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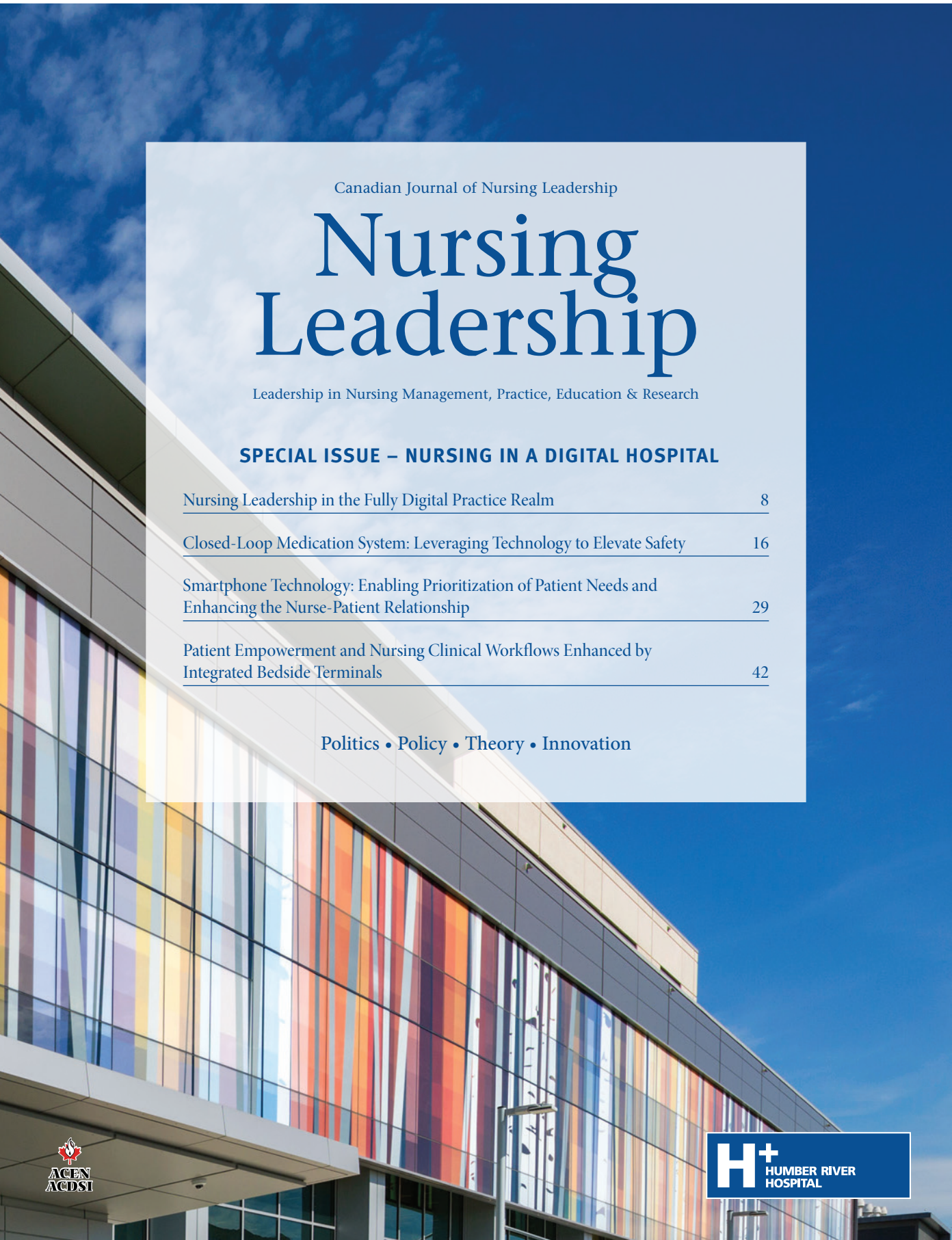
SPECIAL ISSUE – NURSING IN A DIGITAL HOSPITAL

Politics • Policy • Theory • Innovation



Transforming Nursing Practice through Digitalization

Happy Nursing Week! In this special issue of the *Canadian Journal of Nursing Leadership* for Nursing Week, you will find much food for thought. This issue may surprise you while you ponder the workings of Humber River Hospital, the first fully digitalized hospital in North America. Dr. Vanessa Burkoski and her team of researchers present their findings and insights related to the various technologies and the ways in which they impact nurses' work and patients' experiences of care. I imagine you will read with anticipation the ways in which digital health care practices have transformed nursing practice and the patient experience at Humber River Hospital.

When asked if I would agree to be guest editor, I shared with the editorial director some of my thoughts about digitalization. I'll pose a few here as I am wondering if, as you read this special issue, you might like to share some of yours with the authors.

First, what interested me was the effect of these technologies on the elderly and frail elderly, as well as those who are not technologically savvy. I was concerned that my own father, who remained a staunch Luddite by choice, might not have ever wished to learn about new technology such as bedside terminals when in hospital. He had the gift of conversation and humour and loved talking to the nurses, physicians and other patients. In the papers on patient empowerment and smartphone technology, the authors address the potential challenges for the elderly from a nursing perspective. Although the authors see this as a challenge, they find that the challenge is balanced by the opportunities and the many benefits that are achieved in the digitalized hospital, such as patient safety, time management and the potential for patient empowerment.

Other thoughts and questions come to mind. What if the technology fails? What effect might this, or the potential for less than effective use of technology, have on patient care? In her introductory piece on nursing leadership in the fully digital practice realm, Dr. Burkoski notes that nurse leaders will have to intervene to maximize the effective use of technology and that through their understanding of the principles of nursing informatics, quality assurance, etc., they will lay the foundation for engaging staff.

As well, I thought about the nurses. How much of their time was invested in learning the technology? Did they need special training? Does this digitalized hospital attract nurses or cause them to go elsewhere? In the paper on optimizing nursing practice, the authors discuss in depth the kinds of support that nurses are offered. RNAO's Best Practice Guidelines (BPGs), for example, have been embedded in the electronic medical record where the BPGs will serve to supplement the knowledge that nurses already bring to their work. The paper on the experiences of nurses working in a fully digitalized hospital uncovers nurses' perception of technology, whereas the paper on generational differences addresses training for the technological competence needs of nurses across generations.

Another thought: does each form of technology contribute to better healthcare? The What We Learned section in the paper on the closed-loop medication (CLM) system highlights the effectiveness of CLM technology, whereas the paper on violence prevention shares the finding that engaging staff is critical for successful implementation, evaluation and modification of technology.

I also wondered what is the "right" or "best" ratio of technology to human staff? I thought about the work of Donna Haraway (1991), a self-identified cyborg feminist and historian of science who has written about cyborgs and humans. She defines a cyborg as a "hybrid creature composed of organism and machine" (p. XI). In her book entitled *Simians, Cyborgs and Women: The Reinvention of Nature*, Haraway (1991) makes the following claim:

> High tech culture challenges … dualisms in intriguing ways. It is not clear who makes and who is made in the relation between human and machine (p. 177).

As I reread Haraway's work, I wondered if digitalization has caused or will cause nurses to become so attached to the technology that they appear to some as cyborgs, with the technology becoming an extension of their bodies. Does it have an effect on their ability to give care? Who is in charge of care decisions: nurse or machine?

The article on patient empowerment notes that the technology allows patients to have greater authority over their own health information. This is long overdue. But will this contribute to or spark power struggles over who has the right to know? I wonder whether patients will have the right to deny certain health professionals access to their health information. Will they be able to, in effect, choose who can view their records?

As you read each article, your questions may be answered or you may find that certain papers raise more questions than they answer. You may find aspects of the digitalization of healthcare, as explored in this issue, exciting and may hunger for more

information, or you may disagree with certain aspects. All perspectives are critical to the ongoing dialogue around digital practice. This issue is meant to spark conversation, and you are invited to contact the authors with your questions, concerns, or reactions.

I am left with wondering what will come next in the digital healthcare world. Certain questions remain, such as what care is appropriate to be delivered or supported by digitalized forms of technology and what care should remain in the hands of the nurse? Which forms of technology contribute to better healthcare? In a number of papers in this issue, the authors have worked with questions such as these. They also clearly note that these are areas to follow up and address.

This special issue is exciting not only for the insights it offers us as nurses and nurse leaders but also, more notably, the many questions the papers will generate. In 2019, we must certainly begin to attend to them.

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In This Issue

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> ...what is the impact of all this digital infrastructure on nursing practice and patient outcomes?

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Nursing Leadership in the Fully Digital Practice Realm

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Abstract
In the fully digital practice realm, a new relationship has emerged between nurses, patients and technology. Nursing leadership in this unique practice setting requires new and enhanced skills, knowledge and abilities. Maintaining the principles of patient and family centredness, attentiveness to nurses' concerns regarding workflows and involvement of nurses in the design of technologies is critical for creating a safe, professional practice environment in the fully digital hospital. Technology cannot replace the humanness of caring. Mindfulness of the digital impact on the therapeutic relationship is necessary. Competency in technology is the new proficiency that nursing leaders will need to acquire.

By leveraging technology, Toronto's Humber River Hospital (HRH) is aiming to achieve high reliability, a key strategic direction to consistently deliver the safest, highest quality care alongside compassion, professionalism and respect – the core values of the hospital. Across healthcare organizations, many improvements in patient safety have been enabled through access to better information. To my

knowledge, nowhere else in North America is a hospital so rich in usable data that can influence ongoing improvements in the safety and quality of care delivery. The fully digital infrastructure at HRH provides the opportunity for monitoring and analysis of patient outcomes and organizational processes, which has fostered a robust culture of continuous quality improvement.

Figure 1. HRH main hallway/portals of care.

Transforming Care

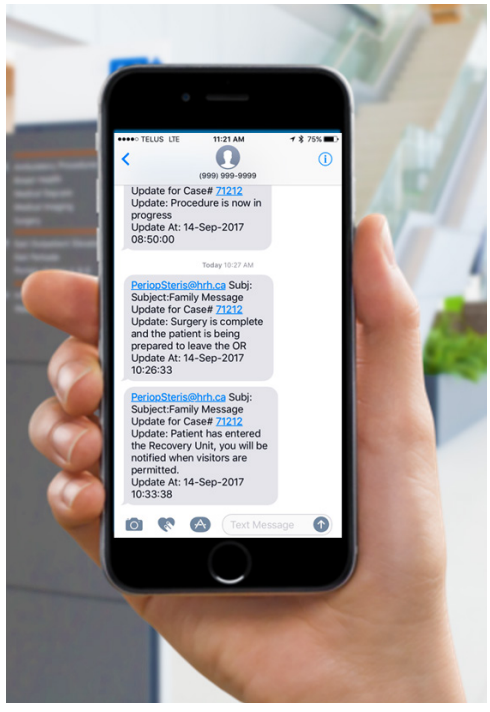
So what is the impact of all this digital infrastructure on nursing practice and patient outcomes? There is clearly a responsibility to examine, explore and investigate whether this unique hospital environment is accomplishing its goals (Figure 1). This special edition of the *Canadian Journal of Nursing Leadership* will share the results of our foundational research, largely examining the intersection of clinical practice and technology from the nurse perspective, as well as one study that includes the patient perspective. We focused our studies on the digital systems and devices that are fundamental to nursing care delivery and might pose the greatest risk to safety and patient experience. For example, the closed-loop medication system (Figure 2), smartphone communication technology, integrated bedside terminal and violence prevention technology were examined to gain a better understanding of the impact of these technologies on nursing practice and patient satisfaction. We also wanted to obtain the perspectives of nurses on their adoption of technology. This was important to us because a digital infrastructure

Figure 2. HRH automated pharmacy.

is of limited value if the end-users are compromised in its adoption. In these studies, we explored nurses' experience of practicing in a fully digital hospital and generational differences in technology adoption. Finally, we provide a discussion paper that describes how HRH has leveraged the electronic medical record (EMR) to increase evidence-based practice integration and improve patient outcomes. The questions we have posed in these studies are just a start. Nursing leaders will need to ask many more important questions over time to steer the integration of technology in a direction that will continue to elevate nursing practice and safeguard the patient experience.

Findings from our studies revealed that the technology at HRH is already having a positive impact on how nurses practise and transform care. One key benefit of the HRH fully digital environment is the ability to provide direct-care nurses and clinical leaders with point-in-time information that can be used to monitor, guide and improve care delivery. At HRH, nursing documentation in the EMR is built to the specifications of the Registered Nurses' Association of Ontario's (RNAO) best practice guidelines, which not only supports a reduction in practice variability but also enables nursing-sensitive indicators to be measured against patient outcomes. Electronic reminders in the EMR improve adherence to evidence-based practice, and data collected through the EMR show nurses which interventions are working or not. Using nursing-sensitive data, leaders can truly identify the value that nursing brings to the optimization of patient health outcomes.

FIGURE 3. STERIS RealView text messages.



At HRH, among our nursing leaders, I have come to appreciate the intimate nature of the relationship between nurses, patients and technology. An example of this relationship often occurs when nurses are conducting their initial clinical assessments. Rather than having to ask patients to repeat their histories yet again, nurses in the digital workplace find that all the required information already exists in the patient's chart. In this case, sometimes patients may feel ignored or perceive that nurses are distracted by the technology. On the other hand, a great example of how technology is serving patients and staff well at HRH has been embedded in the perioperative program. The STERIS RealView patient tracking system is used to monitor surgical patients throughout their perioperative journey. Typically, in a non-digital environment, patients are separated from family and friends to be prepared for their operations. This period of time typically incites a great deal of anxiety for both patients and families. The STERIS RealView surgical patient tracking system at HRH connects care providers and families in real time through frequent communication notifications sent via smartphone or display boards, continually informing families of their loved one's status and progression through the surgical journey, even at home or out of the country (see Figure 3). This has had a significant impact on reducing anxiety for patients and families while fostering positive experiences. The tracking system is also used by HRH staff to communicate between departments, enabling each perioperative area to predict patient flow and guide resource allocation decisions. The tracking system highlights how digital infrastructure has been integrated to support nursing communication and decision making, with concurrent engagement of patients and families. Nurse leaders have an important role to play in advocating for technical solutions that maintain the principles of patient and family centredness through timely and accessible information exchange.

