarizes respondent answers to the question about differences in labelling for plain IV line tubing.

**Table 12: Differences in Labelling for Plain IV Line Tubing—Compliance Question[a,b]**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[c] | |
| **Is the IV tubing used for plain IV lines labelled differently than other IV tubing?** | **n = 44** | | **$\chi^2 = 18.591$**<br>**$P < 0.001$** |
| Yes | 2 | 5 | Post hoc testing showed that "No" and "Plain IV lines are not labelled on my unit" were significantly more likely to be selected than "Yes"<br>There was no significant difference between "No" and "Plain IV lines are not labelled on my unit" |
| No | 25 | 57 | |
| Plain IV lines are not labelled on my unit | 17 | 39 | |

Abbreviation: IV, intravenous.

[a]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[b]One answer category, "Plain IV lines are not used on my unit" was omitted from this table, as no respondent selected this option.

[c]Percentages may appear inexact due to rounding.

There was insufficient power to evaluate differences across hospital types or clinical units. However, when the answer category "Yes" was excluded, there was sufficient power to evaluate differences across hospital types; no significance was found ($\chi^2 = 3.249$; $P = 0.20$). For a detailed breakdown of respondent answers, please see Table A10.

When answering the follow-up exploratory question (How are the IV tubing labels for plain IV lines made distinct from other IV tubing labels?), the 2 units that labelled plain IV lines differently (an oncology unit and an emergency department) indicated that they used a different colour. The respondent from the oncology unit indicated that coloured labelling was used for chemotherapy drug lines.

A number of free-text comments for this question discussed labelling the tubing with date and time information to guide when it should be changed.

**Discussion**

Similar to the previous sub-theme, some respondents appeared to interpret the question as referring to date and time labels, rather than to labels indicating infusion of a plain IV fluid. This limitation makes it unclear whether respondents were answering the survey question with the correct labels in mind. However, assuming the question was correctly interpreted, the majority of clinical units in Ontario did not have practices specifying that plain IV lines be easily identifiable. Roughly 95% of respondents indicated that they did not label plain IV lines at all, or did not label them differently from other IV tubing. Respondents' answers are likely flexible in practice. For example, 1 respondent wrote in the comments that plain IV tubing was labelled only when multiple IV infusions were active, although his/her response to the question was, "Plain IV lines are not labelled on my unit."

As described in the background above, the survey referred to emergency medication lines as *plain IV lines*, as it was felt that most respondents would be familiar with this term. However, there can be a distinction between plain IV lines and emergency medication lines. For example, there may be cases when more than 1 plain IV fluid is infusing into a single patient, but 1 of the plain IV infusions may be joined with another medication prior to reaching the patient's vein (e.g., to ensure catheter patency if the

joined medications are of a low flow rate). In that case, only the line infusing alone is appropriate for use as an emergency medication line. It is possible that respondents were thinking of *plain IV line* as a general term, rather than as an emergency medication line. Still, given the overlap between the 2 definitions in practice, the survey results still suggest that emergency medication lines are not being labelled on a consistent basis.

Although not suggested by any of the respondents' comments, it is conceivable that unlabelled IV tubing might be mistakenly assumed to be plain IV fluid under certain conditions. This would be more likely if it was common practice to label only drug tubing. During Phase 1b observations, some nurses stated that no manipulations to IV infusions are performed without a full trace and reconciliation from the top of the IV bag to the patient, but this process may not always be undertaken when nurses are comfortable with the setup and have performed a trace recently, or when they are under time pressure. For example, noticing an unlabelled line and "knowing" that only 1 plain IV fluid is infusing could be sufficient grounds to use that IV line as an emergency medication line. For this reason, the omission of an IV tubing label is not an appropriate method of identification.

While the data presented here are potentially confounded by confusion about date and time labelling, they do suggest that plain IV lines are not labelled in a number of clinical units, leading to the potential for confusion if a plain IV line is specifically required (e.g., emergency IV pushes, intermittent infusions, fluid boluses). The existing Phase 1b recommendation to label emergency medication lines in a manner that distinguishes them from other IV tubing should continue to be disseminated.

### *Labels Applied to the Exterior of IV Infusion Pumps*

#### Summary of Results

Table 13 summarizes respondent answers to the question about labels applied to the exterior of IV infusion pumps.

**Table 13: Labels Applied to the Exterior of IV Infusion Pumps—Practice Prevalence Question**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Is it standard work practice for nurses to add their own medication labels to the exterior of an infusion pump (i.e., handwritten tape or stickers)?** | **n = 55** | | **$\chi^2$ = 1.945 Not significant (*P* = 0.58)** |
| Yes | 18 | 33 | No pairwise post hoc testing was performed; the Chi-square goodness-of-fit test was not significant |
| No, but many nurses choose to | 11 | 20 | |
| No, and few nurses choose to | 13 | 24 | |
| No, this practice discouraged by the unit | 13 | 24 | |

Abbreviation: IV, intravenous.
[a]Percentages may appear inexact due to rounding.

There was insufficient power to evaluate differences across hospital types or clinical units. To increase the power of the test, the answer categories "Yes" and "No, but many nurses choose to" were grouped, and the remaining 2 answer choices were also grouped. With the grouped answers, it was possible to evaluate differences across hospital types, but no significance was found ($\chi^2 = 0.538$; $P = 0.76$); there was insufficient power to evaluate differences across clinical units. For a detailed breakdown of respondent answers, please see Table A11. An ad hoc descriptive analysis was done to compare respondent answers with the make and model of infusion pump in use (Table A12), but no clear correlations were observed.

Of the 13 respondents who indicated that nurses labelled infusion pumps even though it was not standard work practice, 11 provided comments to explain why. In general, comments indicated that the objective of pump labelling was to increase the visibility of drug names, facilitate the speed of infusion setup, reduce confusion, and generally facilitate nursing work flow.

Table 14 summarizes respondent answers to the exploratory questions for this sub-theme.

**Table 14: Labels Applied to the Exterior of IV Infusion Pumps—Exploratory Questions[a]**

| Survey Questions | Respondents | |
|---|---|---|
| | n | %[b] |
| **What information is included on labels that are applied to the exterior of the pump? Please select all that apply[c]** | **n = 29** | |
| Drug name | 27 | 93 |
| Drug concentration | 5 | 17 |
| IV access location (e.g., right internal jugular, proximal/medial/distal, etc.) | 5 | 17 |
| Volume-rate (e.g., mL/h) | 4 | 14 |
| Dose rate (e.g., unit/h, mg/h, mcg/kg/h, etc.) | 10 | 34 |
| Other (please specify)[d] | 6 | 20 |
| **Is there a standard work practice for how and when to remove externally applied pump labels?** | **n = 29** | |
| Yes | 5 | 17 |
| No | 24 | 83 |

Abbreviation: IV, intravenous.
[a]Only respondents who indicated that it was standard work practice to label IV infusion pumps (or many nurses chose to) were shown these questions.
[b]Percentages may appear inexact due to rounding.
[c]Respondents could select more than 1 answer, so percentages do not total 100.
[d]This was a selectable option that also provided a free-text field for respondents to provide details.

For a detailed breakdown of respondent answers, see Tables A13 and A14 (Appendix 2).

"Other" types of information indicated on the pump label included the patient's name, when the infusion was mixed, or the conditions in which pump labels were used (e.g., only used if more than 1 pump was running, or in practices considered uncommon).

Respondents indicating that a standard work practice existed for removing pump labels generally indicated that it was when the infusion was complete or discontinued, when the bags or tubing were changed, or during cleaning by a health care assistant.

General comments left at the end of this section addressed some of the following points:

- Pump labels are important because they provide highly visible information to facilitate the handling of emergencies or when nurses are covering for each other during breaks.
- Sometimes nurses prefer pump labelling, because it serves as a "back-up" to the pump display.
- Pump labels were double-checked in 1 respondent's unit.
- There was concern about sticky residue left after the label was removed and possible risk of infection.

**Discussion**

There was a wide distribution of responses related to the labelling of IV infusion pumps, ranging from units that required it as part of standard work practice to units that actively discouraged it. There was no significant difference between groups overall, and no interaction was found with hospital type. The sample size was insufficient to investigate interaction with clinical unit.

A variety of factors may affect why some respondents prefer to label pumps. Besides personal preference, the design of the infusion pumps themselves may play a role. For example, pumps from different manufacturers vary in how clearly they display the drug name on the face of the pump (drug name was the primary piece of information contained in pump labels). However, an examination of the types of pumps used by respondents in each answer category showed no apparent correlation between pump type and answers given (Table A12). This finding suggests that infusion pumps do not meet nurses' information needs, irrespective of available pump designs.

The removal of labels from IV pumps is a critical aspect of pump labelling, to prevent confusion when pumps are used again. However, very few respondents indicated a standard work practice for the removal of pump labels.

Findings for this sub-theme suggested ideas for future work:

- IV infusion pumps should be developed that minimize the need for external labels (e.g., manufacturers may be able to develop alternative methods of clearly indicating the drug being infused, among other parameters).
- Clinical units that allow the application of labels to IV infusion pumps should ensure implementation of a standard work practice describing who should remove IV infusion pump labels and when.

Clinical units may also wish to consider the following when reviewing pump labelling practices:

- Specify when IV pump labels should be applied and removed.
- Specify what types of labels should be used (e.g., stickers, tape).
- Specify where labels should be stored, and how they should be distinguished from labels for other purposes (e.g., labels for IV tubing, IV bags, or other bedside equipment such as non-IV pumps).
- Identify potential barriers to pump labelling (e.g., cost-benefit concerns in less critical care areas, infection prevention and control issues due to tape residue).
- Ensure that standard work practices related to pump labelling are reinforced during unit orientation and clinical preceptorships.

Additional findings from Phase 2b will discuss the effectiveness of IV tubing and line-labelling strategies.

### *Shift Handover Practices*

**Summary of Results**

Table 15 summarizes respondent answers to the question about shift handover practices.

**Table 15: Shift Handover Practices—Practice Prevalence Question**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Is there a formal shift handover process between bedside nurses on your unit?** | **n = 64** | | **$\chi^2 = 105.219$**<br>***P* < 0.001** |
| Yes | 60 | 94 | Pairwise comparisons showed only that "Yes" was significantly more likely to be selected than either of the other answer categories |
| No | 1 | 2 | |
| Outpatient unit (no shift handovers) | 3 | 5 | |

Abbreviation: IV, intravenous.

[a]Percentages may appear inexact due to rounding.

Only 1 respondent, from an emergency department, indicated that his/her clinical unit had no formal shift handover process between bedside nurses. There was insufficient power to evaluate differences across hospital types or clinical units. For a detailed breakdown of respondent answers, please see Table A15.

Table 16 summarizes respondent answers to the exploratory questions for this sub-theme.

**Table 16: Shift Handover Practices—Exploratory Questions[a]**

| Survey Questions | Respondents | |
|---|---|---|
| | n | %[b] |
| **Are bedside nurses provided with a documentation tool that was designed specifically to support shift handover?** | **n = 60** | |
| Yes | 44 | 73 |
| No | 16 | 27 |
| **What is the documentation tool?** | **n = 44** | |
| Paper-based tool for nurses to complete by hand | 20 | 45 |
| Computer-based form to be completed electronically | 12 | 27 |
| Audio recorder (e.g., for taped report) | 9 | 20 |
| Whiteboard | 0 | 0 |
| Other (please specify)[c] | 3 | 7 |
| **Does the shift handover tool become a formal part of the patient's chart?** | **n = 44** | |
| Yes | 9 | 20 |
| No | 34 | 77 |
| Not sure | 1 | 2 |
| **Is it standard work practice to conduct handover at the patient's bedside?** | **n = 60** | |
| Yes | 24 | 40 |
| No | 36 | 60 |
| **What information is exchanged during shift handover in regards to the patient's IV therapy? Please select all that apply[d]** | **n = 60** | |
| List of IV drugs being infused | 44 | 73 |
| Presence of a plain IV line | 49 | 82 |
| Location of a plain IV line | 34 | 57 |
| IV access sites (location) | 37 | 62 |
| IV access sites (condition [e.g., IV site may be positional etc.]) | 41 | 68 |
| Infusion pump settings | 47 | 78 |
| All medication orders, or changes to medication orders if patient cared for in previous shift | 41 | 68 |
| Other (please specify)[e] | 18 | 30 |
| **Is it standard work practice for the outgoing nurse to physically point out the contents of each IV tube at each patient's IV access device during handover?[f]** | **n = 60** | |
| Yes | 13 | 22 |
| No | 47 | 78 |

Abbreviation: IV, intravenous.

[a]Only respondents who answered "Yes" to the practice prevalence question were shown these questions. Furthermore, the number of respondents answering the second and third question was limited to respondents who answered "Yes" to the first question.

[b]Percentages may appear inexact due to rounding.

[c]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. The intent of this question was for respondents to select a single answer. Nineteen respondents provided comments in this free-text category, but only 3 had no concurrent response in 1 of the other answer categories. To avoid double-counting respondents, only these 3 respondents are shown in the table.

[d]Respondents could select more than 1 answer, so percentages do not total 100.

[e]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. Since respondents were allowed to select more than 1 answer in this category, any comments in this field were counted as responses.

[f]One answer category, "Other (please specify)" was omitted from this table. It was not a selectable option; it was a free-text field that any respondent could use to provide additional details. The intent of this question was for respondents to select a single answer. Twelve respondents left a comment in this field, describing exceptions to their answer choice (e.g., only if patient was critical and had multiple IV infusions, high-alert drugs only).

For a detailed breakdown of respondent answers, please see Tables A16 to A21 (Appendix 2).

With respect to shift handover tools, respondents commented on tools or combinations they used:

- SBAR technique (Situation, Background, Assessment, and Recommendation) in conjunction with verbal and written handover reports
- checklist reminder posters (not filled out, reference only)
- transfer of accountability checklist
- report sheet
- combination of goal sheet, Kardex, and flow sheet, alongside a computerized medication administration record
- whiteboard to facilitate handovers

With respect to shift handover at the bedside, respondent comments suggested that handover at the bedside might be done under specific conditions, such as:

- when patients were intubated
- for patients in trauma and acute areas (not in the less acute areas of the emergency department)
- if high-alert drugs were present
- if 1-to-1 nursing was available

Some respondents also indicated that shift handover at the bedside would be preferred practice, but that it did not occur consistently. One indicated that his/her clinical unit was in the process of updating its shift handover process to encourage bedside handovers.

With respect to information transferred during shift handovers, some comments touched on additional information that was not explicitly listed in the question, including the following:

- mean arterial pressure goals, to help determine how to titrate inotropes
- type of IV fluid infusing
- infusion amounts given to date, projected completion time of infusions, and reconciliation of remaining IV bag balances with projections
- previous IV attempts (likely in reference to insertion of IV access devices)
- changes of IV medications

Final comments from respondents regarding shift handover addressed the following issues:

- concerns about compliance with existing shift handover practices
- the proximity of patient beds, preventing bedside handovers due to privacy issues
- the impracticality of bedside checks due to the volume of patients and/or nurse-to-patient ratio
- the upcoming implementation of new practices in 1 unit; a 15-minute protected handover period where no interruptions from staff or family are allowed

**Discussion**

The exploratory questions related to shift handover were intended to estimate how and in what dimensions practice varies across clinical units in Ontario, rather than to provide conclusive findings about how shift handover is currently taking place, or should be handled. The data indicated variability in several dimensions, such as where shift handover takes place and the tools used to facilitate handover. Comments were related to concerns about compliance with shift handover policies, and flexibility in the handover process depending on the complexity of the patient's IV treatment.

In light of the variability found in shift handover practices, additional guidance for clinical units may be helpful. However, the full scope of compliance with shift handover policies reaches far beyond the scope of IV therapy. It would be inappropriate to recommend or suggest practices regarding the ideal shift handover process without examining the requirements and context more thoroughly. Overemphasis on the information transfer required for IV infusions may impede or affect other critical aspects of the shift handover.

### *Summary of Findings and Future Work*

The survey revealed variability in both labelling and shift handover practices across Ontario, confirming the findings of the Phase 1b report. This likely mirrors the variability in the survey population, which ranged from specialized academic centres treating patients who require complex IV therapy to smaller non-academic hospitals with different resources and patient acuity. In addition, practice varies widely between clinical units: oncology units, ICUs, and emergency departments have different constraints, and therefore different labelling and shift handover practices.

Future work in the area of labelling and shift handover faces 2 major obstacles. First, the variability in the survey data suggests that different types of clinical units have different needs, and any attempts to create standardized approaches to labelling or shift handovers are likely to face the challenge of being standard enough to remain useful, but flexible enough to address the customization required for each care setting. The variability may be particularly challenging to address when it comes to equipment that has a high capital cost and is difficult to replace (e.g., IV infusion pumps). Issues around patient transfers are also likely to complicate attempts at creating standards, since improvements made in isolation may lead to new and unexpected issues when patients move between care areas. Second, health care staff may struggle to make the time to improve and investigate optimal IV tubing labelling practices, since there is a lack of clear data on how strongly they contribute to patient safety issues. This likely encourages health care staff to make other initiatives a priority (e.g., reducing infection rates or streamlining patient flow to relieve limited bed capacity).

Future work around the development of standards and guidelines for IV pump and tubing labelling, as well as shift handover, is suggested as a priority. Guidance should detail when, where, and with what materials labels should be applied to IV tubing, plain IV lines, and/or infusion pumps, and describe the minimum information requirements and conditions for shift handover, keeping the inherent variability of different clinical units in mind. Further data related to line identification will be discussed in Phase 2b, which will quantify error rates with and without various risk-mitigating strategies.

One key finding of the survey generally unaffected by unit variability is the need for clarity on IV tubing labels designed to indicate when IV tubing should be replaced. At a minimum, nurses should agree on whether the date on IV tubing refers to the date the tubing was initiated or the date it should be replaced.

Standardizing the use of "Date hung" or "Date initiated" is suggested, because it requires less mental effort for nurses to write the current date/time than to calculate when IV tubing should be changed, making it less prone to errors. Using the date of hanging/initiation has benefits for error detection as well. For example, IV tubing containing lipid-based infusions requires more frequent replacement than other IV fluids or medications. If a nurse takes over the care of a patient and notices that the IV tubing for a lipid infusion has the same date as other non–lipid-based infusions, he/she may suspect an error. Such errors are far easier to identify if the IV tubing is labelled with the date hung/initiated.

It is possible nurses may prefer labelling with the IV tubing replacement date in some circumstances. For example, some institutions label peripheral and central venous access devices with the date they should be removed, and they may prefer to continue to do so. In these cases, nurses may prefer to label with the date the IV tubing should be changed to minimize confusion. Nevertheless, in most cases, the study team

suggests that the date of initiation be used, with an explicit statement (e.g., "Date hung:") preceding the date written.

Since no further exploration of shift handovers will occur as part of this study, a brief summary of information the team found important has been listed here.

It was established in the Phase 1b observations that incoming nurses were not consistently made aware of key pieces of information necessary for stabilizing patients who rapidly deteriorate:

- Emergency medication lines and related components should be clearly identified (e.g., the IV container, IV tubing, IV infusion pump, IV connectors, and IV access site) so that the incoming nurse knows where emergency medications can be added if required.
- All actively infusing life-sustaining medications should be identified (e.g., the IV container, the IV tubing, IV infusion pump, IV connectors, and the IV access site).
- Any medications that should not be bolused due to line setup should be identified (e.g., an unusual combination of medications may be co-infusing, so that bolusing one inappropriately also boluses another).

By identifying the IV components and medications that affect the stability of the patient first, the incoming nurse would be better prepared to handle any unexpected changes in the patient's condition related to IV medication administration, particularly if the patient's condition changed before the incoming nurse had a chance to fully assess IV line setup. The third point above is also corroborated in the literature: Lovich et al (26) stated "Alteration of carrier rates or connection arrangements can cause unplanned changes in patient status. Clearly, responsible personnel must understand each patient's drug infusion method, architecture, and the potential consequences of every change." In other words, an explanation of how multiple IV infusions have been connected is an essential component of the shift handover.

The incoming nurse may also benefit from an explanation of the condition of the patient's IV access sites (e.g., patency, upcoming scheduled changes, irritation, previous attempts). The results of the survey indicated that this was not done consistently in all institutions. The need to change ongoing IV infusions from 1 access site to another may require considerable preparation and affect the stability of the patient during changeover. Furthermore, unanticipated deterioration of the patency or stability of any catheter should be identified immediately, as it can result in a stoppage of critical medications or increased risk of infection. Knowledge of previous IV insertion attempts is useful to prevent unnecessary or unsafe selection of alternate insertion sites, particularly when one is being sought under time constraints.

Finally, to the extent possible, incoming nurses should consistently reconcile documented medication orders with the departing nurse to ensure that they are up to date and reflect any conversations with medication prescribers. Efforts should also be made to reconcile verified medication orders with what is currently infusing into the patient. Observations in Phase 1b showed that it is often during shift handovers that discrepancies are noticed, and survey results suggested that not all respondents were currently complying with the practice of discussing medication orders during handover.

Nurses should still be expected to verify the programming of all IV infusions and trace all IV lines as part of their initial patient assessment. However, inclusion of the above considerations into the handover process may help incoming nurses be aware of the reasoning and history behind IV tubing setups.

Further discussion about IV line identification (e.g., tubing and pump labelling) will be presented in the Phase 2b report, and these findings may play a role in facilitating the transfer of information between nurses.

## Theme 3: IV Line Setup and Removal

### *Background*

Line setup and removal refers to the processes of arranging all components of the IV system during infusion initiation, and removing infusions when required. The manipulation of connectors, vascular access devices, IV containers, labels, and other IV-related components is common in cases where multiple infusions are active. The survey addressed 2 topics related to line setup and removal: patient transfers and the types of IV connectors available on the unit.

Observations in Phase 1b showed that patient transfers may require an interruption in the patient's IV therapy to facilitate movement from 1 care area to another. If the receiving care area has IV practices or equipment that is different from the sending care area (e.g., drug concentrations, infusion pumps, or IV tubing), existing infusions must be removed and replaced with a new set of infusions, which may be identical in terms of drugs and dose. This has several disadvantages:

- The patient's IV therapy is interrupted, which may present unnecessary risk if the patient is highly dependent on the drugs being infused and/or the stability of medication levels.
- The duplication of work results in unnecessary waste of supplies.
- There may be an increased risk of infection owing to the use of new IV components.
- There may be an increased risk of setup errors, since multiple infusions are being set up all at once.

One of the Phase 1b recommendations addressed the last bullet point above, suggesting that each infusion be set up completely before the next one is begun, to minimize confusion between IV components during setup. This is known as a "one-at-a-time" setup. The survey was designed to provide greater insight into the potential prevalence of multiple infusion setups during patient transfers, and the potential prevalence of the issues discussed in Phase 1b: specifically, the risk of the IV bag and its infusion pump being mismatched, and the risk of leaks occurring with the use of 3-way stopcocks.

With respect to 3-way stopcocks, Phase 1b also recommended the use of multiport or multi-lead connectors to join multiple IV infusions into a single line, as required. This reduces the risk of leaks because a single rigid connector is more secure than a chain of 3-way stopcocks, which have multiple joints and more potential for leaks or disconnections. This recommendation is important because leaks put the patient's vasculature at a higher risk of infection and may also interrupt or reduce the continuous infusion of critical medications, potentially causing patient harm.

### *Sub-Themes and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **Patient Transfers**
  - Practice prevalence: Identify the potential prevalence of patient transfers that require new IV infusion pump or IV tubing setups to continue existing IV infusions.
  - Exploratory: Identify the potential prevalence of specific factors that may increase the probability that new IV infusion pumps or IV tubing will be required to complete a patient transfer.
- **Availability and Usage of IV Connectors**
  - Compliance: Identify the potential prevalence of chaining multiple stopcocks together to join IV infusions.
  - Exploratory: Identify the potential prevalence of stopcock availability and other components.

### *Patient Transfers*

**Summary of Results**

Table 17 summarizes respondent answers to the question about patient transfers.

**Table 17: Patient Transfers—Practice Prevalence Question[a]**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[b] | |
| **When patients are transferred to your unit, does the transfer process ever require you to change the patient's IV tubing and/or move an infusion to a new infusion pump?** | **n = 55** | | **$\chi^2$ = 42.382** ***P*** **< 0.001** |
| Yes | 32 | 58 | Pairwise comparisons showed that "Yes" was significantly more likely to be selected than all other answer categories<br>"No" was significantly more likely to be selected than both "Not Sure" and "My unit does not receive transfers" |
| No | 17 | 31 | |
| Not sure | 1 | 2 | |
| My unit does not receive transfers (e.g., outpatient unit) | 5 | 9 | |

Abbreviation: IV, intravenous.

[a]One answer category, "Other (please specify)" was omitted from this table because it was an optional free-text field where respondents could provide further details. An answer in this category alone would not be accepted as a response (a selection in 1 of the other answer categories was required). Only the answer categories shown in the table were considered in the statistical analysis.

[b]Percentages may appear inexact due to rounding.

There was insufficient power to evaluate differences across hospital types or clinical units with the initial answer categories. Statistical tests were performed again, excluding "Not sure" and "My unit does not receive transfers," but power was still insufficient for a valid test.

When attempting a Pearson Chi-square test for association to assess differences in answers as a function of hospital type, the statistic approached significance ($\chi^2 = 4.990$; $P = 0.08$); only 1 cell had an expected count of less than 5, at 4.9 (5 is considered a minimum for the test to be considered valid). A post hoc pairwise test showed that non-academic hospitals with fewer than 100 beds were significantly less likely to require pump and/or tubing changes during patient transfers than larger hospitals (i.e., non-academic hospitals with 100 beds or more and academic hospitals; $\chi^2 = 4.360$; $P = 0.04$). The post hoc test also had 1 cell with an expected count of 4.9. For a detailed breakdown of respondent answers, please see Table A22.

Comments from respondents indicated that pump and/or tubing changes were usually restricted to certain contexts (e.g., only patients received from external hospitals or facilities, incompatible tubing). Therefore, in some institutions this issue may exist but occur infrequently.

Table 18 summarizes respondent answers to the exploratory question for this sub-theme.

**Table 18: Patient Transfers—Exploratory Question[a]**

| Survey Question | Respondents | |
|---|---|---|
| | n | %[b] |
| **Why are IV tubing or pump changes required on patient arrival to your unit? Please select all that apply[c]** | **n = 33** | |
| Pump must return to home unit for inventory control purposes | 16 | 48 |
| Drug library is specific to each care area, so must use new pump | 8 | 24 |
| Easier to move to new pump than reselect drug library | 6 | 18 |
| Pump make and model differs between units | 6 | 18 |
| Concentrations differ between units | 6 | 18 |
| Tubing or connectors are incompatible | 11 | 33 |
| Easier to manage a new IV setup than use existing setup | 1 | 3 |
| Other[d] | 7 | 21 |

Abbreviation: IV, intravenous.
[a]Only respondents who answered "Yes" or "Not sure" to the practice prevalence question were shown this question.
[b]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.
[c]Answer text has been shortened from the original for formatting reasons. Please see Appendix 1, Question 46, for the original text.
[d]This was a selectable option that also provided a free-text field for respondents to provide details.

Comments from respondents about IV tubing or pump changes tended to restate that this practice was more common with patient transfers from emergency medical services or other hospitals. Some respondents also elaborated on their situation and confirmed their selection of a predefined category (e.g., indicating that the ICU used a different pump or drug library from the receiving unit, or that anesthesiologists failed to label properly when patients were transferred from the operating room). One respondent suggested that a pre-alert or notification about a patient's medications would be helpful, because those medications could be prepared in advance and minimize setup time during transfer. For a detailed breakdown of respondent answers, please see Table A23.

**Discussion**

The data indicated that over half of respondents encountered the issue of IV pump and/or tubing changes during patient transfers. Prominent reasons for this additional work included inventory control policies, tubing compatibility issues (often when patients are transferred between facilities or from paramedic services), and drug library programming issues with the infusion pump. However, the range of reasons represented in Table 18 shows that this issue is triggered via a number of pathways.

A post hoc test showed that non-academic hospitals with fewer than 100 beds were less likely to experience IV pump and/or tubing changes during patient transfers. However, the test was of questionable validity due to the small sample size. It is possible that patient transfers are more common at larger institutions, which may have more specialized clinical units or greater numbers of patients to be transferred due to greater patient throughput.

Given the risks discussed in the background section above and the potential for unnecessary interruptions in patients' IV therapy, patient transfer policies that minimize the need to switch IV pumps and/or IV tubing should be devised. The actions required to achieve this will be unique to the clinical units that frequently transfer patients.

### *Availability and Usage of IV Connectors*

**Summary of Results**

Table 19 summarizes respondent answers to the question about the availability and usage of IV connectors.

**Table 19: Availability and Usage of IV Connectors—Compliance Question**

| Survey Question | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Are 3-way stopcocks commonly joined together to make a chain of stopcocks for the purposes of connecting multiple infusions to 1 IV access site?** | **n = 62** | | **$\chi^2 = 83.419$, $P < 0.001$** |
| Yes | 4 | 6 | Pairwise comparisons showed only that "No" was significantly more likely to be selected than all other answer categories[b] |
| No | 46 | 74 | |
| 3-way stopcocks not used on the unit | 11 | 18 | |
| Not sure | 1 | 2 | |

Abbreviation: IV, intravenous.

[a]Percentages may appear inexact due to rounding.

[b]No pairwise test was conducted between "Yes" and "Not sure" due to insufficient sample size. However, it is expected that there is no significant difference between the 2, given the lack of significance between "3-way stopcocks not used on the unit" and "Not sure."

There was insufficient power to evaluate differences across hospital types or clinical units. Sample sizes continued to be insufficient when the tests were repeated with only the answer categories "Yes" and "No." For a detailed breakdown of respondent answers, please see Table A24.

Table 20 summarizes respondent answers to the exploratory question for this sub-theme.

**Table 20: Availability and Usage of IV Connectors—Exploratory Question[a,b]**

| Survey Question | Respondents | |
|---|---|---|
| | n | %[c] |
| **Which of the following connectors are used to connect continuous IV infusions together? Please select all that apply** | **n = 64** | |
| Multi-lead connectors (e.g., Y-style connector that can join 2 or more different infusions into 1 IV tube) | 38 | 59 |
| A rigid 1-piece multiport connector (e.g., bridge, manifolds) | 10 | 16 |
| 3-way stopcocks | 19 | 30 |
| The injection port on existing primary infusion tubing connected to patient | 49 | 77 |

Abbreviation: IV, intravenous.

[a]One answer category, "Other (please specify)" was omitted from this table because it was an optional free-text field where respondents could provide further details about how the connectors available in the unit were used.

[b]Since some respondents could have chosen none of the answer categories, it is unclear how many respondents saw the question but did not select any of the options. For simplicity, a full complement of 64 respondents is assumed.

[c]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

For a detailed breakdown of respondent answers, please see Table A25.

Only 3 comments were recorded from respondents. Two noted that stopcocks were restricted to use on umbilical venous catheters or umbilical arterial catheters. The third respondent described how 2-container total parenteral nutrition was administered (lipids were connected to the patient using the injection port closest to the patient on the amino acids tubing).

**Discussion**

The survey findings suggested that most clinical units do not chain stopcocks together to join multiple IV infusions into a single IV access site, representing a generally strong understanding of the existing Phase 1b recommendation. However, some clinical units (all ICUs in either academic hospitals or non-academic hospitals with 100 beds or more) do use this practice (Table A24).

Responses to the exploratory question indicated that most clinical units use multi-lead connectors or the injection port on existing primary infusion tubing, so alternatives to stopcocks are available. Stopcocks are likely to be present for some clinical tasks (e.g., venous or arterial pressure monitoring), but the use of multi-lead connectors or rigid 1-piece multiport connectors to facilitate the joining of multiple IV infusions seems to be a feasible alternative to stopcocks for the majority of units.

### *Summary of Findings and Future Work*

Based on the data collected, the use of 3-way stopcocks to join multiple IV infusions together appears to have low prevalence in Ontario. The availability of IV connectors other than 3-way stopcocks is common, suggesting that units that do chain 3-way stopcocks can transition to a different type of IV connector.

A more challenging issue surrounds patient transfers. About 58% of respondents (from a total of 55) indicated that patients may have their IV infusions interrupted during transfers from 1 care area to another due to the need to change IV tubing and/or IV infusion pumps. The reasons included pump inventory policies and incompatible IV tubing/connectors. This practice was previously discussed in Phase 1b as contributing to the risks of setup errors, because the setup of several IV infusions at once presents higher risks of mix-ups and confusion, particularly in time-sensitive conditions (a characteristic of some patient transfers).

Future work is required to understand how best to handle IV infusion during patient transfers. The survey data suggest that the most common barriers to a seamless transfer of infusion pumps and tubing with the patient to a new care area include pump inventory policies; incompatible IV tubing and connectors; and infusion pumps configured with a drug library specific to the care area they are used in, preventing their transfer to other units. There may be good reasons for each of these barriers, so each clinical unit will have to consider the benefits and drawbacks of altering practices related to patient transfers. Consideration should also be given to implementing standard practices that require the sending unit to alert the receiving unit about a patient's medications to facilitate advance setup. However, this may not always be possible or preferred, depending on the implementation of IV medication/tubing/pump labelling, medication ordering practices, or uncertainty about what patients require until they have been seen by the receiving unit.

## Theme 4: Dead Volume Management

### *Background*

The understanding of dead volume in application is highly dependent on the specific arrangement of IV tubing in any given situation, so survey questions were designed to ask about a common practice that might involve dead volume in a way that does not vary between clinical units. In addition, the survey questionnaire did not define or describe dead volume to avoid introducing bias in respondents' answers. Dead volume management was unique in this sense; survey questions had to be asked covertly (e.g., in contrast, questions about labelling revealed the intent of the question).

The survey asked about policies regarding central venous pressure (CVP) monitoring as an indirect measure of dead volume awareness. Critical care areas typically attach a pressure line with a transducer to a central access port to allow for a CVP waveform and a numerical CVP value to be displayed on a monitor. The CVP line is flushed when it is initially set up (prior to being connected to the central access port), to remove air from the IV tubing and calibrate the physiological monitor for atmospheric pressure. Flushes on the CVP line are performed very easily, because the intraflo valve on the pressure transducer, which restricts the flow of fluid from this pressurized bag, can be "opened" with a simple pull of a "pigtail" or "nipple" valve. Pulling on this valve opens the transducer and administers the contents of the line at a speed driven by the pressurized IV bag. Once set up, this transduced line may be periodically flushed at high speeds to maintain a proper CVP waveform and measurement (the waveform may dampen over time for a variety of reasons). Dead volume concerns can arise when other medications are coadministered on the CVP line, and would be "flushed" (i.e., bolused) as well: when the contents of the dead volume in the CVP line are flushed at high speed, small dose(s) of coadministering medications already in the line may be given at an inappropriately high flow rate.

Given the practice of periodic flushing, the use of a central access port for both transducing and medication administration will lead to periodic boluses of medications. These boluses are small, but may be clinically relevant if, for example, a continuous medication that is highly potent and has a short half-life (e.g., inotropic medications) is being bolused. It is also important to note that flushing not only boluses the medication, but replaces the dead volume with the flush fluid. Therefore, there may also be a subsequent delay in medication delivery after the flush, because the coadministered medication must push through the residual flush fluid. Medications may have a slow flow rate, further increasing the delay until the infusion reaches the patient's bloodstream.

Interruptions in the continuity of coadministered medications may also occur when the transduced line is "zeroed" (i.e., calibrated), or when CVP measurements are taken. The calibration of transduced lines is routinely performed to ensure accurate measurements; during recalibration, any medication infusing through the CVP port will be stopped. Regardless of the underlying reason for stopping a continuous infusion, there may be cause for concern; even a short interruption of an infusion can have a clinical impact.

In summary, respondents who indicated that medications were administered via a CVP line on their unit(s) were also indirectly stating that there was a higher risk of unintentional boluses of medications, and of possible interruptions in the delivery of those medications. These factors may affect the patient directly (e.g., if the medication in the line is a short-acting continuous IV medication) or indirectly (e.g., affecting clinical decision making if blood work shows circulating medication levels are too high or low due to unintended boluses or interruptions).

### *Sub-Theme and Objectives*

The addressed the following objectives, organized by sub-theme:

- **Central Venous Pressure Monitoring**
  - Exploratory: Identify the potential prevalence of CVP monitoring.
  - Practice prevalence: Identify the potential prevalence of CVP lines being used to administer continuous medication infusions.
  - Practice prevalence: Identify the potential prevalence of CVP lines being used to administer intermittent medication infusions.

### *Central Venous Pressure Monitoring*

**Summary of Results**

Table 21 summarizes respondent answers to the exploratory question about CVP monitoring.

**Table 21: CVP Monitoring—Exploratory Question**

| Survey Question | Respondents | |
|---|---|---|
| | n | %[a] |
| **Does your unit use central venous pressure monitoring?** | **n = 63** | |
| Yes | 17 | 27 |
| No | 46 | 73 |

Abbreviation: CVP, central venous pressure.
[a]Percentages may appear inexact due to rounding.

For a detailed breakdown of respondent answers, please see Table A26.

Table 22 summarizes respondent answers to practice prevalence questions for this sub-theme.

**Table 22: CVP Monitoring—Practice Prevalence Questions[a]**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | %[b] | |
| **If a transduced CVP monitoring line is in use, is it permissible for *continuous* IV medications to be infused through the CVP line?** | **n = 17** | | **$\chi^2$ = 4.353 Not significant (*P* = 0.11)** |
| Yes | 9 | 53 | No pairwise comparisons were performed |
| No | 6 | 35 | |
| Not sure | 2 | 12 | |
| **If a transduced CVP monitoring line is in use, is it permissible for *intermittent* IV medications to be infused through the CVP line?** | **n = 17** | | **$\chi^2$ = 14.588 *P* = 0.001** |
| Yes | 13 | 76 | The answer category "Yes" was significantly more likely to be selected than both "No" and "Not sure"[c] |
| No | 1 | 6 | |
| Not sure | 3 | 18 | |

Abbreviation: CVP, central venous pressure; IV, intravenous.
[a]Only respondents who responded "Yes" to the exploratory CVP monitoring question were shown these questions.
[b]Percentages may appear inexact due to rounding.
[c]No pairwise test was conducted between "No" and "Not sure," because the Chi-square required a minimum expected count of 5 for each cell. In this case, the expected count for each cell was 2.

There was insufficient power to evaluate differences across hospital types or clinical units for either question. For a detailed breakdown of respondent answers, please see Tables A27 and A28 (Appendix 2).

Comments about the use of continuous infusions via CVP lines discussed the specific conditions under which the practice would occur. Some indicated concern about measurement accuracy, but only 1 discussed the risks associated with a bolus.

Five respondents commented on the use of continuous infusions on a CVP line and noted the following:

- There was concern about the accuracy of CVP readings when continuous infusions are running, but they thought this was acceptable if there was a need for IV access.
- Vasoactive drugs should not run with drugs that should not be bolused (although this comment could easily apply to any IV line).
- This practice was restricted to IV infusions that could be stopped temporarily for CVP readings.

Eight respondents commented on the use of intermittent infusions on a CVP line and noted the following:

- Potassium might be infused intermittently by using a stopcock with the CVP.
- Intermittent antibiotics and electrolyte replacement were also intermittent infusions that might be used in this way.
- CVP lines were described as being part of a triple port, so there were no concerns relating to this practice (it is unclear how this was relevant unless the CVP line always had its own dedicated line to the patient via a triple-lumen catheter).
- This was rarely done, although possible if there is a lack of IV access.
- There was concern about CVP measurement accuracy, and that too many ports or stopcocks may affect CVP readings.

Comments about CVP in general, provided at the end of this series of questions, repeated sentiments already expressed above.

**Discussion**

As expected, the primary users of CVP monitoring were ICUs (please see Table A26). Roughly half of respondents indicated that they were administering continuous infusions on a transduced CVP line. It is possible that in practice, this only occurs with IV medications that are unlikely to clinically impact the patient; in some cases, respondents may have misinterpreted IV maintenance or replacement fluids containing electrolytes as high-alert medications. For example, in questions about high-alert medications (please see Theme 1), several respondents indicated that they considered a potassium chloride solution such as sodium chloride 0.9% with 20 mmol/L of potassium chloride to be a high-alert medication. However, the ISMP (United States) lists the potassium chloride for injection concentrate as a high-alert medication. Further, Accreditation Canada Medication Management Standards for 2014 (27) identifies potassium salts with a concentration $\geq$ 2 mmol/mL as a concentrated electrolyte. On the other hand, respondents did not identify specifically in response to this survey question what types of continuous infusions would be coadministered on the CVP on their unit. Therefore, some units could very well be unaware of the issues and be coadministering continuous infusions of medications inappropriately with a transduced CVP line.

Clinical units were more likely to coadminister an intermittent medication than a continuous medication with a transduced CVP line. Intermittent medications tend to infuse fairly quickly, and by nature are intermittent because they are longer-acting. Brief interruptions in their delivery are unlikely to be clinically relevant compared to those that require continuous and ongoing administration.

Some respondents were aware of the potential for measurement accuracy issues if and when CVP could be obtained simultaneously while administering a medication, and they indicated a preference to avoid such practices unless there were limitations in IV access site availability. A few respondents suggested that they dedicate 1 lumen on central catheters for transducing CVP (i.e., no IVs coadministered), eliminating both measurement and dead volume issues. One respondent pointed out the dangers of infusing vasoactive drugs this way.

### *Summary of Findings and Future Work*

The survey revealed that 53% of respondents (from a total of 17) administered continuous IV infusions via a port that was also used to measure central venous pressure, and 76% of respondents (from a total of 17) indicated that intermittent IV infusions were also administered in this same way. While this practice was common, many respondents indicated it was not preferred and expressed caution about administering continuous IV medications this way. This is a positive sign, suggesting that at least with respect to CVP lines, dead volume concerns are minimal. More respondents identified concerns about CVP measurement accuracy rather than issues of variable dose delivery due to dead volume, but in practice, attention to measurement accuracy automatically minimizes the risks presented by the dead volume; the survey questions were limited in that they were not able to separate these 2 issues. Results could have been confounded by the fact that respondents considered some continuous IV fluid replacement or maintenance infusions to be medications (e.g., those containing a lower concentration of electrolytes), artificially increasing the number of responses suggesting that continuous IV medications are coadministered through a transduced line; the impact of dead volume may not play as significant a role in such circumstances, so dead volume may affect a smaller proportion of respondents than the data appear to show.

Future surveys may benefit from questions about dead volume in other clinical situations to determine the following:

- whether, aside from medication compatibility, practitioners aim to separate medications of different classes to be administered via different IV access sites (e.g., vasopressors and inotropes administered separately from sedatives and opioids, so that titrations of one do not affect medications of another type)
- if flushes are administered after IV syringe injections ("IV pushes"), and if so, how quickly the flush is administered. If a flush is also administered by syringe, the flow rate of the flush injection should be determined, and whether it is affected by the flush size (e.g., flush syringes larger than IV push syringes may result in inadvertently fast flushes if they are pushed at the same speed). This set of questions may address whether the injected drug is cleared from the dead volume with a flush at the appropriate speed (i.e., at or less than the maximum rate identified for the medication)
- what practices, policies, protocols, or guidelines exist regarding the priming of multi-lead or multiport connectors and tubing during routine IV tubing changes to minimize clinical impact
- whether practices, policies, protocols, or guidelines include mandatory tubing changes when IV continuous medication concentrations are altered

Responses to these questions may assist in revealing respondents' awareness of dead volume and are less likely to be confounded by other concerns, such as CVP measurement accuracy.

Phase 2b findings include quantitative data on error rates related to dead volume. This information will help characterize the potential frequency and severity of some of the dead volume errors that may be occurring.

## Theme 5: IV Bolus Administration

### *Background*

The survey defined a *bolus* as a situation in which an additional dose of a primary continuous infusion was administered (e.g., patient receiving a continuous morphine infusion requires an additional dose for pain management support prior to an invasive procedure). The definition excluded intermittent infusions, loading doses, as-needed doses injected all at once (without a continuous infusion of the same medication running), and IV PCA doses.

Phase 1b identified 1 issue related to IV bolus administration—specifically the risk of nurses increasing the flow rate of a continuously infusion medication and not returning it to the proper flow rate at the appropriate time. Two recommendations were made: (14)

> *Hospitals should develop a policy to limit the practice of manually increasing the infusion rate to administer a medication bolus of a primary continuous infusion. If a separate medication bolus cannot be prepared, and the bolus is administered using the primary continuous infusion pump/pump channel, then the nurse should program the bolus dose parameters (i.e., total amount of medication to be given over a defined duration) into the pump without changing any of the primary infusion parameters. Some examples of how to specify the bolus dose parameters include the following:*
>
> – programming a bolus using a dedicated bolus feature in the pump (preferred, if available)
> – programming a bolus using the pump's secondary feature but without connecting a secondary IV bag (pump will draw the bolus from the primary IV bag)
>
> *Hospitals should ensure that their smart pump drug libraries include hard upper limits for as many high-alert medications as are appropriate for each clinical area, in order to prevent the administration of a bolus by manually increasing the primary flow rate.*

The objective of these recommendations was to minimize the risk of an overdose and/or delay of the continuously infusing medication, which is a possibility whenever the pump parameters of the primary infusion are manipulated. The use of an alternate programming mode (e.g., bolus feature, secondary infusion feature) does not affect the primary parameters, and when the bolus or secondary program is completed, the primary infusion resumes at the correct flow rate and volume to be infused.

### *Sub-Theme and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **IV Bolus Administration**
  - Practice prevalence: Identify the potential prevalence of IV bolus administration in Ontario.
  - Practice prevalence: Identify the potential prevalence of units that have a pump equipped with a built-in bolus feature.
  - Practice prevalence: Identify the potential prevalence of pumps that have not had their bolus functionality enabled.
  - Practice prevalence: Identify the potential prevalence of IV bolus administration techniques in use.

## *IV Bolus Administration*

### Summary of Results

Table 23 summarizes respondent answers to questions about IV bolus administration.

**Table 23: IV Bolus Administration—Practice Prevalence Questions**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | %[a] | |
| **Are IV boluses of continuous primary infusions ever administered on your unit?** | **n = 55** | | **$\chi^2$ = 13.255 *P* < 0.001** |
| Yes | 41 | 75 | No pairwise test needed for binary answers |
| No | 14 | 25 | |
| **Do any of your IV infusion pumps have a built-in bolus feature?[b]** | **n = 41** | | **$\chi^2$ = 16.732 *P* < 0.001** |
| Yes | 23 | 56 | Pairwise tests showed that the answer category "Not sure" was significantly less likely to be selected than "No" and "Yes." No significant difference was found between "Yes" and "No" |
| No | 16 | 39 | |
| Not sure | 2 | 5 | |
| **Is the pump's bolus feature enabled for all drugs where administering a bolus is clinically appropriate and useful for your unit?[c]** | **n = 28** | | **$\chi^2$ = 16.857 *P* = 0.001** |
| No bolus feature available on this pump | 2 | 7 | Pairwise comparisons showed that each of the "Yes" categories was statistically more likely to be selected than all other answer categories.[d] The "Yes" categories were not statistically different from each other |
| Yes, enabled for ALL primary infusions | 9 | 32 | |
| Yes, only for clinically appropriate and useful drugs | 15 | 54 | |
| No, not enabled for some drugs | 0 | 0 | |
| Not sure | 2 | 7 | |
| **Which of the following methods are used to deliver a bolus of medication already running as a primary continuous infusion? Please select all that apply[e,f]** | **n = 23** | | **Cochran Q[g] = 48.509 *P* < 0.001** |
| Manual syringe injection of the bolus dose into a downstream medication port | 11 | 48 | Pairwise comparisons showed that:<br>• Use of the pump's bolus feature was more likely than all other bolus administration methods<br>• "Other methods" of bolus administration and manually holding the pump's prime/purge key were less likely to be used than all other bolus methods[d] |
| Administration of the bolus as an intermittent secondary (piggyback) infusion | 9 | 39 | |
| Program the bolus dose as a secondary infusion without hanging a secondary IV bag so that the bolus dose is drawn directly from the primary continuous IV bag | 7 | 30 | |
| Programming a bolus dose using the pump's dedicated bolus feature | 19 | 83 | There were no other significant pairwise differences |
| Manually hold the pump's prime/purge key | 0 | 0 | |
| Manually increase the flow rate on the primary continuous infusion for the duration of the bolus | 8 | 35 | |
| Other methods (please specify)[h] | 1 | 4 | |

Abbreviation: IV, intravenous.