Reverence for End-Users

Understanding the experience of nurses practising in the digital environment is crucial to ensure that technology does not impair critical thinking or erode the nursing process. A clear example is the manner in which vital signs are captured and displayed in the EMR. When vital signs are assessed, the workflow for

Figure 4. HRH patient room.

electronic documentation should align with the nursing process and the manner in which the data are presented must support the identification of changes and trends in patients' health status over time. Several nurses at HRH raised the concern that the graphic representation of vital signs in the EMR "is hard to read," and all nurses we talked to expressed a preference toward the tabular display of vital signs. Following a heuristic evaluation of how vital signs were captured and presented in the EMR, two key issues emerged. First, variability existed in the level of automation and collection of vital signs. Second, the design of the vital signs display did not make the most of the opportunity to support nurses' identification of trends that might signal patient deterioration. Nurses at the front line of care are in the best position to recognize opportunities for improvement because they are closest to the work. For nurse leaders, sensitivity to operations through attentiveness to front-line nursing concerns is essential for successful integration of technology.

Integrating the EMR into nursing practice is not easy. Nursing leaders need to recognize that technology changes the way care is delivered. One essential strategy for nurse leaders is to have the end-users, nurses, involved in the design of technologies to create systems that complement nursing practice and avoid the conditions that necessitate the development of workarounds. Nurse leaders will have to intervene wherever necessary to maximize the integration of technology that can be used effectively in the context of professional care and minimize the potential of nurses having to compensate for poorly designed systems. Technology should be leveraged to augment nursing care, creating a safer, more effective and efficient practice environment as much as technology supports patients and families with their informational needs (see Figure 4).

One of the major benefits of EMR integration is that it allows nurse leaders the ability to work with the front line to review real-time data, assess and address current challenges and explore potential efficiencies. At HRH, this work is accomplished in an electronic test world that models the live EMR. With this capability, front-line users are able to co-create and test solutions that enhance nursing efficiencies, capture data and optimize patient safety. The ability to build and test solutions by deferring to the experts, in this case nurses, is a hallmark of high-reliability hospitals. Nursing leaders in this environment must understand the principles of nursing informatics, electronic documentation, quality assurance and quality management to lay the foundation for engaging staff. Thus, nurse leaders will need to be mindful of the importance of front-line engagement in the development and design of digital technologies to create systems that work and garner the trust and confidence of nurses.

Nursing Leadership in the New Digital Landscape

New skills are required for nurses to become digitally literate. Nurses need to learn not only how to navigate the technology but also how to use the data and information that are contained in various formats within the technology. Education is essential, and leaders must ensure that dedicated time is carved out for nurses to concentrate on learning the technology. This learning cannot be achieved in the midst of trying to care for patients.

Although data analytics has great potential to improve decision making and care delivery, nursing leaders must be cautious about overloading nurses with digital technologies that may detract from their core responsibility of caring for patients using the nursing process. A requisite of nursing leaders will be to distinguish between technology that enables nurses to deliver better care and technology that burdens nurses in delivering care. When there are too many red dots on the control panel, none of them become the priority. As in the digital environment, when nurses are required to input too many variables or respond to multiple alarms, then none of them become relevant to care. Alarm fatigue in the fully digital environment is a problem that is amplified because of the integrated technology requiring nurse leaders to consider this impact on nursing care delivery. The right balance between nursing notifications that support harm reduction and error prevention and alarm fatigue is difficult to achieve.

Health technology is a professional issue in nursing that impacts practice, care delivery, education and research. Our studies, like others in the literature, alluded to a faint but existing tension between the nursing philosophy of caring and technology integration. Nursing is a uniquely human profession with caring as its central focus. Technology cannot replace the human touch. Just as current

generations grapple with how smart technology has impacted families at the dinner table, nurse leaders will need to understand the perspective of nurses and patients regarding the impact of technology on delivering and receiving care. Otherwise, meeting the patients' spiritual, psychological and social needs (the art of nursing), may not be achieved appropriately within the digital landscape. The introduction of new and evolving technology requires nurse leaders to consider the impact of digitalization on the therapeutic relationship and to ensure that the patient, rather than the technology, remains the central focus.

Healthcare technology is going to take nursing to a new level. At HRH, technology is fostering better communication between nurses, patients, families and the interprofessional team. Some of the intricacies in the EMR touch not only on the importance and opportunity for interoperability between the different technologies (EMR, smartphones, integrated bedside terminal) but also on the nature of interprofessional collaboration. For example, drug libraries on SMART pumps are traditionally governed by pharmacy practice. Becoming fully digital required integration of pharmacy and nursing practice to create the EMR with appropriate inputs, outputs and documentation. This is an essential element in achieving the safest patient care. HRH is already achieving exceptional outcomes that are being sustained over time, such as zero medication errors, lowest percentage incidence of pressure injuries in Canada and highest rated hospital experience in the Central Local Health Integration Network. Technology is being leveraged at HRH so that nurses can accomplish even more in relation to higher quality patient outcomes. At the present time, the fully digital environment at HRH is unique. That won't last long because many other healthcare organizations are on the journey to becoming entirely digital. As chief nursing executive at HRH, I have been stretched to move in a direction that was foreign and uncomfortable. Technological competency was not on my list of most important nursing competencies before I came to HRH. What I have discovered over the past two years is that technology integration requires a consistent process of designing, testing, building, planning, educating and implementing. And once implementation of technology has occurred, there is another process of reflection, evaluation, revision and enhancement that is required to ensure that the system is right for nurses and right for patients. We are pleased to share the findings of our research during this distinctive point in time as North America's first fully digital hospital. Our hope is that these findings will assist others with developing the technological infrastructure to cultivate digitally capable nurses, now and into the future.

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> “...the system automatically verifies that the correct medication is being administered to the right patient, at the right time and at the right dose...

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Closed-Loop Medication System: Leveraging Technology to Elevate Safety

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WHAT WE LEARNED:

1. The implementation of CLMS requires interprofessional and cross-functional collaboration to successfully integrate the requirements of each respective discipline and service.
2. HRH implemented CLMS in several stages, which allowed time for nursing staff to learn how to incorporate barcode scanning of patients and medications into their daily work-flows.
3. There is a need for ongoing planning and implementation of automated system-level improvements for CLMS that interconnect the EMR and other digital devices, such as smart infusion pump drug libraries.

Abstract

Background: Healthcare organizations have long been dependent on the vigilance of nurses to identify and intercept medication errors before they can adversely affect patients. New technologies have been implemented in an effort to reduce medication errors; however, few studies have evaluated the long-term effects of technology-based interventions in reducing medication errors.

Aim: The aim of this study was to evaluate the effects of barcode medication administration (BCMA) and the closed-loop medication system (CLMS) interventions on medication errors and adverse drug event (ADE) rates.

Methods: An autoregressive integrated moving average model for interrupted time series design was used to evaluate the impact of the BCMA and CLMS interventions on the monthly reported medication error and ADE rates at Humber River Hospital between September 2013 and August 2018. Descriptive statistics were generated to evaluate the types of error and their gravity.

Results: A total of 1,712 medication errors and ADEs were reported in the five-year study period. The results of the interrupted time series indicated that the introduction of the BCMA intervention was associated with a statistically significant gradual decrease in reported medication error and ADE rates at 0.002 percentage points per month ($p = 0.003$). The introduction of the CLMS intervention was associated with an immediate absolute decrease in reported medication error and ADE rates of 0.010% ($p = 0.020$).

Conclusion: The findings from this study support the adoption of both BCMA and CLMS interventions to prevent medication errors. Staged implementation of CLMS allows time for learning and incorporating barcode scanning. Interprofessional and cross-functional collaboration is necessary to successfully integrate the requirements of each respective discipline and service in the CLMS.

Background

In Canada, an estimated 1,600 adult patients suffer harm in hospitals across the country each day (Chan and Cochrane 2016). The 2004 Canadian Adverse Events Study reported that more than 185,000 adverse drug events (ADEs) occurred in Canadian hospitals and nearly 40% of these were potentially preventable (Baker et al. 2004). In the decade since the study was published, a follow-up report concluded that there had been only "limited evidence of substantial improvement"

(Baker 2015). These estimates are alarming as medication errors can result in negative health consequences for patients, including increased length of hospital stay, disability and death (Forster et al. 2004; Weingart et al., 2000). Addressing medication safety issues has become a top priority for many Canadian healthcare organizations.

Errors can occur at any stage of the medication management process, from ordering, to preparing and dispensing and, finally, to the administration of the medication to the patient. Nurses are the primary clinicians responsible for administering medications to patients in the acute care hospital setting. The interception of medication errors is highly dependent on the vigilance of nurses to identify discrepancies in the process of medication administration among frequent interruptions and competing priorities (Garrett 2008; Tang et al. 2007). To maximize the safety of medication administration, Humber River Hospital (HRH) has implemented a number of medication safety technologies that establish a systematic safeguard for preventing errors.

Medication Safety Technologies

Barcode medication administration (BCMA) systems have been advocated as a technology that reduces medication errors occurring at the administration phase. The BCMA process begins when the clinician prescribes a medication for the patient, the pharmacist then receives the order and verifies it and the medication order then populates into the electronic medication administration record (eMAR). All medications are dispensed in a unit-dose format and have scannable barcodes. To administer the medication, the nurse must scan the barcode on individually packed medication delivered from the pharmacy as well as the barcode on the patient's identification wristband (Figure 1). The patient's information will then appear on the eMAR, and if there are any discrepancies the computer system alerts, and a warning will appear on the screen. By scanning the patient and medication barcodes, the system automatically verifies that the correct medication is being administered to the right patient, at the right time and at the right dose and automatically documents that it was administered. In the absence of BCMA technology, the nurse must manually ensure the correct medication, dosage, timing, documentation and patient identity for safe administration.

An additional systematic safeguard is the closed-loop medication system (CLMS), which includes the BCMA system and integrates computerized physician order entry (CPOE) technology and automated dispensing technology (robots/units) (Figure 2). CPOE technology enables clinicians to electronically enter a medication order in the eMAR, which is also integrated with the pharmacy information system. CPOE technology's designed use is an integrated systems approach to

Figure 1. Barcode medication administration.

decrease transcription errors associated with written prescription orders. The eMAR system can then also alert the clinician if there are any drug interactions, allergies or ADEs based on the patient's information in the electronic medical record (EMR). Once the pharmacy department receives the order, it will also be

Figure 2. Closed-Loop medication system.

alerted by the safety checks in the system. The information is then electronically sent to the automated dispensing technology (robot/unit), and a medication-dispensing robot will package the medications into unit-dose plastic bags that feature a barcode that can then be scanned by the nurse using the BCMA system. The CLMS provides an end-to-end, safe and efficient electronic medication management system across the full cycle of the medication ordering to administration processes. Nurses have the benefit of a consistently clear and complete medication order from which they can determine its appropriateness before administration to the patient (CNO 2017).

Electronic medication management systems have been recognized as valuable tools in optimal healthcare provision, decreasing turnaround time, increasing efficiency and, most notably, reducing error rates (Franklin et al. 2007; Seibert et al. 2014; Strudwick et al. 2018). However, the published evidence on the effectiveness of BCMA and full CLMS have been limited, and some studies have reported no change in medication error rates before and after implementation of these technologies (Bowers et al. 2015; Helmons et al. 2009). However, these studies only examined the short-term effects of these technologies, without acknowledging that these systems have a moderate learning curve.

The aim of this study was to evaluate the long-term impact of BMCA and CLMS technologies on medication errors and ADEs.

Methods

Setting

The reported medication incident data were collected from three 200- to 250-bed acute community care hospitals, Humber Memorial Hospital, York-Finch Hospital and Northwestern General Hospital (known collectively as the Humber River Regional Hospital Network [HRRH Network]), between September 2013 and September 2015 and one 656-bed acute care community hospital, HRH, between October 2015 and August 2018. The HRRH Network sites closed their doors in October 2015 upon the opening of the new HRH. HRH was built as an all-digital hospital that uses emerging health technologies that enhance patient care. The HRH site was built to replace the HRRH Network sites and serve the same catchment area. The majority of nursing staff transferred employment from the HRRH Network sites to the new HRH, which provided for a consistent and stable nursing workforce. BCMA technology was originally introduced at the HRRH Network sites, with the CLMS integrated later when the new HRH site opened.

Study design and data collection

A quasi-experimental design was used to assess the impact of the BCMA and CLMS interventions on the reported medication error and ADE rate at the HRRH Network and HRH sites. A retrospective audit of self-reported incidence of patient-related medication errors and ADEs submitted through the hospital's EMR into an electronic database was conducted over a five-year period between September 2013 and August 2018. The system is used to report any medication errors and ADEs that caused or had the potential to cause patient harm whether they were preventable or non-preventable.

The main outcome measure was the monthly reported medication error and ADE rate, which was calculated by dividing the total number of reported medication errors and ADEs per month by the number of medication doses administered that month. The monthly number of doses administered was obtained from electronic pharmacy records. Information regarding incident classification (e.g., wrong dose, known medication allergy, etc.) and severity of harm (e.g., no harm, moderate harm) were also extracted from the reporting database.

The study did not require research ethics board approval as the study was considered a program evaluation and involved secondary use data provided without any patient or staff identifiers.

Interventions

Training on the use of BCMA technology was provided to all nurses and other healthcare professionals (as required) at the HRRH Network sites prior to implementation. BCMA technology was then rolled out over four months between May and August 2014. Training on CLMS technology was provided to all nurses and involved hospital staff prior to the relocation of the HRRH Network sites to the HRH site in October of 2015.

Data analysis

The monthly reported medication error and ADE rate was plotted from September 2013 to August 2018. Descriptive statistics were used to present the mean frequencies and percentages of reported medication errors and ADEs across time by incident classification and severity of harm. The dates of the interventions were used to divide the monthly data into three periods: pre-intervention (September 2013 to April 2014); BCMA intervention (May 2014 to September 2015) and CLMS intervention (October 2015 to August 2018).

To evaluate the effects of the BCMA and CLMS interventions on the reported medication error and ADE rate, interrupted time series (ITS) analysis was performed using the autoregressive integrated moving average (ARIMA) model (Bernal et al. 2017). ITS analysis is superior to simple before-and-after study designs due to its ability to evaluate the effect of an intervention while accounting for underlying secular trends.

The reported medication error and ADE rate was analyzed as the outcome variable with calendar month as the unit of analysis. The four months corresponding to the BCMA phase-in period (May 2014 to August 2014) were excluded from the ARIMA model. There were a total of 56 monthly intervals, providing eight pre-intervention, 13 post-BCMA intervention and 35 post-CLMS intervention data points. ITS analysis was used to estimate the changes in level and trend following each intervention. Ljung-Box Q fit statistic and visual inspection of autocorrelation (ACF) and partial autocorrelation (PACF) plots were used to assess for autocorrelation, seasonality and stationarity. Ljung-Box Q fit statistic and visual inspection of the ACF and PACF plots did not indicate the presence of autocorrelation. Examination of the series ACF plot for cyclical or periodic fluctuations at four, six and 12 lags indicated that seasonality was absent. Lastly, the ACF patterns show a clear exponential decay indicative of stationarity. Therefore, adjustments and transformation to the data were not necessary. All analyses were conducted in SPSS version 25 Forecasting module. The results were considered to be statistically significant at $p < 0.05$.

Results

A total of 1,712 medication errors and ADEs were reported in the five-year study period, with a mean of 28.5 ± 7.4 reports per month. The mean medication error and ADE rate for the five-year period was 0.0141% ± 0.0060%.

Severity breakdown is presented in Table 1. Among 1,712 errors and ADEs, the most frequent severity grading across all time periods was "no harm" (43.3–50.2%) and "near miss" (14.6–18.7%). Importantly, in the pre-intervention and post-BCMA intervention time periods, there was no force option to grade the severity of the error/ADE; therefore, 16.6% of the errors and ADEs during these two time periods were classified as "unknown." Because of the large number of errors and ADEs categorized as unknown, it is not possible to accurately compare severity across time periods.

Table 1. Monthly average distribution of severity of harm by pre-intervention, post-BCMA intervention and post-CLMS intervention time points (n = 1,712).

	Time period, mean frequency (%)		
Severity of harm	**Pre-intervention**	**Post-BCMA intervention**	**Post-CLMS intervention**
No harm	14.9 (43.3)	13.5 (44.8)	13.3 (50.2)
Near miss	5.4 (15.6)	5.6 (18.7)	3.9 (14.6)
Mild harm	2.8 (8.0)	3.0 (9.9)	5.7 (21.5)
Moderate harm	0.9 (2.5)	0.8 (2.5)	1.5 (5.7)
Severe harm	0.3 (0.7)	0.1 (0.4)	0.1 (0.3)
Major permanent harm	0.0 (0.0)	0.1 (0.2)	0.0 (0.1)
Reportable incident	3.3 (9.5)	2.6 (8.8)	1.9 (7.4)
Unknown*	7.0 (20.4)	4.4 (14.6)	0.0 (0.1)

* Force option to select error severity was only introduced post-CLMS.
BCMA = barcode medication administration; CLMS = closed-loop medication system.

Incident classification is presented in Table 2. The most frequent errors across the three time periods were related to "medication error – other" (18.5–30.2%) and "dose omission" (18.2–24.9%). There were slight decreases in the average number of "controlled drug count error," "medication – no order," "wrong dose/quantity," "wrong frequency/rate," "wrong medication" and "wrong patient" errors per month across time periods.

Table 2. Monthly average distribution of incident types by pre-intervention, post-BCMA intervention and post-CLMS intervention time points (n = 1,712).

	Time period, mean frequency (%)		
Incident classification	**Pre-intervention**	**Post-BCMA intervention**	**Post-CLMS intervention**
Adverse reaction/effect	1.8 (5.1)	0.9 (2.9)	1.6 (6.2)
BPMH problem*	0.0 (0.0)	1.8 (5.8)	1.2 (4.5)
Controlled drug count error	1.3 (3.6)	1.0 (3.3)	0.4 (1.5)
Dose omission	6.3 (18.2)	5.6 (18.7)	6.6 (24.9)
Duplicate or extra dose	1.0 (2.9)	1.1 (3.7)	0.8 (3.1)
Expired medication	0.3 (0.7)	0.4 (1.2)	0.1 (0.4)
Known medication allergy	0.1 (0.4)	0.4 (1.4)	0.3 (1.1)
Medication – no order	2.1 (6.2)	1.8 (5.8)	1.0 (3.9)
Medication error – other	10.4 (30.2)	5.6 (18.5)	6.0 (22.8)
Medication pump problem**	0.0 (0.0)	0.0 (0.0)	0.2 (0.9)
ADM issue**	0.0 (0.0)	0.0 (0.0)	0.4 (1.5)
Other equipment problem**	0.0 (0.0)	0.0 (0.0)	0.3 (1.2)
Wrong dose/quantity	3.6 (10.5)	2.0 (6.6)	2.2 (8.4)
Wrong duration	0.0 (0.0)	0.2 (0.6)	0.3 (1.3)
Wrong frequency/rate	1.0 (2.9)	1.2 (3.9)	0.5 (1.9)
Wrong medication	3.5 (10.2)	4.1 (13.5)	1.7 (6.5)

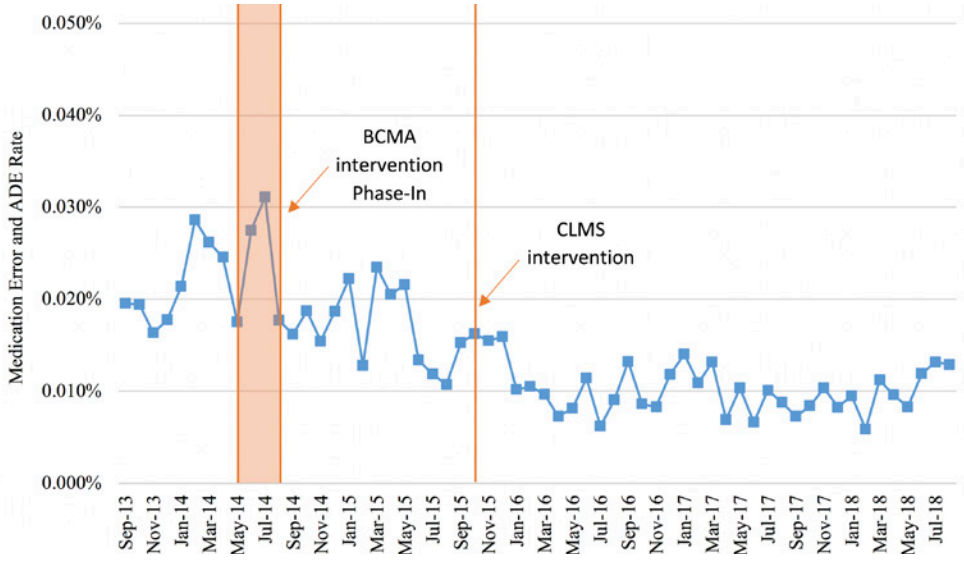
	Time period, mean frequency (%)		
Incident classification	Pre-intervention	Post-BCMA intervention	Post-CLMS intervention
Wrong patient	1.9 (5.5)	1.7 (5.7)	0.8 (2.9)
Wrong route	0.3 (0.7)	0.6 (1.9)	0.4 (1.4)
Wrong strength/concentration	0.4 (1.1)	1.2 (4.1)	0.5 (2.1)
Wrong technique	0.1 (0.4)	0.2 (0.8)	0.2 (0.6)
Wrong time	0.5 (1.5)	0.5 (1.6)	0.7 (2.7)

ADM = administration; BCMA = barcode medication administration; BPMH = best possible medication history; CLMS = closed-loop medication system.
* Category introduced post-BCMA time period.
** Category introduced post-CLMS time period.

Effect of BCMA and CLMS

Overall, there was a general decrease in the rate of reported medication errors and ADEs each month over the observation period (Figure 3). Average medication error and ADE rates reported in the pre-intervention, post-BCMA and post-CLMS periods were 0.0217%, 0.0185% and 0.0102%, respectively. Intervention analysis (Table 3) indicated that there was no immediate effect of the BCMA on reported medication error and ADE rates. However, the introduction of the BCMA intervention was associated with a statistically significant gradual decrease in reported medication error and ADE rates at 0.002 percentage points per month ($p = 0.003$). The CLMS was associated with an immediate absolute decrease in reported medication error and ADE rates of 0.010% ($p = 0.020$) and remained stable, with no statistically significant change in trend.

Figure 3. Interrupted time series showing monthly rate of reported medication errors and ADEs (full model) .



ADEs = adverse drug events; BCMA = barcode medication administration; CLMS = closed-loop medication system.

Table 3. Changes in level and trend of reported medication errors and ADE rate (%): results from the ARIMA analysis.

	Reported medication errors and ADE rate (%)			
	BCMA intervention		CLMS intervention	
	Estimate (*SE*)	*p*	Estimate (*SE*)	*p*
Level change	0.007 (0.004)	0.119	-0.010 (0.004)	**0.020**
Trend change	-0.002 (0.001)	**0.003**	0.000 (0.000)	0.186

ARIMA = autoregressive moving average; ADEs = adverse drug events; BCMA = barcode medication administration; CLMS = closed-loop medication system.

Discussion

Safe administration of medication is essential to improving the quality of patient care (Durham et al. 2016). BCMA and CLMS interventions have been suggested as a highly reliable and proactive approach to reducing medication errors (Seibert et al. 2014; Shi et al. 2018). The process of administering medications safely to patients requires that nurses have high concentration (Qian et al. 2015). Additionally, competence to administer medication, including knowledge and appropriateness of medication, are key requirements for safe medication administration practices (CNO 2017). BCMA and CLMS have a significant impact on the professional practice of nurses by serving as a *systematic safety net* in medication administration and assisting nurses in preventing adverse events (Vanderboom et al. 2016).

The findings from this five-year study revealed that there was a significant, gradual decrease in the rate of reported medication errors and ADEs coinciding with the introduction of the BCMA technology and a significant immediate decrease following the introduction of the CLMS intervention. HRH has taken the lead in adopting advanced information technology to improve patient safety. Because the hospital administers approximately 3.2 million doses of medications per year, BCMA and CLMS technologies are expected to prevent approximately 366 potential medication errors and adverse events per year within the hospital.

The results of this study add to the evidence base providing support for implementing life-saving medication administration technology to reduce medication errors and ADEs.

There have been limited studies assessing the effectiveness of CLMS technology, and much of the previous literature on BCMA has only assessed its short-term impact (Bowers et al. 2015; Helmons et al. 2009). The results of this study suggest that the prevention of medication errors with the BCMA occurs gradually, likely due to the moderate learning curve associated with using the BCMA. The current research study also addresses the gap in the literature regarding the effectiveness of CLMS technology, which resulted in an immediate reduction in the incidence of errors.

There are limitations to the study design which are important to consider in the interpretation of the findings. First, it is likely that some medication errors were not detected or reported to the hospital electronic database; thus, such errors may only represent a portion of all medication errors. Second, this study did not have a control group comparator to further support the hypothesis that the interventions were causally associated with the decrease in medication error and ADE rate. Next, it is impossible to rule out concurrent interventions or changes associated with moving to a new facility that may have influenced the decrease in medication error and ADE rate post-CLMS integration. There may also have been underlying changes that occurred during the five-year span of the study that would have influenced the reported incidence rate, including changes in reporting practices, changes in organizational practices, implementation of smart infusion pumps and definitional changes to the outcome variable. In addition, the study was unable to compare improvements in incident classification and severity of harm over time due to the frequent reporting of the incidents as "other." Finally, analyses were based on a short pre-intervention trend due to the lack of digital data prior to September 2013.

Conclusion

These findings indicate that BCMA and CLMS medication administration technologies can be leveraged to prevent medication errors. The current research study adds to the body of knowledge regarding the effectiveness of CLMS technology, which resulted in an immediate reduction in the incidence of errors.
The findings from this study support the adoption of these technologies in other acute care hospitals to improve the safety of the practice environment, in particular for nurses as the predominant clinicians administering medications to patients.