[a]Percentages may appear inexact due to rounding.

[b]Only respondents who answered "Yes" to practice prevalence question 1 were shown this question.

[c]Only respondents who answered "Yes" to practice prevalence question 2 were shown this question. In addition, respondents were able to answer this question several times for multiple pumps. Since some respondents used more than 1 infusion pump to administer boluses, there were more responses than respondents. There were 23 respondents to this question (i.e., 5 respondents had a second pump).

[d]Statistical pairwise tests cannot be performed when 1 of the answer categories is 0, but because of the similarity of that category to other categories with a low number of respondents, it was treated equivalently.

[e]This question was originally intended to be shown to any respondent who answered "Yes" to practice prevalence question 1. However, due to a survey design error, it was shown only to respondents who answered "Yes" to practice prevalence question 2 (a smaller sample), likely skewing the results.

[f]Respondents could select more than 1 answer, so percentages do not total 100.

[g]A Cochran Q test was performed in this case because a single respondent could select more than 1 answer category.

[h]This was a selectable option that also provided a free-text field for respondents to provide details.

There was insufficient power to evaluate differences across hospital types or clinical units for the first 3 questions above. The statistical test for the question "Do any of your IV infusion pumps have a built-in bolus feature?" was repeated after excluding respondents who answered "Not sure," but the test continued to have insufficient power. For a detailed breakdown of respondent answers, please see Tables A29 to A31 (Appendix 2).

No logical grouping of answer categories for the question "Is the pump's bolus feature enabled for all drugs where administering a bolus is clinically appropriate and useful for your unit?" generated sufficient power to evaluate differences across hospital types or clinical units. Two tests were attempted with other configurations:

- removing all answer categories other than "Yes, enabled for ALL primary infusions" and "Yes, enabled only for clinically appropriate and useful drugs"
- grouping the "Yes" categories together, and the "No" and "Not sure" categories together

However, neither configuration generated sufficient power for a valid test.

No tests evaluating differences across hospital type or clinical unit were performed for the question "Which of the following methods are used to deliver a bolus of medication already running as a primary continuous infusion?" as no appropriate statistical test was identified, and the sample size was deemed likely to be insufficient for a test. For a detailed breakdown of respondent answers, please see Table A32.

The single respondent who chose "Other methods" described the use of a manual syringe injection, but of a preprepared diluted form of epinephrine for unstable patients. The respondent made a specific point of explaining the genesis of this practice, describing the time-consuming nature of the pump's bolus feature, particularly during rapid drops in the patient's blood pressure. To counter this issue, the hemodynamic stability of patients was assessed, and if necessary, orders for highly diluted epinephrine syringes were fulfilled by pharmacy and made available to the patient's nurse.

The study team also decided to compare the make and model of respondents' IV infusion pumps against answers to the question "Do any of your IV infusion pumps have a built-in bolus feature?" to test whether respondents using the same pump would answer the same way. Table 24 summarizes the results.

**Table 24: Response to IV Bolus Administration Question[a] by Hospital and Pump Type[b,c,d]**

| Hospital Type and Pump Type | No | Not Sure | Yes | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **4 (36%)** | **—** | **7 (64%)** | **11** |
| CareFusion Alaris Infusion Pump Modules | — | — | 4 | 4 |
| B Braun Outlook 100 | — | — | 1 | 1 |
| Hospira Plum XL or Plum A+ | 4 | — | 1 | 5 |
| (blank) | — | — | 1 | 1 |
| **Non-academic Hospitals With ≥ 100 Beds** | **4 (24%)** | **3 (18%)** | **10 (59%)** | **17** |
| Baxter Colleague | 1 | 3 | 3 | 7 |
| ESP syringe pump (Excelsior Medical Corp) | — | — | 1 | 1 |
| Hospira (unnamed pump) | — | — | 1 | 1 |
| Hospira Abbott Plum A+ | 3 | — | 3 | 6 |
| Sigma | — | — | 1 | 1 |
| Smiths Medfusion 3500 | — | — | 1 | 1 |
| **Academic Hospitals** | **12 (50%)** | **1 (4%)** | **11 (46%)** | **24** |
| Alaris (unnamed pump) | 3 | — | 1 | 4 |
| CareFusion Alaris infusion pump modules | 2 | 1 | 5 | 8 |
| Alaris Medley | 1 | — | — | 1 |
| Alere pump | 1 | — | — | 1 |
| Smiths Medical Graseby pump | 4 | — | — | 4 |
| Hospira (unnamed pump) | — | — | 2 | 2 |
| Hospira Symbiq large-volume pump | — | — | 1 | 1 |
| MedFusion syringe pump | 1 | — | 1 | 2 |
| Smiths Medical syringe pump | — | — | 1 | 1 |
| **Total** | **20 (38%)** | **4 (8%)** | **28 (54%)** | **52** |

Abbreviation: IV, intravenous.

[a]Do any of your IV infusion pumps have a built-in bolus feature?

[b]Respondents indicated the type of pump they used in a free-text field. As a result, different responses may have referred to the same type of infusion pump. The pump types shown in this table comprise groupings of respondents who appeared to use the same pump. In some cases, the name of the pump manufacturer was listed, but the pump model was ambiguous; these cases were labelled "unnamed pump." To see respondents' exact answers, please see Table A33.

[c]Some respondents indicated they had more than 1 IV infusion pump on their unit; this table includes all pumps in each unit.

[d]Percentages may appear inexact due to rounding.

General comments from respondents suggested that some were aware of the risks associated with manually increasing the flow rate of a primary infusion because of a previous incident, lack of compliance by nurses, or by simply citing the vigilance required when attempting this practice. Other respondents simply described the specifics of how some nurses administer boluses on their unit, which all fell within the categories outlined in the final question of Table 23.

**Discussion**

The majority of clinical units administered boluses as defined by the survey. Roughly half of respondents claimed that their infusion pump was equipped with a built-in bolus feature, and the majority of respondents who had the feature available enabled it for clinically appropriate and useful drugs, or for all drugs.

No respondents indicated that their infusion pump's bolus feature was not enabled, a positive indication that nurses have the option to use it if it is available. However, to verify this response, the make and model of the infusion pump was compared with respondents' answers to the question "Do any of your IV infusion pumps have a built-in bolus feature?" The results (Table 24) showed that respondents using the same make and model of infusion pump chose different answers. This inconsistency may have been understandable if the same pump was used with different software versions (and therefore different bolus functionality), but it was not possible to determine this from the survey data. In some cases, the pump make and model were unclear. Besides these limitations, the data suggest that there may have been a gap in respondents' understanding of what their infusion pumps could do. For a detailed breakdown of respondent answers, please see Table A33.

Examples of discrepancies:

- The Hospira Plum XL and Plum A+ infusion pumps do not have a bolus feature, but at least 4 respondents specified that such a feature existed. Based on observations from Phase 1b, it is possible these respondents may have been referring to other methods of administering boluses, such as backpriming the primary IV solution through the pump cassette's "secondary" port into a syringe and then programming a secondary infusion that, in effect, simulates a bolus.
- The Baxter Colleague Guardian pumps do not have a bolus feature, but 3 respondents indicated that they did.
- The Alaris infusion pumps (both the standalone Medley product and the newer modular system) do have a built-in bolus mode, but 5 respondents, all from academic hospitals, indicated that the pump did not have a built-in bolus feature.

In the last example above, respondents may have simply been responding as if the Alaris pumps at their hospital did not enable the bolus mode, rather than being unaware that the pumps had a bolus feature. However, survey questions were not structured to determine this.

Results from the question "Which of the following methods are used to deliver a bolus of medication already running as a primary continuous infusion?" were of considerable interest, because they suggested that respondents were just as likely to manually titrate the primary infusion flow rate as they were to use safer bolus administration methods (e.g., programming secondary infusions with or without a secondary bag, or manual syringe injections). Given that these safer alternative methods appeared to be feasible to many respondents and that manual titrations of the primary infusion flow rate are known to be risky as suggested in Phase 1b, the survey data suggested that there were opportunities for improvement.

However, it is important to note that an error in the design of the survey caused the above question to be shown only to respondents who stated that their pump had a built-in bolus feature. Those respondents were taken to a page asking about the configuration of their pump's built-in bolus feature *as well as* the methods used to administer boluses (these 2 questions should have been on separate pages). Therefore, the data regarding bolus administration methods in Table 23 are limited to a subpopulation of respondents who indicated the presence of a built-in bolus feature. It is possible that different conclusions might have been drawn had the other respondents been able to contribute answers to this question. Nevertheless, the current results still provide compelling evidence that further work needs to be done to reduce the use of an unsafe practice, given the availability and frequent use of safer alternatives.

### *Summary of Findings and Future Work*

The survey data indicated that IV bolus administration of continuously infusing IV medications is a common practice in Ontario. Only about half of respondents used an IV infusion pump with a built-in bolus feature; in the majority of cases, that feature had been enabled for appropriate drugs. This is 1 of the options recommended by the Phase 1b report.

Unfortunately, 35% of respondents using a bolus-enabled IV infusion pump (from a total of 23) indicated that staff on their unit may manually titrate the primary infusion flow rate to administer a bolus. This practice was found to be dangerous in Phase 1b because the flow rate may not be reset to its intended and prescribed rate after the bolus, leading to a potential overdose of medication. These data were limited in the sense that only respondents with a built-in bolus feature on their infusion pumps answered the question. If the question had been shown to all respondents, this undesirable practice may have been found to be more common. Nevertheless, the conclusions drawn from this limited sample indicated an unnecessary risk. There may be exceptional cases in which manual titration is required, but the Phase 1b report recommended that this practice be avoided whenever possible.

Another key finding was that respondents appearing to use the same make and model of IV infusion pump showed significant variability when asked if the pump possessed a built-in bolus feature. At a minimum, units should be clear about whether their IV infusion pump possesses a bolus feature, and understand why it has been enabled or disabled. Enabling the bolus feature on an IV infusion pump may significantly reduce risks, but the process for enabling a built-in bolus feature is not trivial, and the implementation of new features or bolus limits can require a significant investment of time and resources to ensure it is done safely. In addition, the fact that not all built-in bolus features are designed in a way that supports practice at the institution must also be considered. The Phase 2b report will provide additional evidence related to the efficacy of built-in bolus features that may aid hospitals in evaluating their options.

## Theme 6: Nurse Hiring Requirements

### *Background*

The Phase 1b report collected data on the training of nurses via interviews with nursing educators at the baccalaureate and postgraduate critical care certificate levels. At the baccalaureate level, instruction on the administration of IV infusions did not extend to complex patients where multiple IV infusions may be required.

The postgraduate CCNC program was described as a program that would help nurses become comfortable and proficient with the administration of multiple IV infusions. This is a program administered by an accredited college that contains course work and practical components, and should not to be confused with the Certified Nurse in Critical Care [CNCC] certification from the Canadian Nurses Association. However, it was found that the CCNC program often expects nurses to possess a thorough understanding of common IV infusion tasks, which may not have been covered in detail in the baccalaureate program. The importance of common clinical tasks (e.g., labelling, line tracing) are discussed and encouraged, but instruction may not specify the benefits and disadvantages of various approaches with respect to patient safety. More detailed discussion on the specifics of multiple IV infusion administration is possible at either the baccalaureate or CCNC level, but is usually driven by student questions (often in practical/simulated aspects of training), rather than as a formal part of the curriculum.

At a minimum, all new nurses in Ontario must complete a baccalaureate degree in nursing and receive a licence with the College of Nurses of Ontario prior to practicing. Therefore, when assessing the readiness of nurses to manage multiple IV infusions, hiring managers might consider 2 additional factors:

- the number and type of additional certifications or courses the nurse has completed that address multiple IV infusions
- the nurse's previous experience administering IV infusions

The survey investigated the potential prevalence of both these factors. It also examined whether hospital- and unit-specific orientation programs were mandatory for nurses, as these programs are critical to familiarizing new nurses with the standard work practices of each institution.

### *Sub-Themes and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **Nursing Orientation**
  - Practice prevalence: Identify the potential prevalence of nurses receiving hospital-wide orientation.
  - Practice prevalence: Identify the potential prevalence of nurses receiving unit-specific orientation.
- **Hiring Requirements**
  - Practice prevalence: Identify the potential prevalence of units that hire new nurse graduates.
  - Practice prevalence: Identify the amount and type of experience required if new nurse graduates are not hired.
  - Practice prevalence: Identify the potential prevalence of units that require nurses to have certifications or postgraduate education.

### *Nursing Orientation*

**Summary of Results**

Table 25 summarizes respondent answers to questions about nursing orientation.

**Table 25: Nursing Orientation—Practice Prevalence Questions**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | % | |
| **Are nurses required to receive hospital nursing orientation prior to working on your unit?[a]** | **64** | | **No test performed** |
| Yes | 64 | 100 | — |
| No | 0 | 0 | |
| **Are nurses required to receive unit-specific nursing orientation prior to working on your unit?** | **64** | | **No test performed** |
| Yes | 63 | 98 | — |
| No | 1 | 2 | |

[a]One answer category, "Other (please specify)" was omitted from this table because it was an optional free-text field where respondents could provide further details, but would not constitute an answer to this question on its own.

For a detailed breakdown of respondent answers, please see Tables A34 and A35.

Four comments were received indicating that hospital orientation varied across Ontario, from a minimum of 3 days to a maximum of 2 weeks. One respondent also indicated that an additional 4 weeks were required for buddied shifts as part of orientation. Another respondent indicated that buddied nursing shifts may begin before hospital orientation due to scheduling issues.

**Discussion**

Nursing orientation at the hospital and unit levels is critical to familiarizing nurses with the infusion pumps and standard work practices of the institution and care area. It appears that receiving both types of orientation is standard practice for almost all institutions and units.

Comments suggested that orientations were of variable length, and by extension, likely to have variable amounts of content. Still, given the near-unanimous use of both hospital and unit orientation, these training sessions are ideal opportunities for ensuring that staff come to consensus on the specific strategies and practices used to administer and manage multiple IV infusions. The introduction of new curricular content or safety information related to the administration of IV infusions may better penetrate into clinical practice if it is taught during hospital or unit orientation rather than in educational programs, although representation in both is preferred.

### *Hiring Requirements*

**Summary of Results**

Table 26 summarizes respondent answers to questions about hiring requirements.

**Table 26: Hiring Requirements—Practice Prevalence Questions**

| Survey Questions | Respondents | | Statistics |
|---|---|---|---|
| | n | % | |
| **Do you hire new nurse graduates on your unit?** | **64** | | **$\chi^2$ = 16.000 *P* < 0.001** |
| Yes | 48 | 75 | No pairwise test required |
| No | 16 | 25 | |
| **Are nurses required to have previous experience to be hired on the unit?** | **63** | | **$\chi^2$ = 3.571 Not significant (*P* = 0.06)** |
| Yes | 24 | 38 | No pairwise test required |
| No | 39 | 62 | |
| **Are nurses required to complete any certifications or college-based postgraduate courses to be hired on your unit?** | **63** | | **$\chi^2$ = 5.730 *P* = 0.02** |
| Yes | 41 | 65 | No pairwise test required |
| No | 22 | 35 | |

No significance was found when testing for interactions between respondents' answers and hospital type for any of the questions in Table 26. However, significance was approached for the third question ($\chi^2$ = 4.807; $P$ = 0.09), and cursory review of the distribution of respondents suggested that non-academic hospitals were more likely to require a certification or postgraduate course than academic hospitals. There was insufficient power to evaluate differences across clinical units for any of the 3 questions. For a detailed breakdown of respondent answers, please see Tables A36 to A38 (Appendix 2).

Respondents were asked to leave free-text comments for the question, "If new nurse graduates are hired, please describe if orientation is modified for them, and how." Comments referred to the following:

- additional training required (variable between respondents)
  - extended time with buddied shifts; ranged from 3 weeks to 9 months, depending on the care area
  - longer didactic/theory training
- some respondents sent nurses to specific programs or for additional courses, possibly in-house or an academic program
- frequent use of the Nursing Graduate Guarantee (NGG) by multiple respondents
- no changes were made to the orientation process (1 respondent)
- adjustments were made to orientation on a case-by-case basis

Comments related to the question "Are nurses required to have previous experience to be hired on the unit?" included the following:

- Previous experience was not required, but preferred. One respondent cited experience with specific central venous access as particularly important.
- When previous experience was not required, respondents sometimes cited the fact that those who were hired tended to be students who did their clinical practicums with a staff nurse at the same unit.
- Several respondents currently still "required" previous experience, but in recent years had been forced to hire new graduates or now no longer demanded previous experience. Not all respondents provided a reason for the change, but the ones who did cited nursing shortages, the hiring of part-time nurses (to save money on paying benefits to full-time staff), and the cost-saving benefits of the NGG, which encourages the hiring of new graduates.
- If previous experience was not present but other desirable skills were, exceptions could be made.
- One to 3 years of previous experience were expected in pediatric or neonatal ICUs that requested previous experience.
- Emergency departments requested 1 to 2 years of experience—either general nursing experience, medical surgical experience, or at the very minimum, new graduates should have done consolidation (i.e., clinical practicums) on the unit. One respondent indicated they used the NGG.

Comments related to the question "Are nurses required to complete any certifications or college-based postgraduate courses to be hired on your unit?" included a wide variety of certifications and courses, given the range of clinical units represented. To summarize these data, 7 categories were created to group similar certifications or courses (examples from respondents listed below each major category):

- cardiac care certifications/courses
  - Basic Cardiac Life Support
  - Advanced Cardiac Life Support
  - cardiopulmonary resuscitation
  - defibrillation
- CCNC (or a subset of the required courses)
  - Coronary Care Course, Level I and/or II
  - 12-lead ECG analysis
  - arrhythmia and/or rhythms
  - rhythms and ECG interpretation
- pediatric and neonatal certifications/courses (both emergency care and non-emergency care)
  - Pediatric Advanced Life Support
  - Neonatal Resuscitation Program
  - Emergency Nursing Pediatric Course
  - Perinatal Nursing Certificate
  - Maternal and Child course
  - STABLE certification (Sugar and safe care, Temperature, Airway, Blood pressure, Lab work, Emotional support)

- emergency and/or trauma certifications/courses (not specific to pediatric/neonatal populations)
  - Emergency Nursing Certificate
  - Advanced Trauma Care for Nurses
  - Advanced Trauma Life Support
  - Trauma Nursing Core Course
  - Canadian Triage and Acuity Scale
  - any reference to "emergency preparation"
- chemotherapy certifications/courses
  - De Souza Chemotherapy Administration Course
  - regional cancer centre certification
  - chemotherapy and biotherapy provider program from the Association of Pediatric Hematology and Oncology Nurses
- other certifications/courses
  - annual certification from the Canadian Vascular Access Association
- miscellaneous certifications/courses (includes training that other respondents likely also required but did not mention)
  - Bachelor of Nursing
  - IV below drip administration, IV initiation
  - in-house training
  - registration with College of Nurses of Ontario
  - critical practice orientation

Please note that in several cases, respondents outlined conditions for the courses they listed. For example:

- The course was required only if the nurse did not have previous ICU experience, or was missing a suitable substitute certification.
- The nurse could begin work, but had to complete specific courses within a certain time frame.
- The courses listed were preferred but not required.

Table 27 summarizes the number of respondents who indicated that nurses were required to complete a course or certification from 1 of the categories described above, by both hospital type and clinical unit.

**Table 27: Certifications or Courses Required for Nurses to be Hired by Hospital Type and Clinical Unit[a,b]**

| Hospital Type and Clinical Unit | Cardiac Care | CCNC | Select Courses From CCNC | Pediatric and Neonatal | Emergency and/or Trauma | Chemotherapy | Other | Respondents |
|---|---|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 beds** | **8 (38%)** | **—** | **3 (14%)** | **4 (19%)** | **5 (24%)** | **—** | **—** | **21** |
| Adult ICU | 1 | — | 1 | — | — | — | — | 2 |
| Adult or pediatric oncology unit | 1 | — | — | 1 | 1 | — | — | 2 |
| Emergency department | 3 | — | — | 2 | 3 | — | — | 6 |
| Adult inpatient ward | 3 | — | 2 | 1 | 1 | — | — | 11 |
| **Non-academic Hospitals With ≥ 100 beds** | **8 (36%)** | **4 (18%)** | **6 (27%)** | **8 (36%)** | **5 (23%)** | **1 (5%)** | **1 (5%)** | **22** |
| Adult ICU | 1 | 4 | 1 | — | — | — | — | 6 |
| Pediatric or neonatal ICU | — | — | — | 3 | — | — | — | 3 |
| Adult or pediatric oncology unit | — | — | — | — | — | 1 | 1 | 1 |
| Emergency department | 6 | — | 4 | 5 | 5 | — | — | 6 |
| Adult inpatient ward | 1 | — | 1 | — | — | — | — | 6 |
| **Academic Hospitals** | **2 (10%)** | **1 (5%)** | **1 (5%)** | **3 (14%)** | **2 (10%)** | **2 (10%)** | **—** | **21** |
| Adult ICU | — | 1 | — | — | — | — | — | 4 |
| Pediatric or neonatal ICU | 1 | — | — | 1 | — | — | — | 5 |
| Adult or pediatric oncology unit | — | — | — | — | — | 2 | — | 5 |
| Emergency department | 1 | — | 1 | 2 | 2 | — | — | 5 |
| Adult inpatient ward | — | — | — | — | — | — | — | 2 |
| **Total** | **18 (28%)** | **5 (8%)** | **10 (16%)** | **15 (23%)** | **12 (19%)** | **3 (5%)** | **1 (2%)** | **64** |

Abbreviation: CCNC, Critical Care Nurse Certificate; ICU, intensive care unit.

[a]Answer categories not mutually exclusive.

[b]Percentages may appear inexact due to rounding.

Final comments from respondents answering the question "Do you have any comments, suggestions or concerns about how nurses are trained for the complexity of setting up and managing multiple IV infusions at the bedside?" referenced the following topics:

- additional details of how orientation programs are carried out at their institution
- the resource-limited nature of training and/or follow-up:
  - the desire to provide more education to their staff than is possible in the current state, and that it should include active demonstration; troubleshooting tactics and clear expectations about what constitutes safe practice; and/or more time dedicated to the complex infusion pumps
  - additional training desirable for drugs used for critical patients
  - the burden the NGG places on preceptors (i.e., mentoring nurses)
  - not enough time to learn how to use complex pumps, and/or practice, either during initial orientation or annual review sessions
  - not enough resources to predictably schedule training
  - lack of follow-up after training/orientation to audit how pumps are set up in the unit
- demands on nurses:
  - information overload, as IV administration practices are 1 small part of what nurses are expected to absorb
  - concerns that in time-sensitive and stressful situations, nurses are not always able to look up the medications they have to administer
  - concerns about less experienced nurses in the emergency department caring for ICU-bound patients
  - smaller centres have critical patients less frequently, making it more difficult for nurses to gain and maintain competencies; additional review is required in these circumstances
- discussion of the balance between theoretical and practical aspects of nursing education:
  - overemphasis on practical training may lead to imitation of the nurse preceptor without understanding the reasoning, or using practices that do not adhere to hospital policy
  - concern that preceptors may not be using the most up-to-date practices, and that a selected pool of preceptors should always be used
  - a lack of practical training in nursing school leads to an increased need for training and familiarization when new graduates enter the clinical unit
  - encouraging the use of simulation training to help familiarize nurses, particularly as part of the critical care program that nurses take in the institution
  - nurses coming through the Nurse Graduate Initiative [alternate term for NGG] tend to be better to hire, as they develop the experience that many other new nurse graduates are lacking
- discussion of what kind of general IV infusion safety information can be included in hospital orientation without conflicting with variations in clinical practice
- positive feedback stating that new nurse graduates are prepared well
- an online pre-course for orientation might be helpful, as well as a job-shadowing program to help nurses decide if they like working in that unit
- recognition that multiple IV infusions are not thoroughly discussed in class or clinical areas, and high degree of variability between nurses
- desire for pharmacy to provide tips and pitfalls to nurses during nurse training at the hospital

**Discussion**

The questions in this sub-theme were difficult to interpret without placing them in the context of the comments from respondents. For example, 75% of respondents indicated that they hired new nurse graduates, but only 62% of respondents indicated that previous experience was not required for hiring; these 2 percentages should have been more closely related. Therefore, more than in the other themes presented in this report, the free-text comments provided the most insight into the specific requirements nurses must meet to be hired, and by extension, their preparation to administer multiple IV infusions.

The most common theme in respondents' comments was the reference to the NGG, a program established by Health Force Ontario to help new nurse graduates build experience and help them find employment in Ontario. (28) The NGG provides funding to employers so that they can support a nursing position for 6 months to help new nurse graduates gain the necessary experience to bridge to a full-time position at that institution. If the NGG nurse is not bridged to a full-time position, an additional 6 weeks of funding can be made available to allow for this transition to occur. Given that some respondents discussed nursing shortages and resource limitations, the survey data suggest that NGG program has played an important role in allowing new nurse graduates to be hired and trained in the needs of the specific clinical units they later join as full-time staff. This may account for the discrepancy in responses regarding the hiring of new nurse graduates and the need for previous experience described above.

Based on the free-text comments, new nurse graduates are frequently hired because of resource limitations, nursing shortages, and the cost savings of using the NGG program. New nurse graduates are frequently provided with additional training or buddied shifts to ensure they are adequately prepared to work on their own. Only 1 respondent indicated that training was not altered for new nurse graduates, but since comments on this issue were not mandatory, there may have been other units that do not modify orientation. However, as a whole, clinical units make an effort to provide new nurse graduates with the specialized skills and expectations to work on the unit.

Certifications and/or courses required varied across institutions and clinical units. Emergency departments and pediatric or neonatal ICUs were the most consistent in requiring nurses to have specific certifications or courses to be hired. While it would appear that there may be benefit in ensuring a standard certification process for each type of clinical unit, it is likely that the standard work practices differ between institutions for units of the same type. All courses mentioned by the respondents were treated as if they were required to begin work on the clinical unit. Therefore, Table 27 may overestimate the requirements to work on clinical units in Ontario, because hiring requirements are likely to be more flexible based on other factors (e.g., the nurse's experience level, budgeting concerns). In addition, many specific components of IV practice that relate to the issues identified in Phase 1b (e.g., labelling, line tracing, bolus administration) may differ based on the materials and infusion pumps available at each institution. Certification programs might not be able to adequately prepare students for the specific tools, equipment, and IV disposables they may encounter.

Finally, comments regarding the preparation of nurses to handle multiple IV infusions were varied. There were numerous comments suggesting that a mix of both practical and theoretical/class-based work is necessary, but that resource limitations limit these endeavours. Nurses are required to absorb a large amount of information in a short amount of time, and multiple IV infusions may not be addressed in detail.

### *Summary of Findings and Future Work*

Overall, the data suggested that there were a variety of hiring requirements across Ontario, and it was difficult to determine how consistently and thoroughly nurses are prepared to face the challenges of multiple IV infusion administration. Financial pressures, nursing shortages, the NGG program, and hospital-/unit-specific hiring requirements all influenced hiring. The readiness of nurses to work independently depends strongly on their individual assessment by hiring managers, so hiring and education occurred on a case-by-case basis. Certifications or courses were not consistently required for each type of clinical unit, and hiring requirements were likely to vary depending on the institution, and on specific financial constraints, staff needs, and available applicants.

Taken as a whole, these survey data suggested that fast, efficient, and low-cost training materials/delivery are essential if any additional curricular components are to be added to current training processes.

The recommendations stemming from the Phase 1b study may be beneficial additions to hospital- or unit-specific nursing orientation, as most nurses will pass through those programs and the recommendations are highly specific and easy to learn. Additional experimental findings related to training will be presented in Phase 2b.

## Theme 7: Final Comments from Respondents

### *Background*

This theme addresses any comments received from respondents at the end of the survey. The opportunity to comment at the end was not associated with any of the first 6 themes in this report, instead asking about the administration of multiple IV infusions in general. The Phase 1b report did not provide useful background for this theme.

### *Sub-Theme and Objectives*

The survey addressed the following objectives, organized by sub-theme:

- **Final Comments from Respondents**
  - Identify additional issues or constraints faced by clinical units based in Ontario.
  - Identify unique incidents that may highlight multiple IV infusion–specific errors.

### *Final Comments from Respondents*

**Summary of Results**

At the end of the survey, respondents were asked, "Do you have any other thoughts, suggestions, or concerns about how multiple IV infusions are administered?" Key thoughts and comments are summarized below, organized by topic. Not all comments were specifically relevant to multiple IV infusions, but they have all been presented in summarized form to capture respondents' thoughts.

- comments related to IV infusion pumps:
  - Recently nurses were required to use the drug library in the IV infusion pump and label at the distal end of the IV tubing for patient safety. New smart pumps are being acquired so that the drug library can be more carefully configured, and also be programmed with soft and hard limits.
  - The drug library in the IV infusion pump may not always be used by staff.
  - A lack of IV pumps can be an issue. Nurses are more familiar with infusions run by IV pumps, and when there is an absence of pumps, it can be difficult for staff to calculate drip rates.
- comments related to the policies and practices of the clinical unit:
  - There is a need to reduce distractions in the unit when multiple IV infusions are being programmed.
  - Nurses only add medication stickers to IV bags; never pumps.
  - Nurses in oncology settings do not always know where to attach medication to the IV line, and whether the drug requires a secondary set.
  - Nurses need reminders to use the IV pump's line-labelling feature.
  - There are concerns about ensuring drug compatibility in rural hospitals, as pharmacy services are not available 24 hours a day. Orders received late in the day place additional burden on nurses to cross-reference for reactions between medications, and in some cases, the pharmacy may be available only by phone.
  - Multiple IV infusion errors are the result of not following the 7 rights of medication administration. Greater vigilance is required when multiple IV infusions are administered, and standards of practice need to be more consistent in regards to line labelling, shift handover, and awareness of the frequency and type of IV incidents.
  - Nurses do not encounter multiple IV infusions frequently, and so when these situations occur, it is stressful. Nurses accustomed to administering multiple IV infusions may not recall the

apprehension of those less experienced. Some nurses do not realize the potential errors that are compounded when multiple IV infusions are being managed surrounding drug incompatibilities and recommended dilutions, particularly in low-weight patients (e.g., neonatal and pediatric patients).
  - High-alert medications are changed at a standard time.[5]
  - All high-alert infusions are verified and reconciled at bedside during shift change by the incoming and outgoing nurses; will be documented on the transfer of accountability form.
  - Drug compatibility charts are used, but there is a concern about the body's reactions to the medications alongside the immune system, because there is not enough research.
- comments related to the setup, labelling, and identification of IV infusions
  - IV poles should have a pole top where IV bags are aligned horizontally (i.e., a rake alignment of hooks).
  - IV bags should be labelled. It would be ideal if bag labels were brighter for increased visibility. Pumps are nice to have labelled.
  - There should be a standard best practice driven by practicing health care staff who have an interest in patient safety and best practices. The best practice should describe the what, where, why, and how.[6]
  - Multiple IV infusions should be labelled on the tubing closest to the patient to prevent boluses (e.g., IV syringe pushes) being administered through inappropriate tubing.
  - Colour-coded IV tubing may be helpful for high-risk medications. A clear display of the medication name on the pump screen may also be helpful.
  - The most important thing is a culture of safety and good working habits among nurses, the unit, and the organization. No amount of smart technology can prevent 100% of errors without the help of staff.
  - IV lines are administered through separate access sites if possible. Multiple IV infusions are managed with multiple pumps or multichannel pumps. If drug compatibility is not an issue, then lines can be combined with a Y connector.
  - For particularly complex situations, a diagram of how the IV infusions are connected is made. The diagram also lists which of the patient's medications are compatible with the multiple IV line setup.

Respondents were also asked, "If you are comfortable sharing any incidents related to the administration of multiple IV infusions, please describe the circumstances and patient impact of these incidents." Not all responses described incidents that were specific to multiple IV infusions, but those who did are summarized below:

- After an incident, nurses were encouraged to no longer administer IV boluses using a primary infusion. Now certain medications have to be double-checked according to a policy before being administered as a bolus.
- Nurses have hung IV bags in advance so that they are ready to replace IV bags that are about to run out. However, the new IV bag may then be connected to incorrect IV tubing without a check to see if what was being removed matched the new addition.
- Tubing may not actually be connected to the patient as they leave the operating room, as it was prepared "just in case" for the surgery.

[5]This was presumably in reference to IV tubing changes, but it was not possible to tell based on this respondent's comments.
[6]The respondent did not explain what this comment was in reference to, but the previous section was related to IV pump labelling, and may have been referring to that.

- IV bags have been hung with the incorrect dose.
- IV pumps were programmed with the rate and volume to be infused transposed.
- It is recommended that all hospitals have an IV pump "resource nurse" to ensure that staff are aware of best practices when using the IV infusion pumps, and how to program them. The resource nurse can be paged or emailed for help, and may assist with nursing students and orientation.
- Incompatible solutions or medications (presumably the respondent was indicating that they have been coadministered).
- IV infusion pump may not have a drug dosage calculator, and so infrequently administered medications may not be dosed correctly.
- Pump availability is not consistent due to recalls, causing an increase in errors on the floor as nurses attempt to manage without them.
- A lack of drug compatibility charts.
- Concern about compliance with the new IV infusion pump's drug library. It is taking too long to implement changes to the drug library, particularly due to staff turnover in the group that manages the drug library update process.
- The wrong label has been applied to IV medication tubing.
- The tubing pathway from the IV bag to the patient was not correctly verified, and an incorrect bolus was administered.
- An oncology medication was not connected to the patient prior to the infusion being started, resulting in leakage.
- There is greater diligence when multiple IV infusions are in play, but when managing routine maintenance infusions, basic errors can occur (e.g., wrong solution hung, tubing and bags not labelled with a date, shift handover not thorough).

### *Summary of Findings and Future Work*

Respondents described a variety of issues present in the clinical environment, many of which did not relate specifically to the administration of multiple IV infusions. However, many of the IV infusion errors may become more likely to occur, or more difficult to diagnose and correct, in the context of multiple IV infusions. Comments from respondents touched on structural or organizational issues that may benefit from future work:

- methods to make the identification of drug compatibility issues more accessible to nurses (e.g., more charts, better access to pharmacy support) and ensure that these tools are efficient to use
- the need to ensure staff understand and use the safety features built into IV infusion pumps
- safety issues that occur when nurses are not provided with the tools they are most familiar with, and have become reliant on (e.g., IV infusion pump availability can be affected by recalls or inventory issues, forcing nurses to calculate drip rates and monitor infusions in ways they may not be familiar with)
- references to specific tools or resources that may be helpful in clinical environments (e.g., rake pole tops for IV poles to separate IV bags, pump resource nurses, colour-coded lines, diagrams of IV setup).

These comments confirmed that a number of factors are involved in IV infusion safety, ranging from specific practices or policies at the bedside to broader organizational issues regarding pump selection, pump availability, and staff training. The findings stemming from work performed in Phase 2b will comment on the effectiveness of tools that offer promise in mitigating multiple IV infusion risks.

# Conclusions

Previous work has shown that the administration of multiple IV infusions to a single patient is a complex task with many potential associated patient safety risks. The Ontario survey revealed variability in IV infusion practice across the province and potential opportunities to improve safety. Specific practices and/or technology related to secondary infusions, IV tubing labelling, patient transfers, dead volume management, and IV bolus administration were highlighted as requiring attention.

Many respondents indicated an awareness of previously identified risks (e.g., restricting the serial connections of 3-way stopcocks, minimizing coadministration of infusions with central venous pressure lines). In these cases, the majority of respondents appeared to take the necessary precautions (e.g., the majority of respondents did appear to use a back check valve when secondary infusions were administered).

# Glossary

| | |
|---|---|
| **Bolus** | Refers to an additional dose of a primary **continuous infusion**. For example, a patient receiving a continuous morphine infusion requires an additional dose for pain management support prior to an invasive procedure). For the purposes of this report, *bolus* excludes **intermittent infusions**, loading doses, as-needed doses injected all at once (without a continuous infusion of the same medication running), or IV PCA doses. |
| **Continuous infusion** | An infusion administered on an ongoing (continuous) basis. Some patients require a constant intake of fluids for hydration, and therefore have a continuous, maintenance infusion started (see **plain IV line**). |
| **Dead volume** | The total volume of the catheter and all associated **IV tubing** and connecting components from the point where 2 or more IV fluids/medications meet up until they reach the patient's bloodstream. |
| **Dose error reduction system (DERS)** | A software feature found in **smart infusion pumps** that contains a library of medications and concentrations for nurses to select from when administering IV infusions. Each medication and concentration is associated with dosing limits, so that nurses are warned or prevented from starting the infusion if the dose exceeds the limits. The drug library and its associated dosing limits can be tailored to different clinical care areas and their unique requirements. |
| **Emergency medication line** | Refers to an **IV line** continuously infusing a fluid that is compatible with most IV medications and is not joined with other infusions. It is often kept available in the event that IV drugs are required immediately, and in some institutions, may also be used to deliver intermittent medications (see **plain IV line**). |
| **High-alert medication** | Medications that bear a heightened risk of causing significant patient harm when they are used in error. |
| **Intermittent infusion** | An infusion administered on a periodic basis. For example, an intermittent infusion of antibiotics may require a short IV dose to be administered every 8 hours. Typically, each dose is contained in its own IV bag. |
| **Injection port** | A **luer lock** entry point into **IV tubing**. Due to the fact that it protrudes from the IV tubing at an angle, the combination of 2 IV tubes into 1 resembles the letter Y. May also be referred to as a ***Y-site***. |
| **Intravenous (IV)** | Means "within vein." Any equipment prefaced with the term *IV* refers to its intended use for administering fluids or medications intravenously (e.g., IV infusion pump). |
| **IV tubing** | A tubular pathway for IV agents to travel from 1 location to another. |
| **Large-volume infusion pump** | A programmable device that controls the rate and volume of an infusion. Large-volume infusion pumps can control the flow of IV agents from containers of various sizes, provided the containers are hung above the pump so that gravity encourages them to flow toward the pump. |

| | |
|---|---|
| **Line/IV line** | A pathway for IV agents to enter a peripheral or central venous catheter. In some cases, catheters may consist of multiple **lumens** (see **multi-lumen catheter**) so that several IV agents can infuse through the same catheter without mixing until they reach the bloodstream; each of these lumens is considered a separate IV line. |
| **Luer lock** | A "push and twist" connector system that allows IV components to securely connect together (e.g., **IV tubing**, catheters, syringes). Screw-like threads and the precise tapering of the male/female ends facilitate a tight fit between components. |
| **Lumen** | The tubular space inside **IV tubing** or catheters in which IV agents can flow and be contained. Some IV catheters have multiple lumens (see **multi-lumen catheter**). |
| **Multi-lumen catheter** | A catheter that has more than 1 **lumen**, or tube, inside the catheter. This allows different pathways for IV agents to infuse without interacting until they reach the patient's bloodstream. The lumens exit the catheter at different points inside the patient's vein, minimizing immediate mixing once they leave the catheter. |
| **Piggyback infusion** | See **secondary infusion**. |
| **Plain IV line** | See **emergency medication line**. Note that emergency medication lines are usually plain IV lines, but not necessarily vice versa. There may be multiple plain IV lines, but typically only 1 intended for use as the emergency medication line. For the purposes of this report, the term *plain IV line* was used because not every respondent may be familiar with the term *emergency medication line*, but *plain IV line* was presented alongside the definition shown for emergency medication line. |
| **Primary infusion** | An infusion connected directly to an infusion pump via **primary IV tubing** (i.e., not connected via a medication port). |
| **Primary IV tubing** | **IV tubing** intended for use with a **primary infusion**. Primary infusion tubing (primary infusion "sets") designed for **large-volume infusion pumps** typically features a **Y-site** upstream of the connection to the pump where **secondary IV tubing** can be connected (see **secondary IV port**). Primary IV tubing intended for **syringe pumps** typically does not feature Y-sites. |
| **Secondary infusion** | Also referred to as a **piggyback infusion**. An infusion designed to temporarily interrupt the **primary infusion** so that a second IV fluid/medication can be attached and flow through the **primary IV tubing**. This process requires a separate programming sequence on the infusion pump to control the secondary infusion. When the secondary infusion is completed, the primary infusion resumes at the appropriate flow rate. |
| **Secondary IV tubing** | **IV tubing** intended for use with a **secondary/piggyback infusion**. This tubing is usually shorter than **primary IV tubing**. |

| | |
|---|---|
| **Secondary IV port** | Refers to an **injection port** on the **primary IV tubing** that is typically reserved for secondary IV infusion administration. On primary IV tubing intended for use with IV infusion pumps, the secondary port would be located above the infusion pump after the tubing is loaded into the pump. Injection ports close to the patient end of the IV tubing were *not* considered secondary ports in this report (they may be referred to as *lower injection ports* or *distal ports*). However, lower injection ports are not mandatory; hospitals may elect to use primary IV tubing with no injection ports whatsoever (e.g., similar to IV syringe pump tubing). |
| **Smart infusion pump** | An electronic infusion pump equipped with a **dose error reduction system (DERS)**. A central element of all smart pumps and their DERS software is the ability to provide nurses with an alert when specific dosing limits are exceeded during the infusion programming process. Smart pumps may offer the ability to display clinical advisories (depending on the infusion programmed), communicate wirelessly with a pump server, and record timestamp logs of programming keystrokes. Smart pumps may also employ barcode and/or radio frequency identification technology to reconcile medication, patient, nurse, and prescriber order information. |
| **Standard work practice** | Refers to an established method of performing tasks. The standard work practice may specify when and how certain tasks need to be done, and by whom. The nurse managers/educators expect staff to follow these work practices. The practices may be communicated in a variety of ways (e.g., unit policy guidelines, emails, memos, staff meetings, etc.), but staff members are instructed on their use at some point in their orientation to the clinical unit. |
| **Syringe pump** | An electronic or mechanical device that administers the contents of a syringe at a controlled flow rate. |
| **Three (3)-way stopcock** | An IV connector that joins 3 IV tubes together (usually 2 infusions joining into 1). It is functionally similar to a **Y-site**, with the added ability to stop the flow of 1 of its connections with a handle. |
| **Volume to be infused (VTBI)** | The volume of fluid or medication that is intended to be administered to the patient. |
| **Y-site** | See **injection port**. |

# Acknowledgements


### Editorial Staff

Jeanne McKane, CPE, ELS(D)

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### Members of the Multiple IV Infusions Expert Panel

| Name (Alphabetical) | Expert Panel Role | Organization(s) Represented |
|---|---|---|
| Lisa Burry | Pharmacy and Hospital Representative | Mount Sinai Hospital<br>Canadian Society of Hospital Pharmacists |
| Vania Costa | Liaison to Health Quality Ontario | Health Quality Ontario |
| Pam Cybulski | Nursing Representative | William Osler Health Centre<br>Canadian Association of Critical Care Nurses |
| Brenda Dusek | Nursing Representative | Registered Nurses Association of Ontario |
| Tony Easty | Expert Panel Chair | HumanEra |
| Patrick Fandja | Regulatory Representative | Health Canada |
| Kim Greenwood | Hospital Representative | Children's Hospital of Eastern Ontario<br>Council of Academic Hospitals of Ontario |
| Dr Chris Hayes | Medical, Safety and Hospital Representative | St. Michael's Hospital<br>Canadian Patient Safety Institute |
| Geeta Juta | Safety and Nursing Representative | Institute for Safe Medication Practices Canada |
| Christine Koczmara | Safety and Nursing Representative | Institute for Safe Medication Practices Canada |
| Dr Bob Lester | Hospital Representative | Ontario Hospital Association |
| Mitra Nadjmi | Risk Management Representative | Health Insurance Reciprocal of Canada |
| Kim Newcombe | Nursing Representative | Canadian Vascular Access Association |
| Kim Streitenberger | Pediatric Nursing Representative | The Hospital for Sick Children |
| Jeannette Van Norden | Oncology Nursing Representative | Juravinski Cancer Centre |
| **Past Members** | | |
| Ilhemme Djelouah | Regulatory Representative | Health Canada |
| Bronwen McCurdy | Liaison to Health Quality Ontario | Health Quality Ontario |
| Dr Jennifer Sarjeant | Hospital Representative | Ontario Hospital Association |
| Dr Bill Shragge | Expert Panel Co-Chair | Ontario Health Technology Assessment Committee |
| Fannie St-Gelais | Regulatory Representative | Health Canada |

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  - Chris Colvin
  - Melissa Griffin
  - Sonia Pinkney
  - Farzan Sasangohar (PhD student)
  - Rachel White

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# Appendices

## Appendix 1: Survey Questionnaire

### Welcome

Thank you for your interest in our research study on the management of multiple IV infusions.

This survey will take approximately 20 to 30 minutes to complete. You can leave the survey and resume from where you left off by accessing the same weblink that brought you to this page.

Upon clicking on the "NEXT" button below, you will be asked to read the consent form and decide whether you would like to continue. Please read it carefully before proceeding to the survey questions.

Thank you again for your participation.

### Consent Form

***Consent to Participate in a Research Study***
**Study title:** Mitigating the risks associated with multiple IV infusions: Phase 2 — Ontario Survey
Principal Investigators: Dr. Tony Easty 416-340-4800 ext. 4919 Funder: Health Quality Ontario

**Introduction:** You are being asked to take part in a research study. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, risks, and confidentiality associated with this study. It also describes your right to refuse to participate or withdraw from the study. To decide whether you wish to participate in this research study, feel free to talk about this study with anyone you wish. Participation in this study is voluntary.

**Participation:** Your participation in this study is voluntary. You can choose not to complete the survey and can exit the survey at any time. Whether you choose to participate or not will not affect your relationship with the study investigators, nor will it affect your employment (or potential for employment) at UHN.

**Background:** The administration of multiple IV infusions to a single patient is common. Despite a lack of empirical research, many concerns have been raised regarding the potential for errors during the setup and administration of secondary (piggyback) infusions. The likelihood of error increases as multiple pumps, channels, and infusions are administered to the patient (e.g., care providers have mixed up infusion lines, or pumps/channels, changing the rate on the wrong infusion).

**Purpose:** As part of a research study to improve the safety of multiple IV infusions in Ontario, researchers at the University Health Network (UHN) are conducting a survey of clinical units across Ontario to understand what policies and expectations are in place for the setup, administration, and management of multiple IV infusions. We are also interested in the minimum education requirements that nurses are required to have, and the types of large-volume infusion pumps that are used on the unit. Nursing managers and educators in hospitals across Ontario are being asked to participate. You have been asked to participate because you are aware of the policies and expectations in regards to IV medication processes and therefore have knowledge and experience that is valuable to the study. The results of this research will inform how to improve the safety of multiple IV infusions.