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HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Smartphone Technology: Enabling Prioritization of Patient Needs and Enhancing the Nurse-Patient Relationship

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WHAT WE'VE LEARNED:

1. There are multiple benefits of smartphone technology, including time management, convenience, prioritization, patient safety and enhancement of the nurse-patient relationship. Issues such as patients' lack of knowledge regarding how to use the call system, insufficient sound quality and poor battery life are challenges with the smartphone that need to be addressed.
2. Hospitals proposing to introduce smartphone technology need to educate patients and families about the clinical use and functionality of communication information technology to avoid unfavourable perceptions.
3. Smartphone technology must be integrated with other health information systems and requires interoperability with the EMR to maximize interprofessional communication and exchange of patient information.

Abstract

Background: Mobile health (mHealth) is a rapidly growing field with the potential to transform healthcare delivery. Smartphone technologies have been developed and integrated into the patient call bell system for healthcare staff to receive calls; however, there is a lack of high-quality evidence to support the implementation and evaluate the effectiveness of these devices in a healthcare setting.

Aim: The aim of this study is to explore nurses' perceptions of smartphone technology devices in enhancing the nurse-patient relationship and improving nursing workflows.

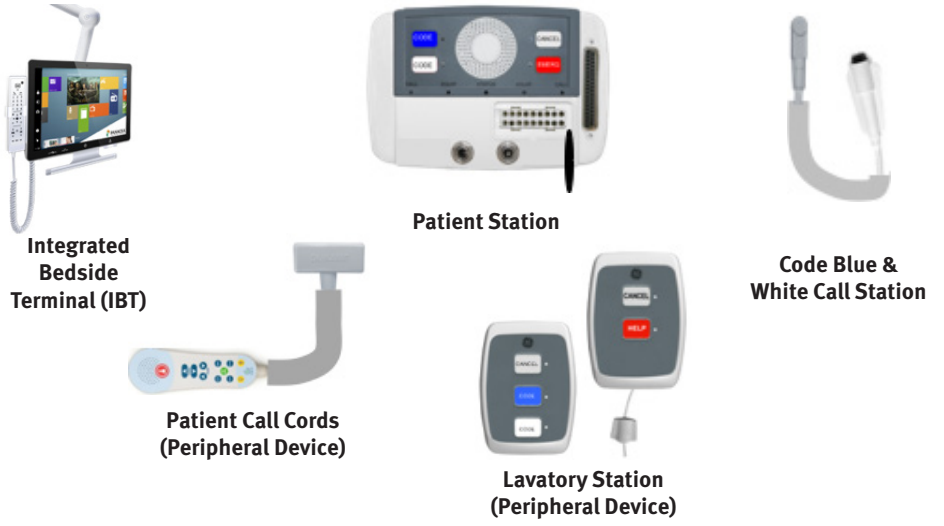
Methods: A semi-structured focus group and interviews were used to illicit nurses' experiences with smartphone technology. Interviews were audio recorded, transcribed and subjected to a content analysis to identify emerging themes from the data.

Results: Interviews with nurses provided insight into the benefits and challenges of smartphone use in the clinical setting. Multiple benefits were identified by nurse participants, including time management and convenience, prioritization, patient safety and enhancement of the nurse-patient relationship.

Conclusion: There are multiple benefits of smartphone technology for both nurses and patients. Hospitals proposing to introduce smartphone technology need to educate patients and families about the clinical use of smartphones to avoid unfavourable perceptions. Smartphone technology must be interoperable with the electronic medical record to optimize interprofessional communication and exchange of patient information.

Mobile technology has evolved from a personal device to a clinical tool with the potential to revolutionize healthcare delivery. Humber River Hospital (HRH) has taken a technological leap by integrating smartphones into the patient call bell system to further support nurses' communication. The new system aims to improve nurses' ability to manage patient calls and prioritize patient needs (Figure 1).

Figure 1. The various components of the nurse call system (ways patients can contact the nurse).



Despite the fact that the patient call-bell system is a vital component of healthcare facilities, it has remained largely unchanged in the last 30 years. With current call-bell systems, the patient presses a button on a hand-held device located near the hospital bed that is linked to the nursing station in the unit. The most basic systems alert the nursing station via a light or audible tone, whereas more advanced systems allow communication with the patient via an intercom. The nurse assigned to that patient's care is paged to the nursing station, where the patient's message is then relayed. The primary disadvantage of conventional patient call-bell systems is that the nurse is frequently required to shift focus from the present task to answer the call, resulting in the interruption of care priorities and disruption in workflow processes (Galinato et al. 2015; Redding and Robinson 2009). Interruptions have been perceived as a threat to patient safety, and previous research has identified a direct association between interruptions and medical errors (Prakash et al. 2014; Tomietto et al. 2012; Westbrook et al. 2010).

A review of published and grey literature evaluating the impact of mobile health (mHealth) on communications between staff has demonstrated that mobile technology (see Figure 2) has the ability to reduce overhead paging noise and positively impact nursing workflow and staff ability to provide safe, high-quality care (Doswell et al. 2013; Whitlow et al. 2014). The aim of this study was to examine the potential of smartphone technology to improve nursing workflows and enhance the nurse-patient relationship at HRH.

Figure 2. Smartphones.

Methods

Study sample and data collection

A qualitative exploratory study was employed to investigate nurses' perceptions of smartphone technology devices in enabling prioritization of patient needs and enhancing the nurse-patient relationship. Selection criteria included the requirement that nurses predominantly provide direct care to inpatients and have at least six months' experience working at the hospital. Research board ethics approval was obtained. Participation in the study was voluntary, and participants were assured of anonymity.

Qualitative approaches were used to explore nurses' perceptions of hospital smartphone technology. In-depth interviews took place in November 2018 in a private room within the hospital setting and were conducted using a semi-structured format. Open-ended interviewing was used to allow participants to supply information unique to their experiences regarding the use of mobile technology within clinical settings. The interviews lasted between 20 and 40 minutes and were

digitally recorded. Observation notes were recorded by the interviewer to document participant expressions and body language. Probing questions were asked by the interviewer to further explore points of interest. Participants were encouraged to express their views freely.

Data analysis

Digital recordings were transcribed and subjected to a content analysis. Transcripts were analyzed to identify perceptions that were common across all participants. Quotations were chosen to illustrate emerging themes from the data.

Results

Of the 12 nurses interviewed, 66.7% were female and the age range for participants was from 20s to 40s. The average number of years of experience for all participants was 3.79 years ($SD = 2.66$), with 3.11 years ($SD = 2.84$) of employment at HRH. The majority of participants had academic preparation at the level of a baccalaureate degree (83.3%) and practised as registered nurses (83.3%).

Time management and convenience

Many of the nurses in this study perceived significant improvements in efficiency over traditional patient call bell systems. The smartphone rings directly to the specific nurse assigned to care for the patient, thereby eliminating the need for the nurse to attend the nursing station to receive information regarding the needs of the patient calling for assistance. This meant that nurses could receive a call from another patient while caring for a patient or involved in a task without having to cease caring for the patient or performing the task at hand. More than half of the nurses from the study stated that the smartphone helped them avoid any unnecessary interruptions:

> We didn't have a [smart] phone [in my previous place of employment], so we had to keep checking the call bell. So this has been a very big change.

> Before, you'd always have to go to the nursing station when a call came in just to find out who's calling.

> At night, if nobody is sitting at the nursing station, nobody is going to know that the patient is calling, or [the traditional call bell] is just so loud that it wakes up all the patients.

Most of the study participants emphasized that having a smartphone was essential because of the magnitude of the physical space of the hospital. One study participant mentioned that if the nursing station is not staffed, it may take a very long time for the patient's call to be answered, and having the smartphone circumvents

this issue. The extensive walking distance between patient rooms, the nursing station and supply rooms was perceived by nurses as necessitating the appropriate tools, such as the smartphone, to manage time efficiently and effectively. Another advantage of the smartphone was convenience, as one nurse in the interview stated:

> The fact [is] that [smartphones] get a call bell to you right away and lab results, and if you have to get a call from a doctor and it goes right to your phone, it's very useful.

With the phone system, any nurse can be easily reached and any critical laboratory results concerning the patient can be delivered directly to the patient's nurse. All of the nurses in the study stated that the smartphone was most beneficial for immediate communication with the interprofessional clinical team, as well as portering services. With the portering service, any nurse will receive a notification by smartphone 15 minutes prior to the patient being transported, allowing nurses additional time to ensure that the patient is prepared for transport when the porter arrives. Some nurses described having the smartphone as a lifeline. One nurse stated,

> I almost don't want to go to [work at] another hospital because of the smartphone. It's so useful.

Prioritization

The smartphone featured a different tone for call bells, alarms activated from the patient's bathroom and alarms activated when patients at high risk for falls exit the bed. Most of the nurses from this study stated that they immediately prioritized bed alarms and bathroom alarms because they presented a safety risk to those patients. Additionally, if a nurse received a call bell from a "high-falls-risk" patient, nurses from this study stated that they would prioritize those requests, knowing that the patient might be requesting help to get up to use the bathroom and would try to do so alone if the nurse did not come promptly.

Patient safety

Most of the study participants believed that the smartphones were crucial to maintaining patient safety. As previously described, when a high-falls-risk patient exits the bed, an alarm is sent to the nurse's phone:

> Some patients try to get up by themselves, or they don't want to wait for a nurse to come to them because they think it will take a while. So we get an alert immediately when a [high falls risk patient] gets up.

In other hospital settings without smartphones, an audible alarm would be triggered near the patient's room. All nurses in the interviews emphasized that having the alarm ring on their phone rather than by the patient's door ensured that the patient's nurse would hear the alarm no matter where they were on the unit. This direct communication allowed nurses to have a quick response to urgent situations. This also provided the additional benefit of reducing overhead noise, which is common with traditional bed exit alarms:

> In a non-digital hospital, they have overhead paging, and patients are trying to sleep, so they get awakened by the overhead paging.

An additional advantage of the smartphone was its ability to send a notification to a secondary nurse if the primary nurse did not answer the call within a specified time. Furthermore, if there was no response from the secondary nurse, the call would automatically go to the nursing team lead. This process ensured that someone would still be notified and accountable for responding and attending to the patient if the primary nurse was unable to attend to them:

> Call bells are answered quickly now, the bed alarm, transfers to [a] secondary nurse – all these really help ensure patient safety.

Nurse-patient relationship

Interviews with nursing staff also highlighted improvements to the nurse-patient relationship. Most of the participants stated that because their patient's call goes straight to them rather than to the nursing station, nurses were able to establish a one-to-one relationship with that patient:

> You can answer the call and tell the patient, "I am coming; I am just busy," and there's that communication with the patient that you build with them so that they don't wonder why you aren't coming.

Smartphone issues

One of the major disadvantages reported by the survey participants was the poor call quality and interference on the smartphones. All nurses experienced at least some call quality issue that prevented them from fully using the phones to speak with patients:

> I would say it's a good system, but the only problem is [there are] some issues with the [smart] phone: calls drop [and] there's a lot of echo sound that is so bad that you have to hang up and call again because you cannot hear the patient properly.

A few nurses stated that they preferred to "just pop by" the patient's room after their phone alerts them of a call bell rather than picking up the call through the smartphone. As well, some nurses reported that some patients did not know how to use the phone in the room to speak to the nurse or had trouble increasing the volume.

Additionally, despite acknowledging that the smartphones had increased efficiency, most of the nurses described experiencing a certain degree of stress due to receiving multiple notifications via the smartphone, similar to the stress experienced due to overuse of personal smartphones:

> [Smartphones] sometimes cause stress. On some floors, every five to 10 minutes their phone is ringing.

> Sometimes I also accidentally hang up the phone because it's touchscreen, so when I put [it] up to my cheek to talk, it hangs up [laughs].

A few of the nurses also stated that when the smartphones were first introduced, they were perceived unfavourably by patients and families. One nurse stated,

> I know that when we first got introduced [to] the [smart] phones, some of the patients mistakenly thought it was a cellphone. So there have been comments that were made by patients saying, "Oh, the nurse is on their cellphone when they are supposed to be with me." But I think now since we are known as a fully digital hospital, the patients who walk through our door … expect it.

Other issues mentioned were system glitches and poor battery life, which the study participants stated were similar to problems experienced with personal smartphones.

Opportunities for improvement

Many of the nurses in the interview described several suggestions for further improvement, including adding the option to text interprofessional team members and adding a phone directory to easily reach staff across the hospital. One nurse noted that there were plans to enable the camera feature in the smartphone to be linked to the patient's electronic medical record (EMR). A few of the nurses stated that this enhancement to the smartphone would be particularly useful for capturing the progress of pressure injuries.

Discussion

Previous research has only examined the response times of healthcare providers with the use of smartphones in the hospital setting (Hardyman et al. 2013; Patel et al. 2015). The findings from a previous systematic review identified just 55 studies related to stand-alone smartphone-based healthcare technologies, with merely five of these studies being specific to clinical communication (Mosa et al. 2012). The current study contributes to the limited body of knowledge regarding the use of clinical communication technology in healthcare by providing a comprehensive evaluation of integrated hospital smartphone technology from the nurse's perspective.

Similar to the findings from previous studies (Wu et al. 2010) that revealed mobile phone communication in critical care areas facilitated the rapid transfer of information, nursing staff in this study perceived the smartphone as a valuable tool in reducing communication delays. The results from this study were also comparable to previous research that characterized the healthcare system as highly mobile and thus required healthcare professionals to be extensively mobile, with the appropriate technological resources to fully support that mobility (Ammenwerth et al. 2000; Bardram and Bossen 2000; Burdette et al. 2008). In the current study, nurses identified the advantage of the smartphone as providing immediate communication with the interprofessional clinical team and service providers, including porters, regardless of their location on the unit or in the hospital. Study participants said a key benefit of the smartphone was convenience and improved efficiency, based on a more timely exchange of information, which is consistent with previous research findings (Mobasheri et al. 2015).