**Procedures:** You will be asked to fill out an electronic survey by clicking on the "Next" button below and by entering your responses. The survey is expected to take approximately 20 to 30 minutes to complete. You may exit the survey and restart where you left off by revisiting the weblink you used to access this webpage. When you have completed the survey, you will click the "Done" button, and your responses will be collected and analyzed by the research team.

**Risks Related to Responding to the Survey:** There is a risk that data collected from this survey could be released inappropriately. The study investigators have taken a number of precautions to prevent this from occurring, including the use of encrypted and password protected computers and servers. In the event that there is an inappropriate release of information, study investigators will attempt to stop any further release of information, retrieve any information possible, notify the University Health Network's (UHN) Research Ethics Board (REB) and Privacy Office, and take steps to implement recommendations from the UHN Privacy Office and REB.

**Benefits to Responding to the Survey:** You will not receive direct benefit from participating in this study. However, information learned from this study will be used to identify recommendations regarding the safe delivery of multiple IV infusions in Ontario. This may also help other health care facilities that deliver complex IV therapy outside of Ontario.

**Confidentiality:** If you agree to join this study, the study investigators will look at the personal health information that you submit. Personal health information is any information that could be used to identify you and includes:

- your name and email address (which we have already collected in order to invite you to participate in this survey)
- the hospital and clinical unit in which you work
- your job title and/or role

The information that is collected for the study will be kept in a locked and secure area by the study investigators for 7 years. Only the study team or the people or groups listed below will be allowed to look at your records.

The following people may look at the study records and check that the information collected for the study is correct and to make sure the study followed proper laws and guidelines:

- University Health Network Research Ethics Board
- U.S. law enforcement officials (this because there is a remote possibility that U.S. Law enforcement officials will access information physically stored on Survey Monkey's servers as part of an anti-terrorism investigation under the authority of the U.S. Patriot Act)

All information collected during this study, including your personal health information, will be kept confidential and will not be shared with anyone outside the study unless required by law. You will not be named in any reports, publications, or presentations that may come from this study.

If you decide to leave the study, the information about you that was collected before you left the study will still be used. No new information will be collected without your permission.

**Questions:** If you have any question about this study please contact the principal investigator Dr. Tony Easty at 416-340-4800 x 4919, or the study co-ordinator Mark Fan at 416-340-4800 x 6229.

If you have any questions about your rights as a research participant or have concerns about this study, call the Chair of the University Health Network Research Ethics Board (REB) or the Research Ethics office number at 416-581-7849. The REB is a group of people who oversee the ethical conduct of

research studies. These people are not part of the study team. Everything that you discuss will be kept confidential.

*1. Do you agree to participate in the survey?[7]

By selecting "Yes" and clicking on the "Next" button below, you are agreeing to voluntarily take part in this study with the understanding that you may withdraw at any time.

- ❒ Yes
- ❒ No

## Things to Keep in Mind When Answering the Survey

### *Survey Objectives*

This survey will ask about the practices and policies surrounding the administration of multiple IV infusions on your unit. Please note that the questions are for *information gathering purposes only* and should not be used to infer best practices, or act as recommendations for how to administer multiple IV infusions in your unit.

### *Progress Bar*

Also, note that there is a progress bar at the top of the survey showing the percentage of questions you have completed. Depending on your answers, you may skip certain sections of the survey and progress many percentage points. This is *normal* and is not an indication of any errors on the survey website.

### *Infusion Pumps: Inclusions and Exclusions*

Please note that the focus of this survey is on the delivery of intravenous (IV) fluids and medications from large volume (i.e., volumetric) infusion pumps, and IV syringe pumps.

Therefore, please exclude pumps intended for rapid fluid delivery (i.e., high volume trauma infusions), IV patient-controlled analgesia (PCA), and all other non-IV infusions (e.g., enteral, epidural, etc.) when answering the survey.

## Demographics

*The following questions target basic details about the unit you work in.*

*By* unit, *we are referring to a patient treatment area that emphasizes a specific type of care (e.g., cardiac intensive care unit, emergency department, etc.). If your institution is not organized in this way, please describe in question 4.*

2. What is your role on the unit?
   - ❒ Nurse manager
   - ❒ Nurse educator
   - ❒ Staff nurse
   - ❒ Other (please specify)
     [Respondent may enter free-text comments]

3. What is the name of your hospital? Please indicate the hospital site as well if there is more than 1. This information is used by the study team to identify duplicate responses.
   [Respondent may enter free-text comments]

[7] Asterisks, which were also visible to respondents, denote a mandatory question. Attempting to progress to the next screen would be met with a the following message being shown to above any question with an asterisk: "! This question requires an answer."

4. What clinical unit are you answering on behalf of?
   - ❒ Adult cardiac ICU
   - ❒ Adult ICU
   - ❒ Pediatric cardiac ICU
   - ❒ Pediatric ICU
   - ❒ Neonatal ICU
   - ❒ Adult oncology unit
   - ❒ Pediatric oncology unit
   - ❒ Emergency department
   - ❒ Adult inpatient ward (noncritical care) containing acute medical/surgical patients
   - ❒ Other (please specify in the comments box below)
     [Respondent may enter free-text comments]

### Nurse Hiring Requirements

5. Are nurses required to complete any certifications or college-based postgraduate courses to be hired on your unit?
   - ❒ Yes
   - ❒ No
   - ❒ If yes, please describe
     [Respondent may enter free-text comments]

6. Are nurses required to receive hospital nursing orientation prior to working on your unit?
   - ❒ Yes
   - ❒ No
   - ❒ Other (please specify)
     [Respondent may enter free-text comments]

7. Are nurses required to receive unit-specific nursing orientation prior to working on your unit?
   - ❒ Yes
   - ❒ No

8. Are nurses required to have previous experience to be hired on the unit?
   - ❒ Yes
   - ❒ No
   - ❒ If yes, please describe
     [Respondent may enter free-text comments]

### New Nurse Graduates and General Training Comments

9. Do you hire new nurse graduates on your unit?
   - ❒ Yes
   - ❒ No

10. If new nurse graduates are hired, please describe if orientation is modified for them, and how.
    [Respondent may enter free-text comments]

11. Do you have any comments, suggestions, or concerns about how nurses are trained for the complexity of setting up and managing multiple IV infusions at the bedside?
    [Respondent may enter free-text comments]

## Handover of Patient Care Between Bedside Nurses

*12. Is there a formal shift handover process between bedside nurses on your unit?
*This is a prescribed hospital/unit specific procedure that nurses are taught, and expected to follow, to ensure that certain pieces of information are transferred from the outgoing nurse to the incoming nurse. The procedure may or may not involve documentation. Examples of handover processes include face-to-face verbal report, taped report, written report etc.*

- ❒ Yes
- ❒ No
- ❒ Outpatient unit (no shift handovers)

## Shift Handover Documentation Tool

*13. Are bedside nurses provided with a documentation tool that was designed specifically to support shift handover?

- ❒ Yes
- ❒ No

## Details of Handover Tool

14. What is the documentation tool?

- ❒ Paper-based tool for nurses to complete by hand
- ❒ Computer-based form to be completed electronically
- ❒ Audio recorder (e.g., for taped report)
- ❒ Whiteboard
- ❒ Other (please specify)
  [Respondent may enter free-text comments]

15. Does the shift handover tool become a formal part of the patient's chart?

- ❒ Yes
- ❒ No
- ❒ Not sure

## Standard Work Practice and Plain IV Lines

*The following questions use the terms **standard work practice** and **plain IV line**. Please use the following definitions whenever these terms are used in the survey.*

***Standard work practice** refers to an established method of performing tasks. The standard work practice may specify when and how certain tasks need to be done, and by whom. The nurse managers/educators expect staff to follow these work practices. The practices may be communicated in a variety of ways (e.g., unit policy guidelines, emails, memos, staff meetings, etc.), but staff members are instructed on their use at some point in their orientation to the clinical unit.*

*A **plain IV line** refers to an IV line continuously infusing a fluid that is compatible with most IV medications, and is not joined with other infusions. It is often kept available in the event that IV drugs are required immediately, and in some institutions, may also be used to deliver intermittent medications.*

## Shift Handover Details

16. Is it standard work practice to conduct handover at the patient's bedside?
    - ❒ Yes
    - ❒ No

17. What information is exchanged during shift handover in regards to the patient's IV therapy? Please select all that apply.
    - ❒ List of IV drugs being infused
    - ❒ Presence of a plain IV line
    - ❒ Location of a plain IV line
    - ❒ IV access sites (location)
    - ❒ IV access sites (condition) (e.g., IV site may be positional etc.)
    - ❒ Infusion pump settings
    - ❒ All medication orders, or changes to medication orders if patient cared for in previous shift
    - ❒ Other (please specify)
      [Respondent may enter free-text comments]

18. Is it standard work practice for the outgoing nurse to physically point out the contents of each IV tube at each patient IV access device during handover?
    - ❒ Yes
    - ❒ No
    - ❒ Other (please specify)
      [Respondent may enter free-text comments]

19. Do you have any comments, suggestions, or concerns about the shift handover process as it concerns IV therapy?
    [Respondent may enter free-text comments]

## IV Tubing Labels

20. Is there a standard work practice in your unit that requires the contents of the IV tubing to be labelled?
    - ❒ Yes, all
    - ❒ Yes, some drugs/fluids
    - ❒ No
    - ❒ If "yes some drugs/fluids" please describe (i.e., drug/fluid name and the type of label requirements)
      [Respondent may enter free-text comments]

## IV Tubing—Standard Work Practice

*The following questions refer specifically to labels that* identify the contents of IV tubing *(e.g., drug name).*

21. Does the standard work practice in your unit specify when labels should be applied to IV tubing?
    - ❒ Yes, as part of infusion setup
    - ❒ Yes, as soon as is reasonable given other work demands
    - ❒ Yes, within a specified period of time after the infusion has been set up (e.g., within an hour of infusion start)
    - ❒ No
    - ❒ If yes, please describe
      [Respondent may enter free-text comments]

22. Does the standard work practice in your unit specify the label location?
- ❒ Yes
- ❒ No
- ❒ If yes, please describe
  [Respondent may enter free-text comments]

23. Does the standard work practice in your unit specify what materials should be used to label IV tubing? For example, preprinted stickers, tape, etc.
- ❒ Yes
- ❒ No
- ❒ If yes, please describe
  [Respondent may enter free-text comments]

24. What materials do nurses use to label IV tubing in your unit? Please select all that apply.
- ❒ Tape (handwritten)
- ❒ Preprinted stickers
- ❒ IV bag labels (commonly used on RN-prepared IV bags)
- ❒ Blank stickers (handwritten)
- ❒ Other (please specify)
  [Respondent may enter free-text comments]

25. If you have any comments on the standard work practice for labelling IV tubing on your unit, please describe them here.
[Respondent may enter free-text comments]

## Labelling of Plain IV Lines

26. Is the IV tubing used for plain IV lines labelled differently than other IV tubing?
- ❒ Yes
- ❒ No
- ❒ Plain IV lines are not labelled on my unit
- ❒ Plain IV lines are not used in my unit

27. Do you have any comments, suggestions, or concerns about the labelling of IV tubing?
[Respondent may enter free-text comments]

## Plain IV Line Labelling Details

28. How are the IV tubing labels for plain IV lines made distinct from other IV tubing labels?
- ❒ Label is a different colour, but same material
- ❒ Label is a different material (e.g., tape instead of sticker)
- ❒ Other (please specify)
  [Respondent may enter free-text comments]

## IV Connectors

29. Which of the following connectors are used to connect continuous IV infusions together? Please select all that apply.
    - ❒ Multi-lead connectors (e.g., Y-style connector that can join 2 or more different infusions into 1 IV tube)
    - ❒ A rigid 1 piece multiport connector (e.g., bridge, manifolds)
    - ❒ 3-way stopcocks
    - ❒ The injection port on existing primary infusion tubing connected to patient
    - ❒ Other (please specify)
      [Respondent may enter free-text comments]

30. Are 3-way stopcocks commonly joined together to make a chain of stopcocks for the purposes of connecting multiple infusions to 1 IV access site?
    - ❒ Yes
    - ❒ No
    - ❒ 3-way stopcocks not used on the unit
    - ❒ Not sure

## Central Venous Pressure Monitoring

*31. Does your unit use central venous pressure monitoring?
    - ❒ Yes
    - ❒ No

## Use of Central Venous Pressure (CVP) Monitoring

32. If a transduced central venous pressure (CVP) monitoring line is in use, is it permissible for *continuous* IV medications to be infused through the CVP line?
    - ❒ Yes
    - ❒ No
    - ❒ Not sure
    - ❒ If yes, please list any IV fluid or medication exceptions, and why they are treated differently
      [Respondent may enter free-text comments]

33. If a transduced central venous pressure (CVP) monitoring line is in use, is it permissible for *intermittent* IV medications to be infused through the CVP line?
    - ❒ Yes
    - ❒ No
    - ❒ Not sure
    - ❒ If yes, please list any IV fluid or medication exceptions and why they are treated differently
      [Respondent may enter free-text comments]

34. Do you have any comments, suggestions, or concerns about how the CVP monitoring line is used to deliver IV medications?
    [Respondent may enter free-text comments]

## IV Large Volume and Syringe Pumps

*The following questions will refer to **large-volume (i.e., volumetric) IV infusion pumps** and **IV syringe infusion pumps**. Please use the following definitions when answering these survey questions.*

***Large-volume infusion pumps** deliver IV medications from bags or bottles. Infusion pumps used for trauma situations, patient controlled analgesia (PCA), enteral feeding and epidural delivery, and any other non-IV route pumps, should NOT be considered when answering survey questions pertaining to large volume infusion pumps.*

***IV syringe infusion pumps** deliver IV medications from syringes only. Please exclude IV PCA syringe pumps and any other non-IV route syringe pumps when answering survey questions pertaining to IV syringe pumps.*

## IV Pumps Used in the Unit

*35. Are large-volume (i.e., volumetric) IV infusion pumps and/or IV syringe pumps used on your unit?

- ❒ Yes
- ❒ No

## Details of the IV Infusion Pumps in Your Unit

*For the following questions, please provide answers for the answer fields that are relevant to you. For example, if you only have 1 IV infusion pump on your unit, please do not provide answers for "Pump 2" and "Pump 3."*

*If you have more than 1 pump on your unit, please identify which pump you have associated with Pumps 1, 2, and 3 so that they always refers to the same pump on your unit. You may wish to record this information in case you return to the survey at a later time and cannot remember what Pumps 1, 2, and 3 refer to.*

36. Please list the make and model of all IV infusion pump(s) in your unit (excluding IV PCA, enteral, epidural and any other non-IV infusion pumps).

- ❒ Pump 1: [Respondent may enter free-text comments]
- ❒ Pump 2: [Respondent may enter free-text comments]
- ❒ Pump 3: [Respondent may enter free-text comments]

37. Approximately how long has this pump model been used by the unit?

*Pump 1:*

- ❒ Less than 6 months
- ❒ 6 months to a year
- ❒ 1–2 years
- ❒ 3–5 years
- ❒ 5+ years
- ❒ Not sure

*Pump 2:*

- ❒ Less than 6 months
- ❒ 6 months to a year
- ❒ 1–2 years
- ❒ 3–5 years
- ❒ 5+ years
- ❒ Not sure

*Pump 3:*

- ❒ Less than 6 months
- ❒ 6 months to a year
- ❒ 1–2 years
- ❒ 3–5 years
- ❒ 5+ years
- ❒ Not sure

38. Do any of these pumps contain drug libraries (or dose error reduction systems [DERS])?
*Pumps with these features allow nurses to select a specific drug name from a drug library. The drug library is usually developed by the hospital. The pumps display warning limits when the dosage of infusions are outside of an appropriate range for that drug. These pumps are often referred to as* smart pumps.

Please select all pumps that have this capability.

- ❒ Pump 1
- ❒ Pump 2
- ❒ Pump 3

## Defining Secondary Infusions

*A* secondary infusion *(sometimes referred to as a* piggyback infusion*) is described below. Please answer questions referring to secondary infusions with this description in mind.*

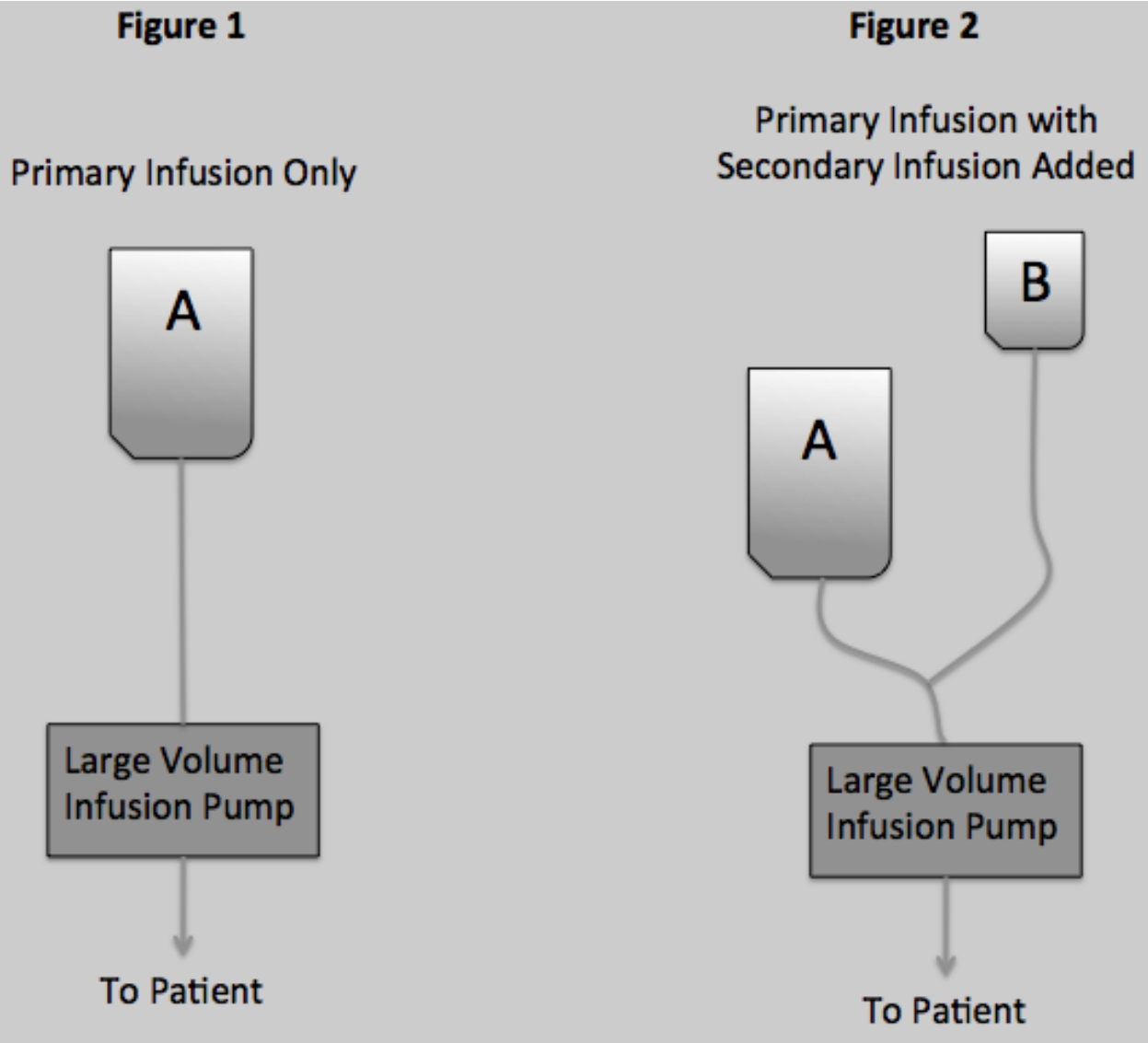


***Figure 1*** *depicts a typical IV infusion setup. The contents of IV bag A will be delivered to the patient at a controlled rate through a large volume infusion pump. This arrangement of components can be referred to as a primary infusion.*

***Figure 2*** *shows the addition of a secondary infusion. A new IV bag ("B") is hung higher than bag A, and is connected to the primary infusion with a short piece of IV tubing (a secondary infusion "set" or tubing). For some pumps (i.e., Hospira Plum A+), this bag height difference is not required.*

*This arrangement results in the contents of bag B being delivered first, followed by the contents of bag A, because gravity will preferentially draw fluid from the higher IV bag.*

*When there is no fluid left in bag B, gravity will ensure that the fluid in bag A will be drawn next, so no intervention is required from the nurse to manage the switchover.*

*It is important to note that the large-volume infusion pump must be programmed to deliver each bag at the appropriate volume rate. Typically a "secondary infusion mode" can be programmed with the pump such that after an appropriate volume has been infused (e.g., the volume of fluid in bag B), the pump will revert back to the appropriate infusion settings for bag A.*

*39. Does your unit administer medications via secondary infusions?

- ❒ Yes
- ❒ No
- ❒ Unit uses only syringe pumps

## Secondary Infusions—Policies

40. Does the large-volume IV pump tubing used in your unit have a back check (i.e., 1-way) valve to prevent fluid from a secondary infusion from traveling backwards up the primary tubing?

*Pump 1:*

- ❒ Secondary infusions not given on this pump
- ❒ Yes
- ❒ No
- ❒ Not sure

*Pump 2:*

- ❒ Secondary infusions not given on this pump
- ❒ Yes
- ❒ No
- ❒ Not sure

*Pump 3:*

- ❒ Secondary infusions not given on this pump
- ❒ Yes
- ❒ No
- ❒ Not sure

41. Does your unit allow secondary infusions to be attached to a high-alert medication delivered on a primary infusion? If yes, please provide 1 or more examples.

- ❒ Yes
- ❒ No
- ❒ Only if absolutely necessary (e.g., no other pumps or patient IV access to administer separately)
- ❒ Not sure
- ❒ Examples of drug/fluid combinations or other comments
  [Respondent may enter free-text comments]

42. On your unit, are continuous high-alert medications ever administered as secondary infusions? If yes, please provide 1 or more examples.
    - ❒ Yes
    - ❒ No
    - ❒ Only if absolutely necessary (e.g. no other pumps or patient IV access to administer separately)
    - ❒ Not sure
    - ❒ Examples of high alert medications infused as secondary infusions, or other comments. [Respondent may enter free-text comments]

43. Do you have any comments, suggestions, or concerns about secondary infusions and how they are expected to be used?
    [Respondent may enter free-text comments]

### Alternative Method of Delivering Intermittent or Single-Dose Meds

44. Given that your unit does not use secondary infusions, what is the standard work practice for delivering intermittent or single doses of IV medication?
    [Respondent may enter free-text comments]

### Patient Transfers

*45. When patients are transferred to your unit, does the transfer process ever require you to change the patient's IV tubing and/or move an infusion to a new infusion pump?
    - ❒ Yes
    - ❒ No
    - ❒ Not sure
    - ❒ My unit does not receive transfers (e.g. outpatient unit)
    - ❒ Other (please specify)
      [Respondent may enter free-text comments]

### Rationale for Pump or IV Tubing Change During/After Patient Transfer

46. Why are IV tubing or pump changes required on patient arrival to your unit? Please select all that apply.
    - ❒ Pumps from an outside unit must immediately return to their home unit for inventory control purposes
    - ❒ The pump contains only the drug libraries specific to their care area, and so the infusions must move to a pump with the appropriate drug library assigned to it
    - ❒ The drug library care area needs to be reselected, which requires a complete reprogramming of the pump, so it is easier to move the infusions to a new pump that can be set up in advance of the patient's arrival to the unit
    - ❒ The make and model of IV infusion pumps are different between clinical units, so infusions need to be changed to the receiving unit's pumps
    - ❒ The concentration of IV medications differs between units, so new IV bags or syringes need to be prepared and administered (requires new IV tubing)
    - ❒ The IV tubing and/or connectors that came with the patient are not compatible with the IV materials on your unit
    - ❒ It is easier to manage the IV tubing if new IV setups are done
    - ❒ Other
    - ❒ If other, please specify
      [Respondent may enter free-text comments]

47. Do you have any comments, suggestions, or concerns about how IV infusions are managed during patient transfers?
[Respondent may enter free-text comments]

## Bolus Usage

*For the purposes of this survey, questions about IV bolusing refer only to situations where an additional dose of a primary continuous infusion is administered.*

*For example, a patient receiving a continuous morphine infusion requires an additional dose for pain management support prior to having an invasive procedure.*

*Therefore, this discussion excludes the following IV administration techniques:*

- intermittent infusions (short infusions delivered on a recurring basis)
- loading doses (e.g., a "start-up" IV dose of medication delivered prior to an infusion of the same medication)
- an as-needed medication dose injected all at once, without a continuous infusion of the same medication running
- IV PCA doses

*48. Are IV boluses of continuous primary infusions ever administered on your unit?