This study also supports the proposition from previous research that suggests stand-alone smartphone applications are limited in their usefulness to healthcare professionals and must be integrated with other health information systems to enhance patient care (Mosa et al. 2012). The findings from the current study revealed that nurses viewed the integration of the smartphone with the patient call-bell system as integral to delivering safe care. Nurses placed a high value on the tone-varied alerts that are received directly through the smartphone and serve as a patient needs prioritization tool – for example, the alarm for preventing a patient fall will sound on the smartphone as a top priority.

The results of this study revealed that nurses perceived that smartphone technology improved relationships with patients because calls are received directly, which fosters continuity and comprehensiveness of care delivery. Similar results were found in a previous study, whereby nurses and physicians reported little support

for the notion that smartphone technology "gets in the way of care" (Moore and Jayewardene 2014). These findings suggest that nurses and other healthcare providers may be more primed than in the past to accept the use of technology as a means to enhance care delivery without compromising the therapeutic relationship.

In addition, the findings from this study were similar to previous research results in which some level of discomfort existed among healthcare providers with using smartphone technology in the presence of patients (Moore and Jayewardene 2014). Nurses in the current study perceived that patients perceived smartphones unfavourably because of misunderstandings about its use for personal versus clinical communication and care delivery. This suggests that hospitals proposing to introduce smartphone technology may need to ensure that patients and families are well educated about the clinical use and functionality of communication information technology.

The smartphone integration at HRH permits nurses to receive information from a variety of digital devices. Currently, the smartphone at HRH serves primarily as a one-way information source for nurses. As nurses in this study have suggested, the ability to text interprofessional team members may support better and faster information exchange between clinicians. However, text communications between healthcare providers pose some risks. First, all patient information must be documented in the EMR to ensure that standards and legal requirements are met in relation to patient care delivery. Second, clear and verifiable mechanisms are required for receiving and confirming medical orders to avoid errors. To become a tool for information exchange between nurses and other clinicians, the smartphone would need to be interoperable with the EMR so that every aspect of care delivery could be digitally recorded, including clinical photographs. HRH is exploring these opportunities to further leverage the use of smartphone technology and maximize the potential for streamlined, ultra-safe care delivery of the highest quality.

Further reflecting on the issue of communication in the fully digital environment, the integration of smartphone technology may provide a crucial connection between healthcare team members. Anecdotally, nurses and other clinicians have commented that with the introduction of computerized provider order entry (CPOE), in which medical orders are completed electronically and automatically sent to nurses or other healthcare providers, there are fewer opportunities to communicate among the team. The introduction of smartphone technology has fostered the opportunity to communicate and reconnect as members of the

healthcare team. Organizations at the initial stages of digitalization may want to consider the integration of smartphone technology alongside CPOE to reduce the likelihood that communications between the interprofessional team are disrupted.

Nurses in this study revealed their experience of being stressed because of receiving multiple notifications via the smartphone. This is an important finding but not surprising given the challenges associated with achieving a balance between alarm support and alarm fatigue. Healthcare organizations will need to be conscious of this phenomenon when implementing technology and strive to create a balance.

Overall, research participants perceived the clinical use of the smartphone and its integrated features in a very positive light. Issues such as patients' lack of knowledge regarding how to use the call system, insufficient sound quality and poor battery life were similar to problems identified in previous studies (Mosa et al. 2012). Considering the multiple benefits of smartphone technology identified by nurse participants in this study, including time management, convenience, prioritization, patient safety and enhancement of the nurse-patient relationship, other healthcare organizations may be persuaded and supported to implement mHealth technology.

Limitations

This study has some limitations, which must be addressed. First, respondent selection was limited due to nurses' busy schedules; therefore, this presents a degree of non-response bias. Next, the data were derived from a single hospital site, limiting the generalizability to other hospital settings, specifically smaller hospitals, which may not have the same needs or obstacles as larger hospitals. Additionally, the study outcome was limited to nurse perceptions of smartphone technology, and patient perceptions were not obtained. Finally, face-to-face interviews may lead to social desirability bias; however, interviews were conducted by the research coordinator to minimize any influence on the participants' responses.

Conclusion

The integration of smartphone technology with the patient call-bell system provides the opportunity to enhance patient safety by supporting nurses' ability to directly communicate and prioritize care delivery. Aside from the potential for harm reduction, the findings from this study suggest further benefits of integrated communication information technology, such as improved nurse-patient relationship, time management and convenience. Integrated smartphones have the prospect of changing the way nursing care is provided. The findings from this study suggest that smartphones can play an important role in enhancing the delivery of high-quality care.

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HUMBER RIVER HOSPITAL

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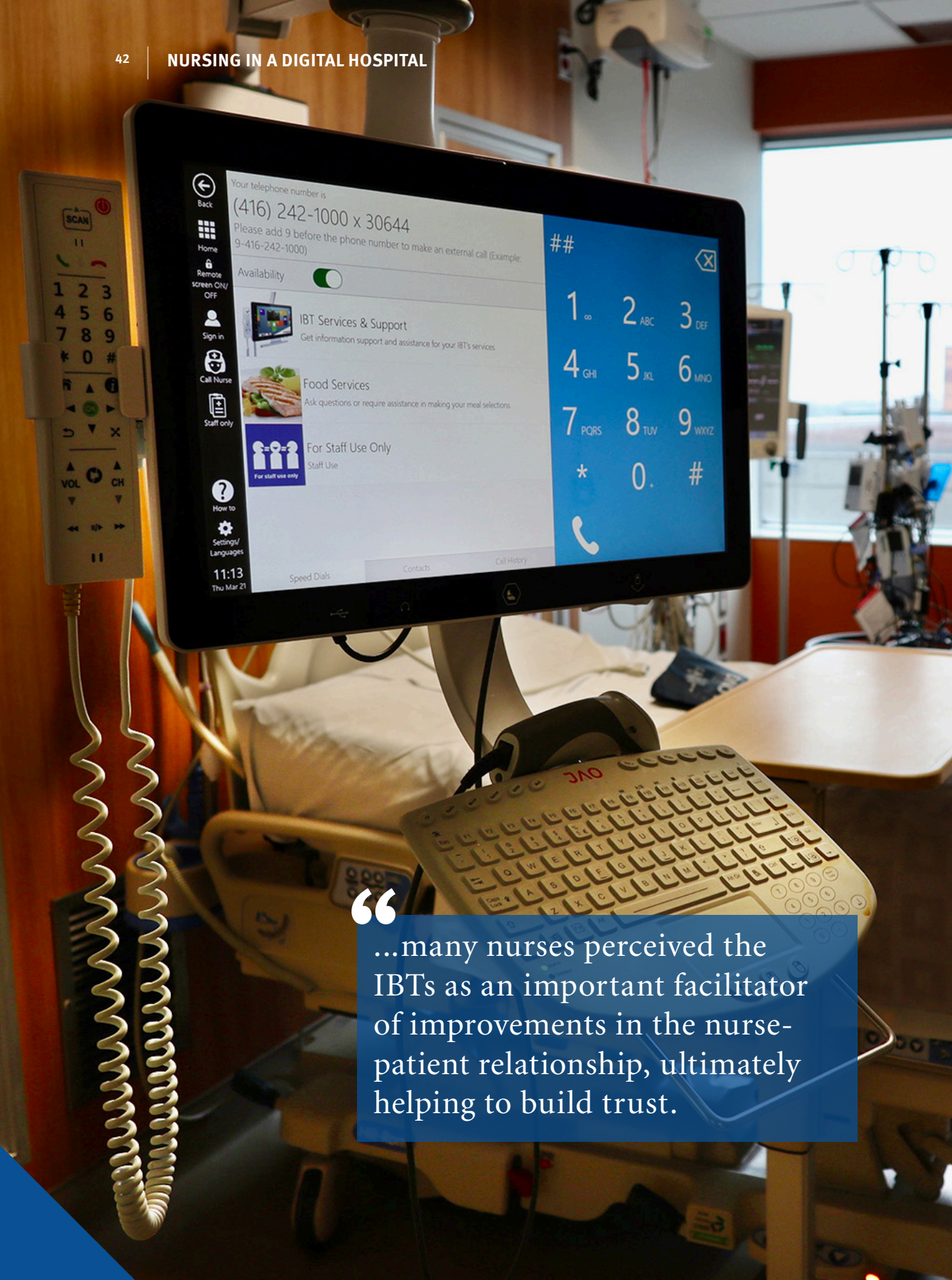
Leading technology & innovation integration in nursing



> “...many nurses perceived the IBTs as an important facilitator of improvements in the nurse-patient relationship, ultimately helping to build trust.

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Patient Empowerment and Nursing Clinical Workflows Enhanced by Integrated Bedside Terminals

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WHAT WE LEARNED:

1. Patients highly valued the sense of empowerment they derived from the IBT service elements, including meal ordering and environmental conditions such as room lighting, temperature and window shades. Future studies need to explore what other service elements patients are seeking to control during their hospital stay.
2. The IBT does not replace the need for nurses to create the conditions by which the delivery of information to patients can support confidence and trust in the care and treatment being received. Ongoing attention must be paid to the potential impact of technology on the nurse-patient relationship.
3. The ability to influence personal health information through, for example, the integration of a patients' notes element into the IBT may provide the necessary level of involvement to garner a greater sense of patient empowerment in relation to health management.

Abstract

Background: Integrated bedside terminals (IBTs) were implemented at Humber River Hospital with the goal of supporting patient independence and autonomy and improving nursing workflows. The IBTs provide access to a range of convenience and entertainment services as well as access to personal health information. Due to the novelty of the technology, there is a paucity of empirical data on patients' use of, satisfaction with and perceptions of bedside terminals.

Aim: The purpose of this study was to evaluate the impact of IBTs on patient empowerment and nursing workflows.

Methods: A mixed methods design was employed using a cross-sectional patient survey and semi-structured interviews with nurses. The patient survey assessed patient empowerment and satisfaction with the range of services offered through the IBT. Patient scores were summarized using descriptive statistics. Additionally, face-to-face interviews with nurses were used to illicit feedback regarding the IBTs' impacts on nursing workflows.

Results: In total, 113 patients and 11 nurses participated in the study. Analysis of patient satisfaction surveys indicated that the IBTs enhanced the patient experience and increased self-care management. Nurses reported that the IBTs helped patients feel comfortable and entertained and helped enhance the nurse-patient relationship. However, nurses also expressed concern that elderly patients were less inclined to use the IBT.

Conclusion: The results from the present study suggest that the IBT system has the potential to empower patients and decrease demands on nurses. Patients' notes incorporated into the IBT may provide the necessary level of involvement to garner a greater sense of patient empowerment. The IBT does not replace the need for nurses to deliver information to patients in a manner that supports their trust.

Background

Health information technology (HIT) has been commonly developed for improving administrative functions and achieving greater operational efficiency, such as nursing clinical workflows. However, a new generation of HIT is emerging, which is aimed at connecting and integrating the hospital information network, clinical services, patient entertainment and communication systems at the point of care (Yoo et al. 2015). Integrated bedside terminals (IBTs) were introduced at Humber River Hospital (HRH) in 2015 with the primary purpose of enhancing the quality and safety of care delivery and elevating the patient experience (Figure 1). IBTs are bedside terminals that enable efficient access to clinical information that nurses and other healthcare providers can use to support care delivery and patients can use for entertainment services, such as television and radio, as well as Internet communication services, such as Skype and instant messaging. Patients also have access to convenience services, such as meal ordering, room environmental controls and personal health information, including the results of lab and diagnostic imaging tests and vital signs data through the bedside IBT. Recognizing that patient experience is a vital measure in the quality of healthcare service, this study set out to understand patient satisfaction and engagement with IBTs.

FIGURE 1. Integrated bedside terminals at Humber River Hospital.

Only a few studies have focused on nurse-centred bedside terminals (Blank and Bauer 1991; Brown et al. 1995). However, in these studies, the digital devices being examined were used solely by nurses for the purpose of documentation and were not intended for patient use. Since few hospitals around the globe have adopted patient-centred IBTs (sometimes referred to as "bedside terminals" or "smart bedside stations"), very few studies have been conducted on patient satisfaction with these devices. One study conducted by Ryu et al. (2016) in a South Korean hospital found that patients were highly satisfied with the bedside system, particularly with personalized services such as viewing lab results and checking hospital fees. Another study compared patient satisfaction associated with meal ordering using a bedside electronic system to traditional paper menus in an oncology ward. The findings revealed that patients who had the bedside electronic meal ordering system not only expressed greater satisfaction with their meals but also tended to order meals that were more nutritious than patients who were given paper menus (Barrington et al. 2018).

These studies provide a glimpse of some of the potential advantages of IBTs. Due to the novelty of the technology and the limited number of healthcare organizations that have implemented IBTs, there is a paucity of literature that examines the benefits of IBTs to patients and nurses. Further research is needed to leverage the capacity of the IBT to enhance the quality and safety of care delivery and elevate the patient experience. The present study was aimed at identifying impacts on patient empowerment and nursing workflows associated with IBT use in an acute care hospital setting.

Methods

Description of the IBT

A total of 724 IBTs were installed in rooms on all wards in 2015. The key services featured on the IBTs are categorized into four services: entertainment, communication, convenience and personal health information. All features are provided free of charge, with the exception of the entertainment services, which carry a fee of $10 per day.