- ❒ Yes
- ❒ No

## Availability of Pump Bolus Feature

*49. Do any of your IV infusion pumps have a built-in bolus feature?

- ❒ Yes
- ❒ No
- ❒ Not sure

## Bolus Features in Infusion Pump

50. Is the pump's bolus feature enabled for all drugs where administering a bolus is clinically appropriate and useful for your unit?

*Pump 1:*

- ❒ No bolus feature available on this pump
- ❒ Yes, enabled for ALL primary infusions
- ❒ Yes, only for clinically appropriate and useful drugs
- ❒ No, not enabled for some drugs
- ❒ Not sure

*Pump 2:*

- ❒ No bolus feature available on this pump
- ❒ Yes, enabled for ALL primary infusions
- ❒ Yes, only for clinically appropriate and useful drugs
- ❒ No, not enabled for some drugs
- ❒ Not sure

*Pump 3:*

- ❒ No bolus feature available on this pump
- ❒ Yes, enabled for ALL primary infusions
- ❒ Yes, only for clinically appropriate and useful drugs
- ❒ No, not enabled for some drugs
- ❒ Not sure

If no, why?
[Respondent may enter free-text comments]

51. Which of the following methods are used to deliver a bolus of medication already running as a primary continuous infusion? Please select all that apply.
    - ❒ Manual syringe injection of the bolus dose into a downstream medication port
    - ❒ Administration of the bolus as an intermittent secondary (piggyback) infusion
    - ❒ Program the bolus dose as a secondary infusion without hanging a secondary IV bag so that the bolus dose is drawn directly from the primary continuous IV bag
    - ❒ Programming a bolus dose using the pump's dedicated bolus feature
    - ❒ Manually hold the pump's prime/purge key
    - ❒ Manually increase the flow rate on the primary continuous infusion for the duration of the bolus
    - ❒ Other methods (please specify)
      [Respondent may enter free-text comments]

## Comments on Bolusing

52. Do you have any comments, suggestions, or concerns about bolus delivery of medication?
    [Respondent may enter free-text comments]

## Externally Applied Medication Labels on Infusion Pumps

*53. Is it standard work practice for nurses to add their own medication labels to the exterior of an infusion pump (i.e., handwritten tape or stickers)?
    - ❒ Yes
    - ❒ No, but many nurses choose to
    - ❒ No, and few nurses choose to
    - ❒ No, this practice discouraged by the unit

## Pump Labels Commonly Applied but Not Standard Work Practice

54. Why do nurses voluntarily add externally applied pump labels to infusion pumps?
    [Respondent may enter free-text comments]

55. What information is included on labels that are applied to the exterior of the pump? Please select all that apply.
    - ❒ Drug name
    - ❒ Drug concentration
    - ❒ IV access location (e.g., right IJ, prox/med/dist, etc.)
    - ❒ Volume rate (e.g., mL/h)
    - ❒ Dose rate (e.g., unit/h, mg/h, mcg/kg/h, etc.)
    - ❒ Other (please specify)
      [Respondent may enter free-text comments]

56. Is there a standard work practice for how and when to remove externally applied pump labels?

- ❒ Yes
- ❒ No

If yes, please describe (e.g., which staff member, what circumstances etc.)
[Respondent may enter free-text comments]

57. Do you have any comments, suggestions, or concerns about labels being applied to infusion pumps?
[Respondent may enter free-text comments]

## Your Thoughts on the Administration of Multiple IV Infusions

58. Do you have any other thoughts, suggestions, or concerns about how multiple IV infusions are administered?
[Respondent may enter free-text comments]

59. If you are comfortable sharing any incidents related to the administration of multiple IV infusions, please describe the circumstances and patient impact of these incidents.
[Respondent may enter free-text comments]

## End of Survey

Thank you very much for participating in our survey. Your confidential responses are important to improving the safety of multiple IV infusion therapy in Ontario.

When you click on the "Done" button below, you will no longer be able to change your answers and you will then be directed to our project website. This is where our overall study findings will be published, and where you can find further updates as our research progresses. Please note the web address for your own reference.

# Appendix 2: Data by Hospital Type and Clinical Unit

## Theme 1: Secondary Infusions

### Table A1: Back Check Valves—Compliance Question[a,b,c]

| Hospital Type and Clinical Unit | Secondary Infusions Not Given on This Pump | Yes | No | Not Sure | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **10 (67%)** | **3 (20%)** | **2 (13%)** | **15** |
| Adult ICU | — | 2 | — | — | 2 |
| Adult or pediatric oncology unit | — | — | 1 | — | 1 |
| Emergency department | — | 2 | 1 | 2 | 5 |
| Adult inpatient ward | — | 6 | 1 | — | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **4 (17%)** | **12 (52%)** | **2 (9%)** | **5 (22%)** | **23** |
| Adult ICU | 1 | 3 | — | 3 | 7 |
| Pediatric or neonatal ICU | — | 1 | — | 1 | 2 |
| Adult or pediatric oncology unit | — | 1 | — | — | 1 |
| Emergency department | 2 | 4 | 2 | — | 8 |
| Adult inpatient ward | 1 | 3 | — | 1 | 5 |
| **Academic Hospitals** | **2 (11%)** | **11 (61%)** | **2 (11%)** | **3 (17%)** | **18** |
| Adult ICU | — | 3 | — | 1 | 4 |
| Pediatric or neonatal ICU | — | 1 | — | 1 | 2 |
| Adult or pediatric oncology unit | 1 | 3 | — | — | 4 |
| Emergency department | 1 | 3 | 2 | 1 | 7 |
| Adult inpatient ward | — | 1 | — | — | 1 |
| **Total** | **6 (11%)** | **33 (59%)** | **7 (13%)** | **10 (18%)** | **56** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Does the large-volume IV pump tubing used in your unit have a back check (i.e., 1-way) valve to prevent fluid from a secondary infusion from travelling backwards up the primary tubing?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question. Seven of the 49 respondents had a second infusion pump used to administer secondary infusions, so this table reflects the number of responses rather than the number of respondents.

[c]Percentages may appear inexact due to rounding.

**Table A2: High-Alert Continuous IV Medications and Secondary Infusions—Compliance Question 1[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Only if Absolutely Necessary | Not Sure | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **5 (33%)** | **8 (53%)** | **1 (7%)** | **1 (7%)** | **15** |
| Adult ICU | — | 1 | 1 | — | 2 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 2 | 3 | — | — | 5 |
| Adult inpatient ward | 2 | 4 | — | 1 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **3 (17%)** | **12 (67%)** | **2 (11%)** | **1 (6%)** | **18** |
| Adult ICU | — | 5 | 1 | — | 6 |
| Pediatric or neonatal ICU | — | 1 | — | — | 1 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 2 | 3 | — | — | 5 |
| Adult inpatient ward | — | 3 | 1 | 1 | 5 |
| **Academic Hospitals** | **—** | **10 (67%)** | **4 (27%)** | **1 (7%)** | **15** |
| Adult ICU | — | 3 | — | 1 | 4 |
| Pediatric or neonatal ICU | — | 2 | — | — | 2 |
| Adult or pediatric oncology unit | — | 2 | 1 | — | 3 |
| Emergency department | — | 2 | 3 | — | 5 |
| Adult inpatient ward | — | 1 | — | — | 1 |
| **Total** | **8 (17%)** | **30 (63%)** | **7 (15%)** | **3 (6%)** | **48** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Does your unit allow secondary infusions to be attached to a high-alert medication delivered on a primary infusion?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A3: High-Alert Continuous IV Medications and Secondary Infusions—Compliance Question 2[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Only if Absolutely Necessary | Not Sure | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **4 (27%)** | **9 (60%)** | **—** | **2 (13%)** | **15** |
| Adult ICU | 1 | 1 | — | — | 2 |
| Adult or pediatric oncology unit | — | 1 | — | — | 1 |
| Emergency department | 1 | 3 | — | 1 | 5 |
| Adult inpatient ward | 2 | 4 | — | 1 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **5 (26%)** | **13 (68%)** | **1 (5%)** | **—** | **19** |
| Adult ICU | 1 | 5 | — | — | 6 |
| Pediatric or neonatal ICU | — | 1 | — | — | 1 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 1 | 5 | — | — | 6 |
| Adult inpatient ward | 2 | 2 | 1 | — | 5 |
| **Academic Hospitals** | **4 (27%)** | **9 (60%)** | **—** | **2 (13%)** | **15** |
| Adult ICU | — | 3 | — | 1 | 4 |
| Pediatric or neonatal ICU | — | 1 | — | 1 | 2 |
| Adult or pediatric oncology unit | 1 | 2 | — | — | 3 |
| Emergency department | 3 | 2 | — | — | 5 |
| Adult inpatient ward | — | 1 | — | — | 1 |
| **Total** | **13 (27%)** | **31 (63%)** | **1 (2%)** | **4 (8%)** | **49** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]On your unit, are continuous high-alert medications ever administered as secondary infusions?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A4: Secondary Infusion Usage—Practice Prevalence Question[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Unit Uses Only Syringe Pumps | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **16 (100%)** | — | — | **16** |
| Adult ICU | 2 | — | — | 2 |
| Adult or pediatric oncology unit | 1 | — | — | 1 |
| Emergency department | 5 | — | — | 5 |
| Adult inpatient ward | 8 | — | — | 8 |
| **Non-academic Hospitals With ≥ 100 Beds** | **19 (90%)** | **2 (10%)** | **—** | **21** |
| Adult ICU | 6 | — | — | 6 |
| Pediatric or neonatal ICU | 1 | 2 | — | 3 |
| Adult or pediatric oncology unit | 1 | — | — | 1 |
| Emergency department | 6 | — | — | 6 |
| Adult inpatient ward | 5 | — | — | 5 |
| **Academic Hospitals** | **15 (79%)** | **2 (11%)** | **2 (11%)** | **19** |
| Adult ICU | 4 | — | — | 4 |
| Pediatric or neonatal ICU | 2 | 2 | 1 | 5 |
| Adult or pediatric oncology unit | 3 | — | 1 | 4 |
| Emergency department | 5 | — | — | 5 |
| Adult inpatient ward | 1 | — | — | 1 |
| **Total** | **50 (89%)** | **4 (7%)** | **2 (4%)** | **56** |

Abbreviation: ICU, intensive care unit.
[a]Does your unit administer medications via secondary infusions?
[b]Percentages may appear inexact due to rounding.

## Theme 2: IV Line Identification

**Table A5: Labels Applied to IV Tubing—Practice Prevalence Question[a,b]**

| Hospital Type and Clinical Unit | Yes, All | Yes, Some Drugs/Fluids | No | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **8 (38%)** | **6 (29%)** | **7 (33%)** | **21** |
| Adult ICU | — | 2 | — | 2 |
| Adult or pediatric oncology unit | 1 | 1 | — | 2 |
| Emergency department | 2 | 1 | 3 | 6 |
| Adult inpatient ward | 5 | 2 | 4 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **11 (50%)** | **3 (14%)** | **8 (36%)** | **22** |
| Adult ICU | 1 | 2 | 3 | 6 |
| Pediatric or neonatal ICU | 2 | — | 1 | 3 |
| Adult or pediatric oncology unit | 1 | — | — | 1 |
| Emergency department | 2 | 1 | 3 | 6 |
| Adult inpatient ward | 5 | — | 1 | 6 |
| **Academic Hospitals** | **9 (43%)** | **8 (38%)** | **4 (19%)** | **21** |
| Adult ICU | 3 | — | 1 | 4 |
| Pediatric or neonatal ICU | 3 | 2 | — | 5 |
| Adult or pediatric oncology unit | 1 | 3 | 1 | 5 |
| Emergency department | 1 | 2 | 2 | 5 |
| Adult inpatient ward | 1 | 1 | — | 2 |
| **Total** | **28 (44%)** | **17 (27%)** | **19 (30%)** | **64** |

Abbreviation: ICU, intensive care unit; IV, intravenous.
[a]Is there a standard work practice in your unit that requires the contents of the IV tubing to be labelled?
[b]Percentages may appear inexact due to rounding.

**Table A6: Labels Applied to IV Tubing—Exploratory Question 1[a,b,c]**

| Hospital Type and Clinical Unit | Yes, as Part of Infusion Setup | Yes, as Soon as is Reasonable Given Other Work Demands | Yes, Within a Specified Period of Time After the Infusion Has Been Set Up | No | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **12 (86%)** | **—** | **—** | **2 (14%)** | **14** |
| Adult ICU | 1 | — | — | 1 | 2 |
| Adult or pediatric oncology unit | 1 | — | — | 1 | 2 |
| Emergency department | 3 | — | — | — | 3 |
| Adult inpatient ward | 7 | — | — | — | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **12 (86%)** | **2 (14%)** | **—** | **—** | **14** |
| Adult ICU | 3 | — | — | — | 3 |
| Pediatric or neonatal ICU | 2 | — | — | — | 2 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 3 | — | — | — | 3 |
| Adult inpatient ward | 3 | 2 | — | — | 5 |
| **Academic Hospitals** | **11 (69%)** | **—** | **1 (6%)** | **4 (25%)** | **16** |
| Adult ICU | 1 | — | — | 2 | 3 |
| Pediatric or neonatal ICU | 5 | — | — | — | 5 |
| Adult or pediatric oncology unit | 2 | — | — | 1 | 3 |
| Emergency department | 1 | — | 1 | 1 | 3 |
| Adult inpatient ward | 2 | — | — | — | 2 |
| **Total** | **35 (80%)** | **2 (5%)** | **1 (2%)** | **6 (14%)** | **44** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Does the standard work practice in your unit specify when labels should be applied to IV tubing?

[b]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A7: Labels Applied to IV Tubing—Exploratory Question 2[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **9 (64%)** | **5 (36%)** | **14** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 2 | — | 2 |
| Emergency department | 2 | 1 | 3 |
| Adult inpatient ward | 4 | 3 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **9 (64%)** | **5 (36%)** | **14** |
| Adult ICU | 2 | 1 | 3 |
| Pediatric or neonatal ICU | 2 | — | 2 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 1 | 2 | 3 |
| Adult inpatient ward | 3 | 2 | 5 |
| **Academic Hospitals** | **8 (50%)** | **8 (50%)** | **16** |
| Adult ICU | 2 | 1 | 3 |
| Pediatric or neonatal ICU | 4 | 1 | 5 |
| Adult or pediatric oncology unit | 1 | 2 | 3 |
| Emergency department | — | 3 | 3 |
| Adult inpatient ward | 1 | 1 | 2 |
| **Total** | **26 (59%)** | **18 (41%)** | **44** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Does the standard work practice in your unit specify the label location?

[b]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A8: Labels Applied to IV Tubing—Exploratory Question 3[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **12 (92%)** | **1 (8%)** | **13** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 2 | — | 2 |
| Emergency department | 3 | — | 3 |
| Adult inpatient ward | 6 | — | 6 |
| **Non-academic Hospitals With ≥ 100 Beds** | **12 (86%)** | **2 (14%)** | **14** |
| Adult ICU | 3 | — | 3 |
| Pediatric or neonatal ICU | 2 | — | 2 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 2 | 1 | 3 |
| Adult inpatient ward | 4 | 1 | 5 |
| **Academic Hospitals** | **8 (50%)** | **8 (50%)** | **16** |
| Adult ICU | 2 | 1 | 3 |
| Pediatric or neonatal ICU | 3 | 2 | 5 |
| Adult or pediatric oncology unit | 1 | 2 | 3 |
| Emergency department | — | 3 | 3 |
| Adult inpatient ward | 2 | — | 2 |
| **Total** | **32 (74%)** | **11 (26%)** | **43** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Does the standard work practice in your unit specify what materials should be used to label IV tubing?

[b]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A9: Labels Applied to IV Tubing—Exploratory Question 4[a,b,c]**

| Hospital Type and Clinical Unit | Tape (Handwritten) | Preprinted Stickers | IV Bag Labels | Blank Stickers (Handwritten) | Other[d] | Respondents |
|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **1 (7%)** | **3 (21%)** | **12 (86%)** | **8 (57%)** | **1 (7%)** | **14** |
| Adult ICU | 1 | 1 | 2 | 1 | — | 2 |
| Adult or pediatric oncology unit | — | — | 1 | 2 | — | 2 |
| Emergency department | — | — | 3 | 2 | — | 3 |
| Adult inpatient ward | — | 2 | 6 | 3 | 1 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **5 (36%)** | **11 (79%)** | **6 (43%)** | **5 (36%)** | **1 (7%)** | **14** |
| Adult ICU | — | 3 | 2 | 1 | 1 | 3 |
| Pediatric or neonatal ICU | — | 1 | 1 | 1 | — | 2 |
| Adult or pediatric oncology unit | — | 1 | — | — | — | 1 |
| Emergency department | 2 | 2 | 1 | 2 | — | 3 |
| Adult inpatient ward | 3 | 4 | 2 | 1 | — | 5 |
| **Academic Hospitals** | **7 (41%)** | **9 (53%)** | **9 (53%)** | **10 (59%)** | **1 (6%)** | **17** |
| Adult ICU | 2 | 1 | 2 | — | — | 3 |
| Pediatric or neonatal ICU | 1 | 3 | 2 | 5 | — | 5 |
| Adult or pediatric oncology unit | 2 | 2 | 2 | 2 | 1 | 4 |
| Emergency department | 2 | 1 | 3 | 2 | — | 3 |
| Adult inpatient ward | — | 2 | — | 1 | — | 2 |
| **Total** | **13 (29%)** | **23 (51%)** | **27 (60%)** | **23 (51%)** | **3 (7%)** | **45** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]What materials do nurses use to label IV tubing in your unit? Please select all that apply.

[b]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

[d]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. Any comments in this field were counted as a response.

**Table A10: Differences in Labelling for Plain IV Line Tubing—Compliance Question[a,b,c,d]**

| Hospital Type and Clinical Unit | Yes | No | Plain IV Lines Are Not Labelled on My Unit | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **6 (43%)** | **8 (57%)** | **14** |
| Adult ICU | — | — | 2 | 2 |
| Adult or pediatric oncology unit | — | 2 | — | 2 |
| Emergency department | — | 1 | 2 | 3 |
| Adult inpatient ward | — | 3 | 4 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **1 (7%)** | **10 (71%)** | **3 (21%)** | **14** |
| Adult ICU | — | 2 | 1 | 3 |
| Pediatric or neonatal ICU | — | 2 | — | 2 |
| Adult or pediatric oncology unit | 1 | — | — | 1 |
| Emergency department | — | 2 | 1 | 3 |
| Adult inpatient ward | — | 4 | 1 | 5 |
| **Academic Hospitals** | **1 (6%)** | **9 (56%)** | **6 (38%)** | **16** |
| Adult ICU | — | 2 | 1 | 3 |
| Pediatric or neonatal ICU | — | 2 | 3 | 5 |
| Adult or pediatric oncology unit | — | 2 | 1 | 3 |
| Emergency department | 1 | 1 | 1 | 3 |
| Adult inpatient ward | — | 2 | — | 2 |
| **Total** | **2 (5%)** | **25 (57%)** | **17 (39%)** | **44** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Is the IV tubing used for plain IV lines labelled differently than other IV tubing?

[b]Only respondents who answered "Yes, all" or "Yes, some drugs/fluids" to the practice prevalence question were shown this question.

[c]One answer category, "Plain IV lines are not used on my unit" was omitted from this table as no respondent selected this option.

[d]Percentages may appear inexact due to rounding.

**Table A11: Labels Applied to the Exterior of IV Infusion Pumps—Practice Prevalence Question[a,b]**

| Hospital Type and Clinical Unit | Yes | No, But Many Nurses Choose To | No, and Few Nurses Choose To | No, This Practice Discouraged by the Unit | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **6 (40%)** | **3 (20%)** | **1 (7%)** | **5 (33%)** | **15** |
| Adult ICU | — | 1 | — | 1 | 2 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 3 | 1 | — | 1 | 5 |
| Adult inpatient ward | 2 | 1 | 1 | 3 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **6 (29%)** | **4 (19%)** | **6 (29%)** | **5 (24%)** | **21** |
| Adult ICU | 1 | 2 | 2 | 1 | 6 |
| Pediatric or neonatal ICU | 3 | — | — | — | 3 |
| Adult or pediatric oncology unit | — | — | — | 1 | 1 |
| Emergency department | 1 | 2 | 2 | 1 | 6 |
| Adult inpatient ward | 1 | — | 2 | 2 | 5 |
| **Academic Hospitals** | **6 (32%)** | **4 (21%)** | **6 (32%)** | **3 (16%)** | **19** |
| Adult ICU | 3 | — | — | 1 | 4 |
| Pediatric or neonatal ICU | — | 2 | 1 | 2 | 5 |
| Adult or pediatric oncology unit | 1 | 1 | 2 | — | 4 |
| Emergency department | 1 | 1 | 3 | — | 5 |
| Adult inpatient ward | 1 | — | — | — | 1 |
| **Total** | **18 (33%)** | **11 (20%)** | **13 (24%)** | **13 (24%)** | **55** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Is it standard work practice for nurses to add their own medication labels to the exterior of an infusion pump (i.e., handwritten tape or stickers)?

[b]Percentages may appear inexact due to rounding.