Study design and sample

A cross-sectional and descriptive study design, using a representative subset of patients and nurses at a single point in time, was applied to assess the impact of the IBT on patient empowerment and nurses' clinical workflow. Permission to carry out the study was obtained from the Institutional Review Board at HRH. Informed consent was obtained from all participants. Participation in the study was voluntary, and all responses were anonymous. For the patient empowerment survey, all inpatients were eligible for inclusion in the study. Inclusion criteria for nurses included the requirement that nurses predominantly provide direct care to inpatients and have at least six months of experience working at HRH since the Wilson site opened in October 2015.

Data collection and instruments

Patients' responses were collected between October and November 2018. Trained volunteer personnel administered the questionnaire among inpatients. Demographic data, including age and gender, were collected through the questionnaire. Participants were asked to rank their confidence in using technology on a four-point Likert-type scale (very confident, somewhat confident, only a little confident and not at all confident) and to indicate whether they had received any training on the use of the IBT (yes/no).

The survey also included measures of satisfaction with patients' use of the IBT. Patient satisfaction with the IBT was quantified using a 14-item scale composed of the four domains of IBT services offered. Patients were asked to rate all of the services available through the IBT menu using a five-point Likert-type scale in which scores of 1 to 5 corresponded to ratings from "very poor" to "excellent." There was an additional option of reporting "N/A" for any service provided through the IBT that the patient did not use.

A 15-item scale, which consisted of items relating to three service domains, measured patient empowerment: access to the health record, access to meal ordering and access to environmental controls such as lighting, window shading, room temperature, etc. (survey adapted from Earnest et al. 2004; Barrington et al. 2018). Participants were asked to rate their level of agreement with each statement using a five-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree or strongly disagree). The scale included items such as "having access to my health information through the IBT has been important to my healing process" and "having access to the room environmental controls has helped me feel more in control of my environment."

Impacts on nursing workflow

In addition to administering the questionnaire, semi-structured interviews were conducted in November 2018 with 11 nurses to assess the impacts of the IBTs on nursing workflow. All interviews were digitally recorded and transcribed. Demographic data were collected, including age, gender, length of employment at HRH and number of years of experience as a registered nurse, registered practical nurse or nurse practitioner.

Data analysis

Patient demographic data were summarized using descriptive statistics. Chi-square test and Fisher's exact test were used to compare categorical variables (gender, age category, confidence using technology and training received) between IBT users and non-users. As there were few participants in the 16 to 24 years category, this age group was combined with the 25 to 34 years category for the chi-square analysis. The 14 items related to patient satisfaction with the IBT services, as well as the 15 items related to the three patient empowerment domains, were summarized using frequencies and percentages. Additionally, a content analysis was conducted on nurses' textual interview data. Quantitative statistical analyses were performed using IBM SPSS Statistics (version 25). A p value of < 0.05 was considered statistically significant.

Results

Inpatient characteristics

A total of 113 inpatients participated in the study. Participant characteristics are summarized in Table 1. The majority of participants were female (58.4%) and over the age of 65 (30.6%), and many were "very confident" using technology (42.9%). Nearly 70% of participants indicated that they used the IBT during their stay, and 60% of participants indicated that they did not receive training on how to use the IBT.

Comparison of characteristics between IBT users and non-users indicated that IBT users were more likely to be "very confident" using technology compared to non-users (49.3% versus 28.1%, $\chi 2\ [1, N = 105] = 4.08$, $p = 0.043$). Non-users were more likely "not at all confident" with technology compared to IBT users (37.5% versus 12.4%, $\chi 2\ [1, N = 105] = 8.81$, $p = 0.003$). Receiving training on

the IBT was also associated with IBT use versus non-use (49.4% versus 13.9%, $\chi 2$ [1, $N = 113$] = 13.09, $p < 0.001$). There was no statistically significant difference between IBT users and non-users with regard to gender and age group.

Table 1. Comparison of baseline characteristics in inpatients by IBT user and non-user, *n* (%)

	Total (%) (*n* = 113)	IBT user (%) (*n* = 77)	Non-user (%) (*n* = 36)	*p* value
Gender (*n* = 113)				
Female	66 (58.4)	42 (54.5)	24 (66.7)	0.22
Male	47 (41.6)	35 (45.5)	12 (33.3)	
Age group (*n* = 108)				
16–34	20 (18.5)	15 (20.3)	5 (14.7)	0.33
35–44	12 (11.1)	6 (8.1)	6 (17.6)	
45–54	18 (16.7)	14 (18.9)	4 (11.8)	
55–64	25 (23.1)	19 (25.7)	6 (17.6)	
65+	33 (30.6)	20 (27.0)	13 (38.2)	
Confidence using technology (*n* = 105)				
Very confident	45 (42.9)	36 (49.3)	9 (28.1)	**0.043**
Somewhat confident	19 (18.1)	13 (17.8)	6 (18.8)	0.908
Only a little confident	20 (19.0)	15 (20.5)	5 (15.6)	0.554
Not at all confident	21 (20.0)	9 (12.3)	12 (37.5)	**0.003**
Training provided on using the IBT (*n* = 111)				
Yes	43 (38.1)	38 (49.4)	5 (13.9)	**< 0.001**
No	70 (61.9)	39 (50.6)	31 (86.1)	

IBT = integrated bedside terminal.

Patient empowerment and satisfaction with the IBT

The percentage of patients rating the patient empowerment items on a five-point scale from strongly agree to strongly disagree can be seen in Table 2. Overall patient empowerment ratings for access to health record services were neutral. Although most patients rated the subscale items as agree/strongly agree (40.0–49.1% of patients), almost one third rated the items as disagree/strongly disagree (23.6–32.7% of patients). "Having access to my personal health information has been important to my healing process" received the highest portion of agree/strongly agree ratings (49.1%).

Meal ordering services received higher patient empowerment ratings, with most patients rating the items as agree/strongly agree (51.5–71.9% of patients). The most highly rated patient empowerment item was "I was happy with what I ordered" (71.9%). Environmental control features also received high patient empowerment ratings, with most patients rating the items as agree/strongly agree (65.6–70.2% of patients). The most highly rated patient empowerment item was "having access to the room environmental controls allowed me not to have to rely on others as much" (70.2%).

Table 2. Patient empowerment ratings

Patient empowerment items	*n*	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)
Having access to my personal health information has ...						
helped me gain more knowledge about my medical condition	55	5 (9.1)	8 (14.5)	19 (34.5)	17 (30.9)	6 (10.9)
helped me better understand my doctor's instructions	55	5 (9.1)	12 (21.8)	15 (27.3)	17 (30.9)	6 (10.9)
helped me be more involved in the treatment	55	5 (9.1)	13 (23.6)	15 (27.3)	14 (25.5)	8 (14.5)
helped me feel more in control of my medical care	55	7 (12.7)	11 (20)	14 (25.5)	14 (25.5)	9 (16.4)
been important to my healing process	55	6 (10.9)	9 (16.4)	13 (23.6)	17 (30.9)	10 (18.2)
Meal ordering service						
I was happy with what I ordered	64	1 (1.6)	7 (10.9)	10 (15.6)	24 (37.5)	22 (34.4)
I felt in control over what I ordered	64	3 (4.7)	8 (12.5)	9 (14.1)	21 (32.8)	23 (35.9)
Using the meal ordering service was enjoyable	64	5 (7.8)	6 (9.4)	14 (21.9)	18 (28.1)	21 (32.8)
The menu was visually appealing and influenced my menu order decisions	64	5 (7.8)	7 (10.9)	19 (29.7)	15 (23.4)	18 (28.1)
The meal ordering service has been important in allowing me to heal	64	5 (7.8)	5 (7.8)	18 (28.1)	18 (28.1)	18 (28.1)
Having access to the room environmental controls (e.g., lighting, window tint) has ...						
allowed me to sleep better	67	4 (6)	6 (9)	13 (19.4)	22 (32.8)	22 (32.8)
helped me feel more in control of my environment	67	3 (4.5)	5 (7.5)	13 (19.4)	24 (35.8)	22 (32.8)
allowed me not to have to rely on others as much	67	4 (6)	5 (7.5)	11 (16.4)	29 (43.3)	18 (26.9)
allowed me to make my room more comfortable	67	3 (4.5)	7 (10.4)	11 (16.4)	25 (37.3)	21 (31.3)
been important to my healing process	67	5 (7.5)	3 (4.5)	15 (22.4)	24 (35.8)	20 (29.9)

The percentage of patients rating their satisfaction with the IBT services on a five-point scale from "very poor" to "excellent" can be seen in Table 3. Overall, patients rated the IBT services positively. More than 90% of patients reported satisfaction with the instant messaging services (94.1% rated good/excellent). Similarly, most patients were satisfied with the lighting controls (80.4% rated good/excellent) and hospital information (79.1% rated good/excellent) features within the IBT. The

services with the lowest satisfaction ratings were meal order (14.6% rated very poor/poor), Internet services (19.2% rated very poor/poor) and Skype (21.4% rated very poor/poor); however, the Skype feature was also rated positively by 71.4% of patients.

Table 3. Patient satisfaction ratings with IBT services

	*n**	Very poor (%)	Poor (%)	Acceptable (%)	Good (%)	Excellent (%)
Entertainment						
TV	71	3 (4.2)	2 (2.8)	15 (21.1)	27 (38.0)	24 (33.8)
Radio	34	0 (0)	1 (2.9)	7 (20.6)	13 (38.2)	13 (38.2)
Music	27	1 (3.7)	1 (3.7)	6 (22.2)	9 (33.3)	10 (37.0)
Internet	26	2 (7.7)	3 (11.5)	6 (23.1)	7 (26.9)	8 (30.8)
Communication						
Skype	14	2 (14.3)	1 (7.1)	1 (7.1)	3 (21.4)	7 (50.0)
Instant messaging	17	0 (0)	1 (5.9)	0 (0)	5 (29.4)	11 (64.7)
Convenience						
Meal orders	62	4 (6.5)	5 (8.1)	14 (22.6)	16 (25.8)	23 (37.1)
Lighting controls	56	2 (3.6)	1 (1.8)	8 (14.3)	23 (41.1)	22 (39.3)
Temperature controls	54	4 (7.4)	3 (5.6)	8 (14.8)	20 (37.0)	19 (35.2)
Call bell system	49	1 (2.0)	3 (6.1)	11 (22.4)	11 (22.4)	23 (46.9)
Personal health information						
Resources	27	1 (3.7)	0 (0)	6 (22.2)	7 (25.9)	13 (48.1)
Hospital information	24	0 (0)	0 (0)	5 (20.8)	5 (20.8)	14 (58.3)
Lab test results	19	0 (0)	2 (10.5)	4 (21.1)	3 (15.8)	10 (52.6)
Medical record	16	0 (0)	1 (6.3)	4 (25.0)	2 (12.5)	9 (56.3)

*Total $n = 77$.
IBT = integrated bedside terminal.

Impacts on nursing workflow and the nurse-patient relationship

Of the 11 nurses interviewed, 63.6% were female, and the age range for participants was in the 20s to 40s. The average number of years of experience for all participants was 3.87 years ($SD = 2.79$), with 3.11 years ($SD = 2.99$) of employment at HRH. The majority of participants were graduates of a baccalaureate nursing program (81.8%) and practised as registered nurses (72.7%).

Nurses shared their perceptions and observations of the IBT system. Four themes, including positive patient outcomes, improved nurse-patient relationship, technological difficulties and older patients' need for companionship, as well as suggestions for improvement, were identified through face-to-face interviews.

Positive patient outcomes

Generally, the IBT technology was seen as having the potential to positively influence nursing workflow. Nurses reported that from their perspective, the IBT was a good source of entertainment and enjoyment for the patient to pass time and relieve boredom and agitation during a hospital admission. One nurse commented that she thought the IBT was a particularly good distraction for patients experiencing acute pain. Others noted that patients would often watch television from the IBT at night to fall asleep. Several nurses also noted that turning on the news channel on the IBT served as a reorientation strategy for reducing delirium among older patients. Additionally, having the environmental controls embedded within the IBT provided patients with greater independence. These were cited as having a positive impact on nursing workflow through decreasing demands on the nurse.

Improved nurse-patient relationship

Nurses also reported improvements to the nurse-patient relationship. Several nurses stated that they were able to use the IBT to lessen the patient's anxiety. The system contains a number of resources for patients to browse on a plethora of medical conditions, and several nurses reported opening up the resource page and educating patients on new diagnoses using the information resources on the IBT. As one nurse commented, "My patient was going for angioplasty, and she was very worried about the procedure. So I could pull out the material on the IBT, and she got an idea about what to expect. That made her feel a little better." As well, nurses frequently mentioned that patients or their family members would inquire regarding the results of a recent medical laboratory test, and the nurse would be able to pull up the results of the test on the IBT, without leaving the patient's room to obtain the results from the chart. Participants stated that this helped build trust between patients and the nurse as patients could become dissatisfied if the nurse did not immediately recall the patient's clinical findings.

Technological difficulties

Although the IBT system was generally regarded as a valuable and convenient tool, nurses did report some negative impacts on nursing workflow because of the IBT. The most common complaint was workload demands associated with providing training to patients and family members on the use of the IBT. Several nurses commented that older patients had a high degree of difficulty using the IBT because they had limited knowledge and experience using technology. Many nurses were very willing to help patients learn to use the IBT but stated that this imposed a time burden on their daily workload.