**Table A12: Labels Applied to the Exterior of IV Infusion Pumps—Ad Hoc Pump Analysis of Practice Prevalence Question[a,b,c]**

| Hospital Type and Pump Type | Yes | No, But Many Nurses Choose To | No, and Few Nurses Choose To | No, This Practice Discouraged by the Unit | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **6 (40%)** | **3 (20%)** | **1 (7%)** | **5 (33%)** | **15** |
| Alaris infusion pump—fluid module, PCA | 3 | — | — | — | 3 |
| Alaris infusion pumps | — | — | — | 1 | 1 |
| B Braun Outlook 100 | — | — | 1 | — | 1 |
| Baxter Colleague Pump | — | — | — | 2 | 2 |
| Baxter IV pump | — | — | — | 1 | 1 |
| Braun Outlook 100 | — | 1 | — | — | 1 |
| Hospira Plum XL | 1 | — | — | — | 1 |
| Plum A | 1 | — | — | — | 1 |
| Plum XL | — | — | — | 1 | 1 |
| Plum XL from Abbott | — | 2 | — | — | 2 |
| (blank) | 1 | — | — | — | 1 |
| **Non-academic Hospitals With ≥ 100 Beds** | **6 (29%)** | **4 (19%)** | **6 (29%)** | **5 (24%)** | **21** |
| Baxter Colleague CXE 2M9161 | — | — | 1 | — | 1 |
| Baxter Colleague | 1 | 1 | — | — | 2 |
| Baxter Colleague Guardian | — | — | — | 1 | 1 |
| Baxter Colleague Pump | — | — | 1 | — | 1 |
| Baxter Colleague Guardian volumtetric 3cxe | — | — | — | 1 | 1 |
| Hospira | 2 | — | — | — | 2 |
| Hospira (Abbott) Plum A single pump | — | — | — | 1 | 1 |
| Hospira Abbott Plum A+ IV pump | — | — | 1 | — | 1 |
| Hospira Plum A | 1 | — | 1 | — | 2 |
| Hospira Plum A+ | — | 2 | — | 1 | 3 |
| Hospira Plum Set IV infusion pump | — | — | 1 | — | 1 |
| Hospira Plum smart pumps | 1 | — | — | — | 1 |
| Hospira single pump | — | — | 1 | — | 1 |
| Hospital plum a | — | — | — | 1 | 1 |
| IVAC pump | 1 | — | — | — | 1 |
| Sigma | — | 1 | — | — | 1 |
| **Academic Hospitals** | **6 (32%)** | **4 (21%)** | **6 (32%)** | **3 (16%)** | **19** |
| Alaris | — | 2 | 1 | 1 | 4 |
| Alaris (Care Fusion) Infusion Pump-Main Point of Care infusion pump | — | 1 | — | — | 1 |
| Alaris Medley | — | — | 1 | — | 1 |
| Alaris pump | — | 1 | — | — | 1 |
| Alaris pumps | 1 | — | — | — | 1 |

| Hospital Type and Pump Type | Yes | No, But Many Nurses Choose To | No, and Few Nurses Choose To | No, This Practice Discouraged by the Unit | Total |
|---|---|---|---|---|---|
| Alaris IV Pump System with Guardrails Dose Error Reduction Software | — | — | 1 | — | 1 |
| Carefusion (Alaris) Large volume pump 8100 series | — | — | — | 1 | 1 |
| Graseby 3000 | 1 | — | 1 | — | 2 |
| Graseby pump | 2 | — | — | — | 2 |
| Graseby pump by Smiths Medical | — | — | 1 | — | 1 |
| Hospira | — | — | — | 1 | 1 |
| Hospira 8080 | 1 | — | — | — | 1 |
| Hospira Symbiq large-volume pump | — | — | 1 | — | 1 |
| Plum A | 1 | — | — | — | 1 |
| **Total** | **18 (33%)** | **11 (20%)** | **13 (24%)** | **13 (24%)** | **55** |

Abbreviation: IV, intravenous; PCA, patient-controlled analgesia.

[a]Is it standard work practice for nurses to add their own medication labels to the exterior of an infusion pump (i.e., handwritten tape or stickers)?

[b]Only the first IV infusion pump listed by the respondent was used for this table; responses are direct transcriptions.

[b]Percentages may appear inexact due to rounding.

**Table A13: Labels Applied to the Exterior of IV Infusion Pumps—Exploratory Question 1[a,b]**

| Hospital Type and Clinical Unit | Drug Name | Drug Concentration | IV Access Location | Volume Rate | Dose Rate | Other | Respondents |
|---|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **7 (78%)** | **6 (67%)** | **1 (11%)** | **1 (11%)** | **5 (56%)** | **3 (33%)** | **9** |
| Adult ICU | 1 | — | 1 | — | — | — | 1 |
| Adult or pediatric oncology unit | 1 | 1 | — | — | 1 | — | 1 |
| Emergency department | 3 | 3 | — | 1 | 3 | 1 | 4 |
| Adult inpatient ward | 2 | 2 | — | — | 1 | 2 | 3 |
| **Non-academic Hospitals With ≥ 100 Beds** | **10 (100%)** | **5 (50%)** | **2 (20%)** | **1 (10%)** | **4 (40%)** | **2 (20%)** | **10** |
| Adult ICU | 3 | 1 | 1 | — | — | — | 3 |
| Pediatric or neonatal ICU | 3 | 3 | — | — | 2 | 1 | 3 |
| Adult or pediatric oncology unit | 0 | — | — | — | — | — | 0 |
| Emergency department | 3 | 1 | 1 | — | 1 | 1 | 3 |
| Adult inpatient ward | 1 | — | — | 1 | 1 | — | 1 |
| **Academic Hospitals** | **10 (100%)** | **3 (30%)** | **2 (20%)** | **2 (20%)** | **1 (10%)** | **1 (10%)** | **10** |
| Adult ICU | 3 | 1 | 1 | 1 | — | — | 3 |
| Pediatric or neonatal ICU | 2 | — | — | — | — | — | 2 |
| Adult or pediatric oncology unit | 2 | — | — | — | — | 1 | 2 |
| Emergency department | 2 | 1 | 1 | — | — | — | 2 |
| Adult inpatient ward | 1 | 1 | — | 1 | 1 | — | 1 |
| **Total** | **27 (93%)** | **14 (48%)** | **5 (17%)** | **4 (14%)** | **10 (34%)** | **6 (20%)** | **29** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]What information is included on labels that are applied to the exterior of the pump? Please select all that apply.

[b]Only respondents who indicated that it was standard work practice to label IV infusion pumps (or many nurses chose to) were shown this question.

[c]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

**Table A14: Labels Applied to the Exterior of IV Infusion Pumps—Exploratory Question 2[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **9 (100%)** | **9** |
| Adult ICU | — | 1 | 1 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | — | 4 | 4 |
| Adult inpatient ward | — | 3 | 3 |
| **Non-academic Hospitals With ≥ 100 Beds** | **3 (30%)** | **7 (70%)** | **10** |
| Adult ICU | 1 | 2 | 3 |
| Pediatric or neonatal ICU | 2 | 1 | 3 |
| Adult or pediatric oncology unit | — | — | 0 |
| Emergency department | — | 3 | 3 |
| Adult inpatient ward | — | 1 | 1 |
| **Academic Hospitals** | **2 (20%)** | **8 (80%)** | **10** |
| Adult ICU | 1 | 2 | 3 |
| Pediatric or neonatal ICU | — | 2 | 2 |
| Adult or pediatric oncology unit | 1 | 1 | 2 |
| Emergency department | — | 2 | 2 |
| Adult inpatient ward | — | 1 | 1 |
| **Total** | **5 (17%)** | **24 (83%)** | **29** |

Abbreviation: ICU, intensive care unit; IV, intravenous.
[a]Is there a standard work practice for how and when to remove externally applied pump labels?
[b]Only respondents who indicated that it was standard work practice to label IV infusion pumps (or many nurses chose to) were shown this question.
[c]Percentages may appear inexact due to rounding.

**Table A15: Shift Handover Practices—Practice Prevalence Question[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Outpatient Unit (No Shift Handovers) | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **20 (95%)** | **—** | **1 (5%)** | **21** |
| Adult ICU | 2 | — | — | 2 |
| Adult or pediatric oncology unit | 1 | — | 1 | 2 |
| Emergency department | 6 | — | — | 6 |
| Adult inpatient ward | 11 | — | — | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **21 (95%)** | **—** | **1 (5%)** | **22** |
| Adult ICU | 6 | — | — | 6 |
| Pediatric or neonatal ICU | 3 | — | — | 3 |
| Adult or pediatric oncology unit | — | — | 1 | 1 |
| Emergency department | 6 | — | — | 6 |
| Adult inpatient ward | 6 | — | — | 6 |
| **Academic Hospitals** | **19 (90%)** | **1 (5%)** | **1 (5%)** | **21** |
| Adult ICU | 4 | — | — | 4 |
| Pediatric or neonatal ICU | 5 | — | — | 5 |
| Adult or pediatric oncology unit | 4 | — | 1 | 5 |
| Emergency department | 4 | 1 | — | 5 |
| Adult inpatient ward | 2 | — | — | 2 |
| **Total** | **60 (94%)** | **1 (1%)** | **3 (5%)** | **64** |

Abbreviation: ICU, intensive care unit.

[a]Is there a formal shift handover process between bedside nurses on your unit?

[b]Percentages may appear inexact due to rounding.

**Table A16: Shift Handover Practices—Exploratory Question 1[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **11 (55%)** | **9 (45%)** | **20** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 3 | 3 | 6 |
| Adult inpatient ward | 6 | 5 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **18 (86%)** | **3 (14%)** | **21** |
| Adult ICU | 6 | — | 6 |
| Pediatric or neonatal ICU | 2 | 1 | 3 |
| Adult or pediatric oncology unit | — | — | 0 |
| Emergency department | 5 | 1 | 6 |
| Adult inpatient ward | 5 | 1 | 6 |
| **Academic Hospitals** | **15 (79%)** | **4 (21%)** | **19** |
| Adult ICU | 2 | 2 | 4 |
| Pediatric or neonatal ICU | 5 | — | 5 |
| Adult or pediatric oncology unit | 4 | — | 4 |
| Emergency department | 2 | 2 | 4 |
| Adult inpatient ward | 2 | — | 2 |
| **Total** | **44 (73%)** | **16 (27%)** | **60** |

Abbreviation: ICU, intensive care unit.

[a]Are bedside nurses provided with a documentation tool that was designed specifically to support shift handover?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A17: Shift Handover Practices—Exploratory Question 2[a,b,c,d]**

| Hospital Type and Clinical Unit | Paper-Based Tool for Nurses to Complete by Hand | Computer-Based Form to be Completed Electronically | Audio Recorder | Other[e] | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **2 (18%)** | **1 (9%)** | **7 (64%)** | **1 (9%)** | **11** |
| Adult ICU | — | — | 1 | — | 1 |
| Adult or pediatric oncology unit | — | — | 1 | — | 1 |
| Emergency department | — | — | 2 | 1 | 3 |
| Adult inpatient ward | 2 | 1 | 3 | — | 6 |
| **Non-academic Hospitals With ≥ 100 Beds** | **11 (61%)** | **7 (39%)** | **—** | **—** | **18** |
| Adult ICU | 5 | 1 | — | — | 6 |
| Pediatric or neonatal ICU | — | 2 | — | — | 2 |
| Adult or pediatric oncology unit | — | — | — | — | 0 |
| Emergency department | 4 | 1 | — | — | 5 |
| Adult inpatient ward | 2 | 3 | — | — | 5 |
| **Academic Hospitals** | **7 (47%)** | **4 (27%)** | **2 (13%)** | **2 (13%)** | **15** |
| Adult ICU | 1 | 1 | — | — | 2 |
| Pediatric or neonatal ICU | 2 | 2 | — | 1 | 5 |
| Adult or pediatric oncology unit | 2 | — | 2 | — | 4 |
| Emergency department | — | 1 | — | 1 | 2 |
| Adult inpatient ward | 2 | — | — | — | 2 |
| **Total** | **20 (45%)** | **12 (27%)** | **9 (20%)** | **3 (7%)** | **44** |

Abbreviation: ICU, intensive care unit.

[a]What is the documentation tool?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]One answer category, "Whiteboard," was omitted from this table, as no respondent selected this option.

[d]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. The intention of this question was for respondents to select a single answer. Nineteen respondents provided comments in this free-text category, but only 3 respondents did not have a concurrent response in 1 of the other answer categories. To avoid double-counting respondents, only these 3 respondents are shown in the table.

[e]Percentages may appear inexact due to rounding.

**Table A18: Shift Handover Practices—Exploratory Question 3[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **1 (9%)** | **9 (82%)** | **1 (9%)** | **11** |
| Adult ICU | — | 1 | — | 1 |
| Adult or pediatric oncology unit | — | 1 | — | 1 |
| Emergency department | — | 3 | — | 3 |
| Adult inpatient ward | 1 | 4 | 1 | 6 |
| **Non-academic Hospitals With ≥ 100 Beds** | **5 (28%)** | **13 (72%)** | **—** | **18** |
| Adult ICU | 1 | 5 | — | 6 |
| Pediatric or neonatal ICU | 1 | 1 | — | 2 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | 1 | 4 | — | 5 |
| Adult inpatient ward | 2 | 3 | — | 5 |
| **Academic Hospitals** | **3 (20%)** | **12 (80%)** | **—** | **15** |
| Adult ICU | 1 | 1 | — | 2 |
| Pediatric or neonatal ICU | 2 | 3 | — | 5 |
| Adult or pediatric oncology unit | — | 4 | — | 4 |
| Emergency department | — | 2 | — | 2 |
| Adult inpatient ward | — | 2 | — | 2 |
| **Total** | **9 (20%)** | **34 (77%)** | **1 (2%)** | **44** |

Abbreviation: ICU, intensive care unit.
[a]Does the shift handover tool become a formal part of the patient's chart?
[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.
[c]Percentages may appear inexact due to rounding.

**Table A19: Shift Handover Practices—Exploratory Question 4[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **20 (100%)** | **20** |
| Adult ICU | — | 2 | 2 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | — | 6 | 6 |
| Adult inpatient ward | — | 11 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **14 (67%)** | **7 (33%)** | **21** |
| Adult ICU | 5 | 1 | 6 |
| Pediatric or neonatal ICU | 3 | — | 3 |
| Adult or pediatric oncology unit | — | — | 0 |
| Emergency department | 2 | 4 | 6 |
| Adult inpatient ward | 4 | 2 | 6 |
| **Academic Hospitals** | **10 (53%)** | **9 (47%)** | **19** |
| Adult ICU | 3 | 1 | 4 |
| Pediatric or neonatal ICU | 5 | — | 5 |
| Adult or pediatric oncology unit | 1 | 3 | 4 |
| Emergency department | 1 | 3 | 4 |
| Adult inpatient ward | — | 2 | 2 |
| **Total** | **24 (40%)** | **36 (60%)** | **60** |

Abbreviation: ICU, intensive care unit.
[a]Is it standard work practice to conduct handover at the patient's bedside?
[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.
[c]Percentages may appear inexact due to rounding.

**Table A20: Shift Handover Practices—Exploratory Question 5[a,b,c]**

| Hospital Type and Clinical Unit | List of IV Drugs Being Infused | Presence of a Plain IV Line | Location of a Plain IV Line | IV Access Sites (Location) | IV Access Sites (Condition) | Infusion Pump Settings | All Medication Orders, or Changes to Medication Orders if Patient Cared for in Previous Shift | Other | Respondents |
|---|---|---|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **13 (65%)** | **16 (80%)** | **6 (30%)** | **6 (30%)** | **10 (50%)** | **17 (85%)** | **14 (70%)** | **6 (30%)** | **20** |
| Adult ICU | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 1 | 1 | — | — | — | 1 | 1 | — | 1 |
| Emergency department | 6 | 5 | 2 | 1 | 1 | 5 | 5 | 2 | 6 |
| Adult inpatient ward | 5 | 8 | 3 | 3 | 7 | 9 | 7 | 3 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **17 (81%)** | **17 (81%)** | **14 (67%)** | **15 (71%)** | **15 (71%)** | **15 (71%)** | **14 (67%)** | **6 (29%)** | **21** |
| Adult ICU | 5 | 3 | 3 | 4 | 4 | 4 | 5 | 4 | 6 |
| Pediatric or neonatal ICU | 2 | 3 | 3 | 3 | 3 | 2 | 2 | — | 3 |
| Adult or pediatric oncology unit | — | — | — | — | — | — | — | — | 0 |
| Emergency department | 6 | 5 | 3 | 4 | 5 | 4 | 5 | 1 | 6 |
| Adult inpatient ward | 4 | 6 | 5 | 4 | 3 | 5 | 2 | 1 | 6 |
| **Academic Hospitals** | **14 (74%)** | **16 (84%)** | **14 (74%)** | **16 (84%)** | **16 (84%)** | **15 (79%)** | **13 (68%)** | **6 (32%)** | **19** |
| Adult ICU | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 |
| Pediatric or neonatal ICU | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 5 |
| Adult or pediatric oncology unit | 2 | 1 | 1 | 3 | 2 | 2 | 1 | 2 | 4 |
| Emergency department | 3 | 4 | 2 | 2 | 4 | 3 | 3 | 1 | 4 |
| Adult inpatient ward | — | 2 | 2 | 2 | 1 | 1 | — | — | 2 |
| **Total** | **44 (73%)** | **49 (82%)** | **34 (57%)** | **37 (62%)** | **41 (68%)** | **47 (78%)** | **41 (68%)** | **18 (30%)** | **60** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]What information is exchanged during shift handover in regards to the patient's IV therapy? Please select all that apply.

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

[d]This was not a selectable option; it was a free-text field that any respondent could use to provide additional details. Since respondents were allowed to select more than 1 answer in this category, any comments in this field were counted as a response.

**Table A21: Shift Handover Practices—Exploratory Question 6[a,b,c,d]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **1 (5%)** | **19 (95%)** | **20** |
| Adult ICU | — | 2 | 2 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | — | 6 | 6 |
| Adult inpatient ward | 1 | 10 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **5 (24%)** | **16 (76%)** | **21** |
| Adult ICU | — | 6 | 6 |
| Pediatric or neonatal ICU | 2 | 1 | 3 |
| Adult or pediatric oncology unit | — | — | 0 |
| Emergency department | 1 | 5 | 6 |
| Adult inpatient ward | 2 | 4 | 6 |
| **Academic Hospitals** | **7 (37%)** | **12 (63%)** | **19** |
| Adult ICU | 1 | 3 | 4 |
| Pediatric or neonatal ICU | 4 | 1 | 5 |
| Adult or pediatric oncology unit | 1 | 3 | 4 |
| Emergency department | 1 | 3 | 4 |
| Adult inpatient ward | — | 2 | 2 |
| **Total** | **13 (22%)** | **47 (78%)** | **60** |

Abbreviation: ICU, intensive care unit.

[a]Is it standard work practice for the outgoing nurse to physically point out the contents of each IV tube at each patient IV access device during handover?

[b]Only respondents who answered "Yes" to the practice prevalence question were shown this question.

[c]One answer category, "Other (please specify)" was omitted from this table. It was not a selectable option; it was a free-text field that any respondent could use to provide additional details. The intention of this question was for respondents to select a single answer. Twelve respondents left a comment in this field, either describing exceptions to their answer choice (e.g., only if patient was critical and had multiple IV infusions, high-alert drugs only).

[d]Percentages may appear inexact due to rounding.

## Theme 3: IV Line Setup and Removal

**Table A22: Patient Transfers—Practice Prevalence Question[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Not Sure | My Unit Does Not Receive Transfers | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **6 (40%)** | **8 (53%)** | **—** | **1 (7%)** | **15** |
| Adult ICU | 2 | — | — | — | 2 |
| Adult or pediatric oncology unit | — | 1 | — | — | 1 |
| Emergency department | 2 | 2 | — | 1 | 5 |
| Adult inpatient ward | 2 | 5 | — | — | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **13 (62%)** | **3 (14%)** | **1 (5%)** | **4 (19%)** | **21** |
| Adult ICU | 5 | 1 | — | — | 6 |
| Pediatric or neonatal ICU | 3 | — | — | — | 3 |
| Adult or pediatric oncology unit | — | — | — | 1 | 1 |
| Emergency department | 1 | 1 | 1 | 3 | 6 |
| Adult inpatient ward | 4 | 1 | — | — | 5 |
| **Academic Hospitals** | **13 (68%)** | **6 (32%)** | **—** | **—** | **19** |
| Adult ICU | 2 | 2 | — | — | 4 |
| Pediatric or neonatal ICU | 3 | 2 | — | — | 5 |
| Adult or pediatric oncology unit | 2 | 2 | — | — | 4 |
| Emergency department | 5 | — | — | — | 5 |
| Adult inpatient ward | 1 | — | — | — | 1 |
| **Total** | **32 (58%)** | **17 (31%)** | **1 (2%)** | **5 (9%)** | **55** |

Abbreviation: ICU, intensive care unit.

[a]When patients are transferred to your unit, does the transfer process ever require you to change the patient's IV tubing and/or move an infusion to a new infusion pump?

[b]Percentages may appear inexact due to rounding.

**Table A23: Patient Transfers—Exploratory Question[a,b,c,d]**

| Hospital Type and Clinical Unit | Pumps Must Return to Home Unit for Inventory Control Purposes | Drug Library Is Specific to Each Care Area, so Must Use New Pump | Easier to Move to New Pump Than Reselect Drug Library | Pump Make and Model Differs Between Units | Concentrations Differ Between Units | Tubing or Connectors Are Incompatible | Easier to Manage a New IV Setup Than Use Existing Setup | Other | Respondents |
|---|---|---|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **4 (67%)** | **1 (17%)** | **—** | **—** | **—** | **3 (50%)** | **—** | **2 (33%)** | **6** |
| Adult ICU | 1 | 1 | — | — | — | 1 | — | 1 | 2 |
| Adult or pediatric oncology unit | — | — | — | — | — | — | — | — | 0 |
| Emergency department | 2 | — | — | — | — | 2 | — | — | 2 |
| Adult inpatient ward | 1 | — | — | — | — | — | — | 1 | 2 |
| **Non-academic Hospitals With ≥ 100 Beds** | **9 (64%)** | **4 (29%)** | **2 (14%)** | **4 (29%)** | **2 (14%)** | **5 (36%)** | **—** | **1 (7%)** | **14** |
| Adult ICU | 3 | 1 | — | 2 | 1 | 2 | — | — | 5 |
| Pediatric or neonatal ICU | 3 | 1 | — | 1 | 1 | 1 | — | 1 | 3 |
| Adult or pediatric oncology unit | — | — | — | — | — | — | — | — | 0 |
| Emergency department | 1 | 1 | 1 | 1 | — | 1 | — | — | 2 |
| Adult inpatient ward | 2 | 1 | 1 | — | — | 1 | — | — | 4 |
| **Academic Hospitals** | **3 (23%)** | **3 (23%)** | **4 (31%)** | **2 (15%)** | **4 (31%)** | **3 (23%)** | **1 (8%)** | **4 (31%)** | **13** |
| Adult ICU | — | — | — | 1 | 1 | 1 | — | — | 2 |
| Pediatric or neonatal ICU | — | 2 | 2 | — | 2 | — | — | 1 | 3 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 | — | 1 | — | 2 |
| Emergency department | 1 | 1 | 2 | 1 | — | 2 | — | 3 | 5 |
| Adult inpatient ward | 1 | — | — | — | — | — | — | — | 1 |
| **Total** | **16 (48%)** | **8 (24%)** | **6 (18%)** | **6 (18%)** | **6 (18%)** | **11 (33%)** | **1 (3%)** | **7 (21%)** | **33** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Why are IV tubing or pump changes required on patient arrival to your unit? Please select all that apply.

[b]Only respondents who answered "Yes" or "Not sure" to the practice prevalence question were shown this question.

[c]Answer text has been shortened from the original for formatting reasons. Please see Appendix 1, Question 46, for the original text.

[d]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

**Table A24: Availability and Usage of IV Connectors—Compliance Question[a]**

| Hospital Type and Clinical Unit | Yes | No | 3-Way Stopcocks Are Not Used on the Unit | Not Sure | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **17 (85%)** | **3 (15%)** | **—** | **20** |
| Adult ICU | — | 2 | — | — | 2 |
| Adult or pediatric oncology unit | — | 1 | 1 | — | 2 |
| Emergency department | — | 6 | — | — | 6 |
| Adult inpatient ward | — | 8 | 2 | — | 10 |
| **Non-academic Hospitals With ≥ 100 Beds** | **1 (5%)** | **17 (77%)** | **4 (18%)** | **—** | **22** |
| Adult ICU | 1 | 4 | 1 | — | 6 |
| Pediatric or neonatal ICU | — | 3 | — | — | 3 |
| Adult or pediatric oncology unit | — | 1 | — | — | 1 |
| Emergency department | — | 5 | 1 | — | 6 |
| Adult inpatient ward | — | 4 | 2 | — | 6 |
| **Academic Hospitals** | **3 (15%)** | **12 (60%)** | **4 (20%)** | **1 (5%)** | **20** |
| Adult ICU | 1 | 2 | — | 1 | 4 |
| Pediatric or neonatal ICU | 2 | 3 | — | — | 5 |
| Adult or pediatric oncology unit | — | 3 | 1 | — | 4 |
| Emergency department | — | 4 | 1 | — | 5 |
| Adult inpatient ward | — | — | 2 | — | 2 |
| **Total** | **4 (6%)** | **46 (74%)** | **11 (18%)** | **1 (2%)** | **62** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Are 3-way stopcocks commonly joined together to make a chain of stopcocks for the purposes of connecting multiple infusions to 1 IV access site?

[b]Percentages may appear inexact due to rounding.

**Table A25: Availability and Usage of IV Connectors—Exploratory Question[a,b,c,d]**

| Hospital Type and Clinical Unit | Multi-Lead Connectors | Rigid 1-Piece Multiport Connector | 3-Way Stopcocks | Injection Port on Existing Primary Infusion Tubing Connected to Patient | Respondents |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **8 (38%)** | **2 (10%)** | **2 (10%)** | **21 (100%)** | **21** |
| Adult ICU | 1 | — | 1 | 2 | 2 |
| Adult or pediatric oncology unit | 2 | — | — | 2 | 2 |
| Emergency department | 2 | 1 | — | 6 | 6 |
| Adult inpatient ward | 3 | 1 | 1 | 11 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **17 (77%)** | **4 (18%)** | **5 (23%)** | **13 (59%)** | **22** |
| Adult ICU | 5 | 2 | 2 | 2 | 6 |
| Pediatric or neonatal ICU | 3 | 1 | 2 | 2 | 3 |
| Adult or pediatric oncology unit | 1 | — | — | — | 1 |
| Emergency department | 6 | 1 | 1 | 5 | 6 |
| Adult inpatient ward | 2 | — | — | 4 | 6 |
| **Academic Hospitals** | **13 (62%)** | **4 (19%)** | **12 (57%)** | **13 (62%)** | **21** |
| Adult ICU | 2 | 3 | 3 | 2 | 4 |
| Pediatric or neonatal ICU | 5 | 1 | 5 | 4 | 5 |
| Adult or pediatric oncology unit | 3 | — | — | 1 | 5 |
| Emergency department | 2 | — | 4 | 5 | 5 |
| Adult inpatient ward | 1 | — | — | 1 | 2 |
| **Total** | **38 (59%)** | **10 (16%)** | **19 (30%)** | **47 (73%)** | **64** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Which of the following connectors are used to connect continuous IV infusions together? Please select all that apply.

[b]Since some respondents could have chosen none of the answer categories, it is unclear how many respondents saw the question but did not select any of the options. For simplicity, a full complement of 64 respondents is assumed.

[c]One answer category, "Other (please specify)," was omitted from this table because it was an optional free-text field where respondents could provide further details about how the connectors available in the unit were used.

[d]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

## Theme 4: Dead Volume Management

### Table A26: CVP Monitoring—Exploratory Question[a,b]

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **2 (10%)** | **19 (90%)** | **21** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | — | 2 | 2 |
| Emergency department | 1 | 5 | 6 |
| Adult inpatient ward | — | 11 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **8 (36%)** | **14 (64%)** | **22** |
| Adult ICU | 6 | — | 6 |
| Pediatric or neonatal ICU | 1 | 2 | 3 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | 1 | 5 | 6 |
| Adult inpatient ward | — | 6 | 6 |
| **Academic Hospitals** | **7 (35%)** | **13 (65%)** | **20** |
| Adult ICU | 4 | — | 4 |
| Pediatric or neonatal ICU | 3 | 2 | 5 |
| Adult or pediatric oncology unit | — | 4 | 4 |
| Emergency department | — | 5 | 5 |
| Adult inpatient ward | — | 2 | 2 |
| **Total** | **17 (27%)** | **46 (73%)** | **63** |

Abbreviation: CVP, central venous pressure; ICU, intensive care unit.
[a]Does your unit use central venous pressure monitoring?
[b]Percentages may appear inexact due to rounding.

**Table A27: CVP Monitoring—Practice Prevalence Question 1[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **1 (50%)** | **—** | **1 (50%)** | **2** |
| Adult ICU | — | — | 1 | 1 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | 1 | — | — | 1 |
| Adult inpatient ward | — | — | — | 0 |
| **Non-academic Hospitals With ≥ 100 Beds** | **4 (50%)** | **4 (50%)** | **—** | **8** |
| Adult ICU | 3 | 3 | — | 6 |
| Pediatric or neonatal ICU | 1 | — | — | 1 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | — | 1 | — | 1 |
| Adult inpatient ward | — | — | — | 0 |
| **Academic Hospitals** | **4 (57%)** | **2 (29%)** | **1 (14%)** | **7** |
| Adult ICU | 2 | 1 | 1 | 4 |
| Pediatric or neonatal ICU | 2 | 1 | — | 3 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | — | — | — | 0 |
| Adult inpatient ward | — | — | — | 0 |
| **Total** | **9 (53%)** | **6 (35%)** | **2 (12%)** | **17** |

Abbreviation: CVP, central venous pressure; ICU, intensive care unit.

[a]If a transduced central venous pressure (CVP) monitoring line is in use, is it permissible for *continuous* IV medications to be infused through the CVP line?

[b]Only respondents who answered "Yes" to the exploratory question were shown this question.

[c]Percentages may appear inexact due to rounding.

**Table A28: CVP Monitoring—Practice Prevalence Question 2[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **1 (50%)** | **—** | **1 (50%)** | **2** |
| Adult ICU | — | — | 1 | 1 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | 1 | — | — | 1 |
| Adult inpatient ward | — | — | — | 0 |
| **Non-academic Hospitals With ≥ 100 Beds** | **6 (75%)** | **1 (13%)** | **1 (13%)** | **8** |
| Adult ICU | 5 | — | 1 | 6 |
| Pediatric or neonatal ICU | — | 1 | — | 1 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | 1 | — | — | 1 |
| Adult inpatient ward | — | — | — | 0 |
| **Academic Hospitals** | **6 (86%)** | **—** | **1 (14%)** | **7** |
| Adult ICU | 3 | — | 1 | 4 |
| Pediatric or neonatal ICU | 3 | — | — | 3 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | — | — | — | 0 |
| Adult inpatient ward | — | — | — | 0 |
| **Total** | **13 (76%)** | **1 (6%)** | **3 (18%)** | **17** |

Abbreviation: CVP, central venous pressure; ICU, intensive care unit.

[a]If a transduced central venous pressure (CVP) monitoring line is in use, is it permissible for *intermittent* IV medications to be infused through the CVP line?

[b]Only respondents who answered "Yes" to the exploratory question were shown this question.

[c]Percentages may appear inexact due to rounding.

## Theme 5: IV Bolus Administration

**Table A29: IV Bolus Administration—Practice Prevalence Question 1[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **11 (73%)** | **4 (27%)** | **15** |
| Adult ICU | — | 2 | 2 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 4 | 1 | 5 |
| Adult inpatient ward | 6 | 1 | 7 |
| **Non-academic Hospitals With ≥ 100 Beds** | **13 (62%)** | **8 (38%)** | **21** |
| Adult ICU | 6 | — | 6 |
| Pediatric or neonatal ICU | 1 | 2 | 3 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 4 | 2 | 6 |
| Adult inpatient ward | 1 | 4 | 5 |
| **Academic Hospitals** | **17 (89%)** | **2 (11%)** | **19** |
| Adult ICU | 4 | — | 4 |
| Pediatric or neonatal ICU | 5 | — | 5 |
| Adult or pediatric oncology unit | 3 | 1 | 4 |
| Emergency department | 5 | — | 5 |
| Adult inpatient ward | — | 1 | 1 |
| **Total** | **41 (75%)** | **14 (25%)** | **55** |

Abbreviation: ICU, intensive care unit; IV, intravenous.
[a]Are IV boluses of continuous primary infusions ever administered on your unit?
[b]Percentages may appear inexact due to rounding.

**Table A30: IV Bolus Administration—Practice Prevalence Question 2[a,b,c]**

| Hospital Type and Clinical Unit | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **7 (64%)** | **4 (36%)** | **—** | **11** |
| Adult ICU | 1 | — | — | 1 |
| Adult or pediatric oncology unit | — | — | — | 0 |
| Emergency department | 2 | 2 | — | 4 |
| Adult inpatient ward | 4 | 2 | — | 6 |
| **Non-academic Hospitals With ≥ 100 Beds** | **8 (62%)** | **4 (31%)** | **1 (8%)** | **13** |
| Adult ICU | 3 | 2 | 1 | 6 |
| Pediatric or neonatal ICU | 1 | — | — | 1 |
| Adult or pediatric oncology unit | — | 1 | — | 1 |
| Emergency department | 3 | 1 | — | 4 |
| Adult inpatient ward | 1 | — | — | 1 |
| **Academic Hospitals** | **8 (47%)** | **8 (47%)** | **1 (6%)** | **17** |
| Adult ICU | 2 | 2 | — | 4 |
| Pediatric or neonatal ICU | 2 | 2 | 1 | 5 |
| Adult or pediatric oncology unit | — | 3 | — | 3 |
| Emergency department | 4 | 1 | — | 5 |
| **Total** | **23 (56%)** | **16 (39%)** | **2 (5%)** | **41** |

Abbreviation: ICU, intensive care unit; IV, intravenous.
[a]Do any of your IV infusion pumps have a built-in bolus feature?
[b]Only respondents who answered "Yes" to practice prevalence question 1 were shown this question.
[c]Percentages may appear inexact due to rounding.

**Table A31: IV Bolus Administration—Practice Prevalence Question 3[a,b,c,d]**

| Hospital Type and Clinical Unit | No Bolus Feature Available on This Pump | Yes, Enabled for ALL Primary Infusions | Yes, Only for Clinically Appropriate and Useful Drugs | Not Sure | Total |
|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **—** | **2 (29%)** | **5 (71%)** | **—** | **7** |
| Adult ICU | — | — | — | — | 0 |
| Adult or pediatric oncology unit | — | — | 1 | — | 1 |
| Emergency department | — | — | 2 | — | 2 |
| Adult inpatient ward | — | 2 | 2 | — | 4 |
| **Non-academic Hospitals With ≥ 100 Beds** | **1 (10%)** | **5 (50%)** | **4 (40%)** | **—** | **10** |
| Adult ICU | — | 2 | 2 | — | 4 |
| Pediatric or neonatal ICU | — | — | 1 | — | 1 |
| Adult or pediatric oncology unit | — | — | — | — | 0 |
| Emergency department | 1 | 3 | — | — | 4 |
| Adult inpatient ward | — | — | 1 | — | 1 |
| **Academic Hospitals** | **1 (9%)** | **2 (18%)** | **6 (56%)** | **2 (18%)** | **11** |
| Adult ICU | — | — | 1 | 1 | 2 |
| Pediatric or neonatal ICU | 1 | — | 3 | — | 4 |
| Adult or pediatric oncology unit | — | — | — | — | 0 |
| Emergency department | — | 2 | 2 | 1 | 5 |
| Adult inpatient ward | — | — | — | — | 0 |
| **Total** | **2 (7%)** | **9 (32%)** | **15 (54%)** | **2 (7%)** | **28** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Is the pump's bolus feature enabled for all drugs where administering a bolus is clinically appropriate and useful for your unit?

[b]Only respondents who answered "Yes" to practice prevalence question 2 were shown this question. In addition, respondents were able to answer this question several times for multiple pumps. Since some respondents used more than 1 infusion pump to administer boluses, there were more responses than respondents. There were 23 respondents to this question (e.g., 5 respondents had a second pump).

[c]One answer category, "No, not enabled for some drugs" was omitted from this table as no respondent selected this option.

[d]Percentages may appear inexact due to rounding.

**Table A32: IV Bolus Administration—Practice Prevalence Question 4[a,b,c,d]**

| Hospital Type and Clinical Unit | Manual Syringe Injection of the Bolus Dose Into a Downstream Medication Port | Administration of the Bolus as an Intermittent Secondary (Piggyback) Infusion | Program the Bolus Dose as a Secondary Infusion Without a Secondary IV Bag so That the Bolus Dose is Drawn Directly From the Primary Continuous IV Bag | Programming a Bolus Dose Using the Pump's Dedicated Bolus Feature | Manually Increase the Flow Rate on the Primary Continuous Infusion for the Duration of the Bolus | Other Methods (Please Specify)[e] | Respondents |
|---|---|---|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **4 (57%)** | **4 (57%)** | **4 (57%)** | **5 (71%)** | **2 (29%)** | **—** | **7** |
| Adult ICU | — | — | — | — | — | — | 0 |
| Adult or pediatric oncology unit | 1 | 1 | 1 | 1 | — | — | 1 |
| Emergency department | 1 | 1 | 1 | 2 | — | — | 2 |
| Adult inpatient ward | 2 | 2 | 2 | 2 | 2 | — | 4 |
| **Non-academic Hospitals With ≥ 100 Beds** | **4 (50%)** | **1 (13%)** | **2 (25%)** | **7 (88%)** | **3 (38%)** | **—** | **8** |
| Adult ICU | 3 | — | — | 2 | — | — | 3 |
| Pediatric or neonatal ICU | — | — | 1 | 1 | — | — | 1 |
| Adult or pediatric oncology unit | — | — | — | — | — | — | 0 |
| Emergency department | 1 | 1 | 1 | 3 | 3 | — | 3 |
| Adult inpatient ward | — | — | — | 1 | — | — | 1 |
| **Academic Hospitals** | **3 (38%)** | **4 (50%)** | **1 (13%)** | **7 (88%)** | **3 (38%)** | **1 (13%)** | **8** |
| Adult ICU | 1 | 1 | 1 | 1 | 1 | — | 2 |
| Pediatric or neonatal ICU | 1 | — | — | 2 | 1 | 1 | 2 |
| Adult or pediatric oncology unit | — | — | — | — | — | — | 0 |
| Emergency department | 1 | 3 | — | 4 | 1 | — | 4 |
| Adult inpatient ward | — | — | — | — | — | — | 0 |
| **Total** | **11 (48%)** | **9 (39%)** | **7 (30%)** | **19 (83%)** | **8 (35%)** | **1 (4%)** | **23** |

Abbreviation: ICU, intensive care unit; IV, intravenous.

[a]Which of the following methods are used to deliver a bolus of medication already running as a primary continuous infusion? Please select all that apply.

[b]This question was originally intended to be shown to any respondent who answered "Yes" to practice prevalence question 1. However, due to a survey design error, it was shown only to respondents who answered "Yes" to practice prevalence question 2 (a smaller sample), likely skewing the results.

[c]One answer category, "Manually hold the pump's prime/purge key," was omitted from this table as no respondent selected this option.

[d]Percentages may appear inexact due to rounding; respondents could select more than 1 answer.

[e]This was a selectable option that also provided a free-text field for respondents to provide details.

**Table A33: Exact Responses to IV Bolus Administration—Practice Prevalence Question 2[a,b,c]**

| Hospital Type and Pump Type | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **7 (64%)** | **4 (36%)** | **—** | **11** |
| Alaris infusion pump—fluid module, PCA | 3 | — | — | 3 |
| Alaris infusion pumps | 1 | — | — | 1 |
| B Braun Outlook 100 | 1 | — | — | 1 |
| Hospira Plum XL | — | 1 | — | 1 |
| Plum A | 1 | — | — | 1 |
| Plum XL | — | 1 | — | 1 |
| Plum XL from Abbott | — | 2 | — | 2 |
| (blank) | 1 | — | — | 1 |
| **Non-academic Hospitals With ≥ 100 Beds** | **10 (67%)** | **4 (27%)** | **1 (7%)** | **15** |
| Baxter Colleague CXE 2M9161 | 1 | — | — | 1 |
| Baxter Colleague | 1 | — | 1 | 2 |
| Baxter Colleague Guardian | 1 | — | — | 1 |
| Baxter Colleague Guardian volumetric 3cxe | — | 1 | — | 1 |
| ESP syringe pumps (Excelsior Medical Corp) | 1 | — | — | 1 |
| Hospira | 1 | — | — | 1 |
| Hospira Abbott Plum A+ IV pump | 1 | — | — | 1 |
| Hospira Plum A | 1 | — | — | 1 |
| Hospira Plum A+ | — | 1 | — | 1 |
| Hospira Plum smart pumps | 1 | — | — | 1 |
| Hospira single pump | — | 1 | — | 1 |
| Hospital Plum A | — | 1 | — | 1 |
| Sigma | 1 | — | — | 1 |
| Smiths Medfusion 3500 | 1 | — | — | 1 |
| **Academic Hospitals** | **11 (50%)** | **10 (45%)** | **1 (5%)** | **22** |
| Alaris | 1 | 3 | — | 4 |
| Alaris (Care Fusion) infusion pump–main point of care infusion pump | 1 | — | — | 1 |
| Alaris Medley | — | 1 | — | 1 |
| Alaris pump | — | — | 1 | 1 |
| Alaris pumps | 1 | — | — | 1 |
| Alaris® IV Pump System with Guardrails® Dose Error Reduction Software | 1 | — | — | 1 |
| Alere pump | — | 1 | — | 1 |
| Carefusion (Alaris) large-volume pump 8100 series | 1 | — | — | 1 |
| Carefusion (Alaris) syringe pump 8110 series | 1 | — | — | 1 |
| Graseby 3000 | — | 2 | — | 2 |
| Graseby pump | — | 1 | — | 1 |
| Graseby pump by Smiths Medical | — | 1 | — | 1 |
| Hospira | 1 | — | — | 1 |
| Hospira 8080 | 1 | — | — | 1 |
| Hospira Symbiq large-volume pump | 1 | — | — | 1 |
| Medfusion | 1 | — | — | 1 |
| MedFusion syringe pump | — | 1 | — | 1 |
| Smith Medical syringe pump | 1 | — | — | 1 |
| **Total** | **28 (58%)** | **18 (38%)** | **2 (4%)** | **48** |

Abbreviation: IV, intravenous; PCA, patient-controlled analgesia.

[a]Do any of your IV infusion pumps have a built-in bolus feature?

[b]Aggregate of all pumps in each unit. Seven respondents had a second pump available, boosting the total count.

[c]Percentages may appear inexact due to rounding.

## Theme 6: Nurse Hiring Requirements

### Table A34: Nursing Orientation—Practice Prevalence Question 1[a,b,c]

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **21 (100%)** | **—** | **21** |
| Adult ICU | 2 | — | 2 |
| Adult or pediatric oncology unit | 2 | — | 2 |
| Emergency department | 6 | — | 6 |
| Adult inpatient ward | 11 | — | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **22 (100%)** | **—** | **22** |
| Adult ICU | 6 | — | 6 |
| Pediatric or neonatal ICU | 3 | — | 3 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 6 | — | 6 |
| Adult inpatient ward | 6 | — | 6 |
| **Academic Hospitals** | **21 (100%)** | **—** | **21** |
| Adult ICU | 4 | — | 4 |
| Pediatric or neonatal ICU | 5 | — | 5 |
| Adult or pediatric oncology unit | 5 | — | 5 |
| Emergency department | 5 | — | 5 |
| Adult inpatient ward | 2 | — | 2 |
| **Total** | **64 (100%)** | **—** | **64** |

Abbreviation: ICU, intensive care unit.

[a]Are nurses required to receive hospital nursing orientation prior to working on your unit?

[b]One answer category, "Other (please specify)," was omitted from this table because it was an optional free-text field where respondents could provide further details, but would not constitute an answer to this question on its own.

[c]Percentages may appear inexact due to rounding.

**Table A35: Nursing Orientation—Practice Prevalence Question 2[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **20 (95%)** | **1 (5%)** | **21** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 2 | — | 2 |
| Emergency department | 6 | — | 6 |
| Adult inpatient ward | 11 | — | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **22 (100%)** | **—** | **22** |
| Adult ICU | 6 | — | 6 |
| Pediatric or neonatal ICU | 3 | — | 3 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 6 | — | 6 |
| Adult inpatient ward | 6 | — | 6 |
| **Academic Hospitals** | **21 (100%)** | **—** | **21** |
| Adult ICU | 4 | — | 4 |
| Pediatric or neonatal ICU | 5 | — | 5 |
| Adult or pediatric oncology unit | 5 | — | 5 |
| Emergency department | 5 | — | 5 |
| Adult inpatient ward | 2 | — | 2 |
| **Total** | **63 (98%)** | **1 (2%)** | **64** |

Abbreviation: ICU, intensive care unit.
[a]Are nurses required to receive unit-specific nursing orientation prior to working on your unit?
[b]Percentages may appear inexact due to rounding.

**Table A36: Hiring Requirements—Practice Prevalence Question 1[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **16 (76%)** | **5 (24%)** | **21** |
| Adult ICU | 2 | — | 2 |
| Adult or pediatric oncology unit | 1 | 1 | 2 |
| Emergency department | 3 | 3 | 6 |
| Adult inpatient ward | 10 | 1 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **17 (77%)** | **5 (23%)** | **22** |
| Adult ICU | 5 | 1 | 6 |
| Pediatric or neonatal ICU | 1 | 2 | 3 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | 5 | 1 | 6 |
| Adult inpatient ward | 6 | — | 6 |
| **Academic Hospitals** | **15 (71%)** | **6 (29%)** | **21** |
| Adult ICU | 2 | 2 | 4 |
| Pediatric or neonatal ICU | 3 | 2 | 5 |
| Adult or pediatric oncology unit | 3 | 2 | 5 |
| Emergency department | 5 | — | 5 |
| Adult inpatient ward | 2 | — | 2 |
| **Total** | **48 (75%)** | **16 (25%)** | **64** |

Abbreviation: ICU, intensive care unit.
[a]Do you hire new nurse graduates on your unit?
[b]Percentages may appear inexact due to rounding.

**Table A37: Hiring Requirements—Practice Prevalence Question 2[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **6 (29%)** | **15 (71%)** | **21** |
| Adult ICU | 1 | 1 | 2 |
| Adult or pediatric oncology unit | 1 | 1 | 2 |
| Emergency department | 2 | 4 | 6 |
| Adult inpatient ward | 2 | 9 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **9 (43%)** | **12 (57%)** | **21** |
| Adult ICU | 2 | 4 | 6 |
| Pediatric or neonatal ICU | 3 | — | 3 |
| Adult or pediatric oncology unit | — | 1 | 1 |
| Emergency department | 4 | 1 | 5 |
| Adult inpatient ward | — | 6 | 6 |
| **Academic Hospitals** | **9 (43%)** | **12 (57%)** | **21** |
| Adult ICU | 1 | 3 | 4 |
| Pediatric or neonatal ICU | 3 | 2 | 5 |
| Adult or pediatric oncology unit | 2 | 3 | 5 |
| Emergency department | 2 | 3 | 5 |
| Adult inpatient ward | 1 | 1 | 2 |
| **Total** | **24 (38%)** | **39 (62%)** | **63** |

Abbreviation: ICU, intensive care unit.
[a]Are nurses required to have previous experience to be hired on the unit?
[b]Percentages may appear inexact due to rounding.

**Table A38: Hiring Requirements—Practice Prevalence Question 3[a,b]**

| Hospital Type and Clinical Unit | Yes | No | Total |
|---|---|---|---|
| **Non-academic Hospitals With < 100 Beds** | **13 (62%)** | **8 (38%)** | **21** |
| Adult ICU | 2 | — | 2 |
| Adult or pediatric oncology unit | 2 | — | 2 |
| Emergency department | 5 | 1 | 6 |
| Adult inpatient ward | 4 | 7 | 11 |
| **Non-academic Hospitals With ≥ 100 Beds** | **18 (82%)** | **4 (18%)** | **22** |
| Adult ICU | 5 | 1 | 6 |
| Pediatric or neonatal ICU | 3 | — | 3 |
| Adult or pediatric oncology unit | 1 | — | 1 |
| Emergency department | 6 | — | 6 |
| Adult inpatient ward | 3 | 3 | 6 |
| **Academic Hospitals** | **10 (50%)** | **10 (50%)** | **20** |
| Adult ICU | 3 | 1 | 4 |
| Pediatric or neonatal ICU | 1 | 3 | 4 |
| Adult or pediatric oncology unit | 3 | 2 | 5 |
| Emergency department | 2 | 3 | 5 |
| Adult inpatient ward | 1 | 1 | 2 |
| **Total** | **41 (65%)** | **22 (35%)** | **63** |

Abbreviation: ICU, intensive care unit.
[a]Are nurses required to complete any certifications or college-based postgraduate courses to be hired on your unit?
[b]Percentages may appear inexact due to rounding.

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