Older patients' need for companionship

Furthermore, some nurses noted that the IBT was not a source of diversion for older patients experiencing loneliness as they would still often seek the attention of nurses. Nurses reported that, generally, patients were enamoured with the novelty of the technology, and all nurses were optimistic that the IBT would be most used and valued by the next generation of patients, who place a high value on information technology.

Suggestions for improvement

A common complaint conveyed by nurses in this study was recurrent breakdowns of the IBT system. Nurses provided several suggestions for improving the IBT system, including increasing the text size for improved readability, increasing touchscreen and keyboard sensitivity and offering the option to display text in multiple languages to accommodate the diversity of the patient population. Nurses suggested adding a video tutorial to assist patients with learning to use the system themselves.

Discussion

To our knowledge, based on an exhaustive search of the CINAHL, ProQuest, and PubMed databases, this is the first study of its kind assessing the impact of smart bedside terminals on patient empowerment and nursing workflows. The findings from this study revealed that the majority of patient participants used the IBT during their stay to access their health record, order meals and regulate the environmental conditions in their room. Similar findings from Caligtan et al. (2012) revealed that patient room orientation and access to their own clinical information were two of the most important elements patients sought in bedside information systems. The results of this study suggest that there is alignment between the essential information patients are seeking and the data elements that are integrated into the bedside terminals at HRH. Validation of these data elements, in the context of their importance to patients, further enhances the opportunity to build bedside terminals that promote satisfaction and the potential for increased self-care management.

The highest empowerment ratings from patients who participated in this study were associated with feeling "more in control over meal ordering" and "more in control of [their] environment." This study found that the lowest rated feeling of empowerment was in relation to patients' control of medical care, understanding of the doctor's instructions and involvement in treatment. Although several studies found an association between access to information and increased participation in health management and improved outcomes, the findings from this study suggest that mere access to personal health information does not necessarily lead to patients' feeling of empowerment related to health management (Adamson and Bachman 2010; Poon et al. 2010; Schnipper et al. 2008).

The findings from our study led us to reflect on what more can be done to strengthen patients' experience of power and control over their own care. Presently, at HRH, the elements in the IBT that are associated with service domains such as meal ordering and room lighting are designed to actively involve patients. Conversely, the elements in the IBT that are associated with personal health information are built to prevent manipulation by the patient. To clarify, for the service domains, patients are free to make adjustments based on their preferences. However, for personal health information, patients are limited to simply viewing their medical information. The findings from previous studies revealed that when patients were proactive participants in their care, with access to health information and active involvement in developing their treatment plans, safety was enhanced and patient satisfaction improved (Campbell and Park 2008; Caruso 2007; Chaboyer, et al. 2010; Meuthing et al. 2007).

Our study suggests that the ability to influence personal health information through, for example, the integration of a patients' notes element into the IBT may provide the necessary level of involvement to garner a greater sense of patient empowerment in relation to health management. We thought about the relationship of the electronic medical record (EMR) to the hospital and the patient. The hospital is the custodian of the EMR, and the patient is the owner of the information contained within the EMR. Nurses and other clinical providers of the hospital are legally required to document and record their clinical impressions in the EMR. Once the information is entered, any changes to the EMR are conducted in the form of an addition versus a deletion. To clarify, if the nurse documented that the right leg was swollen but, in fact, the left leg was, the nurse would add the correction to the documentation and not delete the previous incorrect entry. Thus, if a patients' notes section of the EMR were introduced, we would suggest that a similar process could be established. That is, patients would be able to enter additional information but would not be permitted to delete or manipulate other information in the EMR. Potentially, this would provide patients and their families with the opportunity to add information that clarifies, enhances or corrects information contained in the EMR. Patients may benefit from a deeper level of engagement in the management of their health information and possibly gain a greater sense of empowerment over their care. Nurses and other healthcare providers may use the patients' notes to enhance patient-centred care by aligning expectations about treatment plans and avoiding potential errors and misunderstandings that may compromise care.

One of the challenges we anticipate with the introduction of the patients' notes element into the EMR is the resistance of some nurses, physicians and other healthcare providers to support the approach of patients having greater authority over their health information. The potential to incorporate a patients' notes section into the EMR may generate similar anxiety, as expressed by nurses and other healthcare providers when patient and family advisors were introduced into the healthcare system. Across healthcare organizations, concerns about exposure to greater liability and the inability to manage patients' expectations related to care delivery were commonly expressed. Those concerns have not been realized, and by all accounts, the engagement of patient and family advisors has been enlightening and a value-add for healthcare organizations. There will need to be more dialogue with patients and families, nurses, physicians and other clinicians to better understand the benefits and challenges of introducing the patients' notes section into the EMR. HRH is poised to take the lead on this conversation and leverage its technology to improve the patient experience and consistently deliver the safest and highest quality care.

Overall, IBT services rated highest by patients included instant messaging, hospital information and medical records. Our study supports previous research findings suggesting that communication tools and access to personal health information are valued elements in bedside information technology systems (Caligtan et al. 2012). Patients' perspectives indicate that models of care delivery incorporating IBTs to enable transparency and foster communication are essential ingredients for generating satisfaction and empowerment.

Most of the nurses participating in this study viewed the entertainment services of the IBT as an important method of providing entertainment and distraction for patients; relieving boredom, anxiety and pain; and serving as a reorientation tool for patients with delirium. The findings from this study are similar to previous research in which distraction techniques involving technology resulted in patients experiencing decreased pain and anxiety (Li et al. 2011; Hudson et al. 2015; Tashjian et al. 2017). Our study suggests that the IBT at HRH is an effective, safe and simple means of helping patients remain oriented, stimulated and comfortable. Additionally, the findings from this study suggest that the distraction potential of the IBT entertainment services improved nursing workflow by decreasing the demands on nurses. In particular, the ability for patients to control the environmental conditions in their room alleviated the necessity for nurses to perform ancillary care responsibilities such as dimming lights and adjusting temperature settings, leaving more time for nurses to focus on direct care responsibilities. Our study did not have the opportunity to validate the usefulness of the IBT for distraction purposes from the patient perspective. A future study could explore this matter further to gain a better understanding of this potential benefit of the IBT for patients.

An interesting outcome of this study is that many nurses perceived the IBTs as an important facilitator of improvements in the nurse-patient relationship, ultimately helping to build trust. Patient education and information about numerous medical conditions is available through the IBTs, and according to the nurses in our study, is a valuable resource for patients and families. Additionally, several nurses commented that bedside access through the IBT to patient health information such as test results enabled them to save time, immediately respond to requests for information and provide education and reassurance to patients. This is an important finding of our study because some of the previous literature has suggested that technology may compromise the therapeutic relationship (Baysari et al. 2018; Rathert et al. 2017).

In our study, the IBTs served to build trust between patients and nurses, thereby strengthening the therapeutic relationship and facilitating safer care and positive patient experiences. Our findings suggest that the process by which technology is integrated into care delivery versus the technology itself might lead to improved relationships. For example, regardless of whether or not the information is accessible at the bedside, nurses must be open and responsive to the informational needs of patients and make the time to ensure that those needs are met. Having patient information contained in one location and accessible at the bedside makes conversations with patients timely but does not ensure that patients' informational needs are satisfied. The nurse remains central in creating the conditions by which the delivery of information to patients supports or erodes their confidence and trust in the care being delivered. Ongoing attention must be paid to the potential impact of technology on the nurse-patient relationship.

Essentially, our study found that nurses considered the IBT system a valuable and convenient tool for themselves and patients. However, several nurses complained of the additional workload that IBTs imposed because patients and families needed to

be taught how to use the system. Our findings suggest that the time burden spent teaching patients to use IBTs needs to be examined further and alternative methods need to be developed to ensure that every patient receives adequate teaching regarding the use of IBTs. Failure to do so may begin to erode the many benefits attributed to IBTs from both the patient and the nurse perspective. Shortly following this study, hospital volunteers were trained to teach patients and family members about the use of the IBT. Future research will evaluate the initiative from the patient, volunteer and nurse perspectives to gain a better understanding of the strengths and challenges of educating patients and families on the use of the IBT.

Also, several nurses in this study expressed concern for elderly patients and their inability to grasp the use of the IBT. The use of bedside technology may not be suitable for all patients. However, IBT technology is highly valued by patients who are able to use it. Anecdotally, patients who were interviewed in this study reminded nurses and surveyors who moved the IBTs away from the bedside to complete the surveys that they needed to return it back to the bedside. As with any tools or resources provided to patients, such as call bells, if they are inaccessible to the patient, then they cannot be used, whether embedded in the technology or attached to the bed linen. As the digital footprint grows across healthcare organizations, basic nursing considerations must be maintained.

Our study caused us to reflect on the circumstances where patients are unable to use the IBT. We are currently exploring other effective approaches to maintain equitable access to personal health information and support patient empowerment in circumstances where patients cannot use the IBT. With this feedback from patients and staff regarding IBT use, HRH has developed a patient and family advisory committee dedicated to the improvement and uptake of IBTs across the hospital. This committee is composed of representatives from patients and families with first-hand experience using the IBTs, nursing staff and leaders, the information technology and services team and human factors engineers. As a high-reliability hospital, this study has highlighted the importance of broad stakeholder engagement required to implement continuous improvement and explore the opportunities for enhancing both patient and staff experience with the IBTs. Items that have been discussed to date include modifying information displays (e.g., larger text sizes), alternative language options and video lessons (i.e., IBT tutorials to both provide patients an orientation to the IBTs and serve as a resource to review how to access information if a patient had forgotten how to do so).

Limitations

The small sample size of this study provided the opportunity to gain in-depth insights into the impact of IBTs on patient empowerment and nursing workflows. Although the findings may not be widely generalizable, the results of this study revealed important information that other hospitals seeking to integrate IBTs may consider to support their implementation. The results are based on self-reported

data, which may be subject to social desirability bias, especially when audio recorded. However, nurses were equally open regarding both the advantages and limitations of IBT technology. As well, interviews with nurses were administered and analyzed by the research coordinator to minimize any influence on the participants' responses.

The limitations of the patient surveys include its cross-sectional design, which may be prone to non-response bias. Also, the study measured satisfaction with the IBT at a single hospital site; therefore, generalizations to other patient populations must be made with caution and may not be extended to broader healthcare settings.

Conclusion

A major advantage of this study is that responses regarding the IBT's impacts were sought from both patients and nurses. To our knowledge, this is the only study of its kind. IBTs were introduced at HRH with the principal goal of enhancing the quality and safety of care delivery and elevating the patient experience. Our study reveals where this goal was met and adds new knowledge to the existing body of literature about patient and nurse satisfaction and engagement with IBTs. Importantly, this study contrasts to others suggesting that mere access to personal health information leads to patient empowerment in relation to health management. Our study revealed that the IBT at HRH is an effective, safe and simple means of helping patients remain oriented, stimulated and comfortable, with the distraction potential of the IBT entertainment services improving nursing workflow and leaving more time for nurses to focus on direct care responsibilities. Another new finding of our study is that the IBTs served to build trust between patients and nurses because the system enables immediate responses to patient requests for information and education. Finally, strategies must be considered to maintain equitable access to personal health information and empowerment strategies in circumstances where bedside technology may not be suitable for patients.

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> “...You feel more safe as a nurse, so I have to say that it’s a great tool to have.

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Violence Prevention: Technology-Enabled Therapeutic Intervention

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WHAT WE LEARNED:

1. Engaging staff, patients and families in this unique digital and technology-enriched environment has been critical for the successful implementation, evaluation and modification of the violence prevention electronic flagging system.
2. The patient and family education pamphlet served as an excellent tool to communicate the message that the electronic signage outside the patient room means that therapeutic interventions are in place to provide patients with the potential for violence with the safest and highest quality care possible.
3. In a fully digital environment, policies and procedures to support ongoing safety with regard to violence prevention require that robust downtime procedures are established.

Abstract

Background: Nurses are disproportionately prone to experience incidents of violent victimization. Despite the vast literature on violence in healthcare settings, few studies have identified effective violence prevention interventions.

Aim: The aim of the study was to explore the experiences of nurses regarding the implementation of technology-based violence prevention interventions.

Methods: Qualitative data were collected through semi-structured focus groups and interviews with 11 nurses at Humber River Hospital. Interviews were audiotaped, transcribed and subjected to a content analysis to identify core themes from the data.

Results: Three themes were identified: reassurance of safety, an increase in proactive measures and limitations of technology. Nurses held positive perceptions of the impact of technology-based interventions on violent incidents. The interventions were regarded as effective for the detection of potentially violent patients as well as for providing assistance from security staff when a violent incident occurs or appears imminent. However, nurses also acknowledged that patient-related violence was "unavoidable" and that technology cannot fully prevent violence from occurring.

Conclusion: The findings from this study support the replication of these interventions in other healthcare facilities. Engaging staff, patients and families in this unique digital and technology-enriched environment has been critical for the successful implementation of the violence prevention electronic flagging system. Patient and family education and communication were essential for addressing concerns related to "labelling."

Recent estimates suggest that in Canada, over one-quarter of incidents of violent victimization occurred in the victim's place of work (Perreault 2015). Given the crisis-oriented nature of hospital care, healthcare workers disproportionately experience workplace violence (Perreault 2015). Nurses often interact with patients and family members under stressful situations, which can increase the risk of violence (Koller 2016). One study revealed that as many as a third of

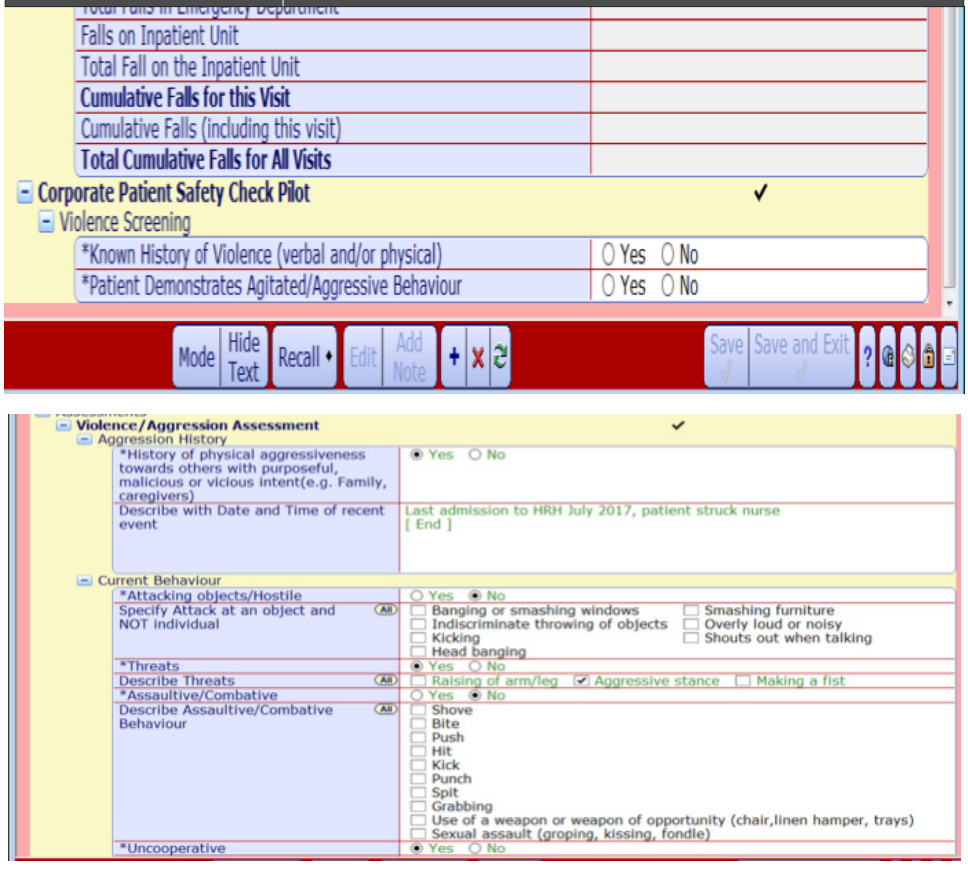
Canadian nurses reported being confronted by physical violence from patients and nearly half of Canadian nurses reported experiencing emotional abuse (Shields & Wilkins 2009).

Violent incidents in hospitals can take many forms, including physical violence, such as hitting and biting; non-physical violence, such as ridicule and verbal threats; and sexual violence (Duncan et al. 2016). Many cases of workplace violence go unreported because nurses become desensitized and accept violence as "part of the job" (Stevenson et al. 2015). Yet numerous studies have pointed out that there are major consequences of workplace violence (Gerberich et al. 2004; Lanctôt and Guay 2014; Park et al. 2015). In a systematic review, Lanctôt and Guay (2014) identified consequences of workplace violence among healthcare workers, including physical trauma, such as bruises and lacerations, as well as torn clothing and broken eyeglasses, and psychological consequences, such as changes in mood and cognition, anxiety and burnout. Many healthcare workers also reported that the violence had affected their life outside of work, and healthcare workers who experienced workplace violence took more sick leave and thought about quitting more than workers who had not experienced violence (Lanctôt and Guay 2014). Unfortunately, 2.3% of victims also reported that the violence they experienced had resulted in permanent disability (Lanctôt and Guay 2014).

The prevention and control of workplace violence are a top priority for Humber River Hospital (HRH), and major steps have been taken in accordance with *Ontario's Occupational Health and Safety Act* (1990) to "take every precaution reasonable in the circumstances for the protection of a worker." HRH has implemented a comprehensive violence prevention program encompassing annual violence risk assessments, specific de-escalation training, stakeholder engagement through the Joint Health and Safety Committee as well as patients and families, statistical review of events, public posters regarding zero tolerance and a personal safety response system. One additional proactive initiative is the electronic flagging system, which communicates the risk of violent or aggressive behaviour to healthcare staff for patients who have previously displayed violent behaviour. The flagging system, which is fully integrated into HRH's digital infrastructure, involves the use of standardized symbols that can be seen in the patient's medical record as well as on the digital signage next to the door of the patient's room (Figure 1 and Figure 2). One of the key advantages of the system at HRH is the use of digital signage over traditional paper-based signage as data automatically update once the information is added to the patient's medical record. The system also uses minimalist symbols, which avoids visual clutter and does not disclose more information on a patient than is needed, while still supporting workers' "right to know" about potential dangers. The flagging system is also able to alert all staff, including maintenance workers and volunteers who do not have access to patients' charts, of any known risks before they enter a patient's room.

Organizations may experience challenges identifying such patients openly, a controversy organizations have to manage to mitigate the perception of "labelling patients" while maintaining confidentiality.

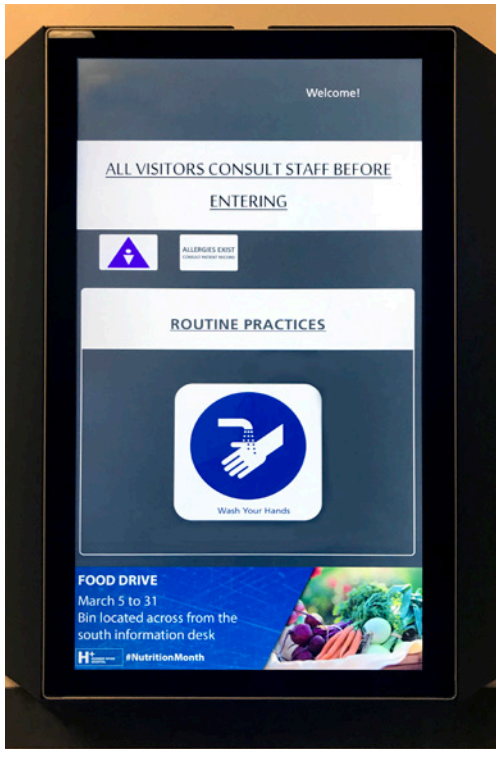
Figure 1. Flagging system.



Electronic flag

As this electronic flagging system was never intended to label patients but rather to provide caution that strategies to support patients are in place, leaders, staff members, patients and families supported the development of education pamphlets entitled "Contributing to a Safer Hospital Workplace: It's Everyone's Responsibility." This pamphlet includes an explanation of the automated signage outside a patient room, as well as assurances that the signage will not affect the quality of care patients will receive.

FIGURE 2. Digital Signage outside patient rooms.



HRH has also implemented the personal safety response system (PSRS), known informally as the "panic alarm button," a wearable technology with a silent panic button (Figure 3). The device is located on the back of the employee's badge and when pressed sends an SOS distress signal to summon immediate assistance from security staff. The device is also equipped with a real-time locating system (RTLS), "indoor GPS" allowing hospital security to be automatically informed of the staff's location within the hospital premises. The advantage of the PSRS system is that it allows security services to be called immediately and discreetly.

The aim of this study was to provide a qualitative description of the experience of nurses regarding violence prevention technology at HRH.

Methods

Study design and participants

A qualitative assessment (based on basic interpretive study design, providing an enriched descriptive account) of nurses' perspectives on the effectiveness of the flagging system and panic alert button was conducted at HRH. Eligibility criteria for participating nurses included working on inpatient units, working at the hospital for least six months and willingness to participate in the study. Written informed consent was obtained from all participants, and approval for the study was obtained from the HRH Research Ethics Board.

FIGURE 3. Personal safety response system.

Violence prevention interventions

A search of peer-reviewed and grey literature was conducted to determine existing violence screening tools that can be used to identify potentially violent patients. Three violence risk assessment tools were identified and were further evaluated: the Violence Assessment Tool (VAT) (Wilkes et al. 2010), the Dynamic Appraisal of Situational Aggression (DASA) (Ogloff and Daffern 2006) and the Brøset Violence Checklist (BVC) (Almvik and Wood 1998). The VAT was selected as the most appropriate tool following consultations with internal stakeholders and other healthcare organizations. Additionally, an environmental scan was undertaken to determine the best technologies that could be used to inform staff of patients who are potentially aggressive or violent. Information technology (IT) staff were involved in making recommendations regarding violence prevention technology.

Clinical practice leaders collaborated with IT staff to build an algorithm within the electronic medical record (EMR) that would identify potentially violent patients based on the VAT. Patients are assessed within the emergency department and at each shift in the inpatient units. The information is then visible by all staff who access the patient's medical record. Additionally, when a violent or aggressive patient is identified in the inpatient units, a symbol is generated on the digital display by the patient's room. The symbol provides a visual alert to hospital staff regarding violent patients but does not explicitly disclose the information to non-staff.

RTLS devices containing the PSRS were affixed to employee ID badges and implemented across all hospital units in October 2016. Digital maps of all floors and rooms within the hospital, as well as all parking lots, were created to provide accurate location information. The occupational health and safety team, information services, information technology and security staff were involved in the process of developing and executing the violence prevention system.

Although all hospitals must plan for any period of downtime due to power or equipment failure, HRH has developed robust policies and procedures to enable the continuity of clinical and business operations given the fully digital infrastructure nurses practise in. For example, during any period that the EMR is unavailable, such as during software upgrades, HRH has procedures in place for manual documentation and tracking of patient flagging, printed paper signs and tape located in "downtime boxes" that are available at every nursing station. Following the downtime period, there is also a procedure for the back entry of data assessments into the EMR.

Data collection

Semi-structured, in-depth interviews with nurses were conducted in October and November 2018 to conduct a qualitative assessment of violence prevention technology at HRH. The option of participating in either a focus group or a one-on-one interview was offered to all participants. Those who were unable to attend the group discussion or wanted to share information in private chose to participate in the one-on-one interview. Three nurses took part in the one-on-one interviews and eight nurses took part in the one-hour focus group. One-on-one interviews ranged from 15 to 30 minutes. Interviews continued until data saturation was reached. Demographic data were collected at the time of the interviews.

Data analysis

Demographic data were summarized. Data were qualitatively analyzed using content analysis. The following steps were taken to conduct the qualitative analysis: (1) all interviews were digitally recorded and transcribed verbatim; (2) statements were grouped into categories reflecting similar central messages; and (3) core themes were identified from the data and were critically analyzed, described and verified.

Results

Participant characteristics

Twelve nurses participated in the study. Participants were in their 20s and 30s, and the majority (66.7%) of participants were female. Content analysis revealed three themes with regard to nurses' experiences with the violence prevention technology: reassurance of safety, an increase in proactive preventive measures and limitations of technology. The results are presented under thematic headings with selected interview responses given.

Reassurance of safety

Both violence prevention technologies provided participants with the reassurance of safety. Participants regarded the interventions as highly beneficial because the signage warning was digital and updated directly with any new entry in the EMR. Nurses stated that in other hospitals, paper signage warning staff members of violent patients could get easily misplaced and was not consistently updated when a new patient was admitted in the room:

> I think it's helpful when you're entering a patient's room and you see that sign; you know what the risk is, and it's not really conveyed to anyone else that's going into the room other than staff.

> We had many abusive incidents [on the previous hospital site], and now we really don't have that much because of the safety precautions.

> You feel more safe as a nurse, so I have to say that it's a great tool to have.

Regarding the panic alarm button, none of the participants reported ever having had to use the device. However, all participants noted that the panic alarm button provided them with reassurance:

> I've not had to use it, thankfully, but from people that I know that have had to use it, it alerts staff on the unit, and they get help within a couple of seconds.

> They are very helpful, especially on the mental health unit, because they can activate it quickly if they need to.

Increase in proactive preventive measures

Participants felt that due to the flagging system, they were better able to anticipate imminent violence and were, therefore, better able to take personal preventive measures to manage potentially violent patients. Participants identified a number of personal preventive measures, including conscious awareness, communication and tactical strategies:

> Once I see that sign on the board, I would be a little more diligent in talking to that patient.

> It's made me more cautious when entering a patient's room; I keep it in the back of my mind.

Communication strategies included being kind, making eye contact and comforting the patient:

> If you have a nice tone with them, make eye contact, listen to what they have to say, usually even someone who has a flag can be calmed down quite easily.

Tactical strategies used by participants included standing in a position that would allow them to exit the room quickly, removing any objects in the room that can be used to harm either the nurse or the patient and bringing another nurse along to help protect them:

> I always try to find where my exit doors are in case I need to leave.

> I would just kind of peek in and make sure everything is okay and just ask him or her if they are okay and just take a look at the environment [within the room] and see if there is anything in the room that would put them or myself at risk.

Limitations of technology

Participants also noted that violence prevention technologies and interventions as a whole were somewhat limited in their ability to prevent patient-related violence. Although the flagging system can warn nurses of the potential for a violent event, it cannot prevent it. One nurse stated, "There's only so much that technology can help."

The participants did not expect this technology or any other components of the hospital violence prevention system to result in a decrease in violent incidents. Most nurses reported that they expected to experience some form of violence because of their job. Nurses seemed to accept that patient violence was somewhat unavoidable due to several factors known to precipitate violence, such as pain, anxiety and aggression due to anaesthetics or a medical condition (e.g., dementia):

> Most of the time, [the violence is] unpredictable … Sometimes it's because of illness, or they don't know where they are, they are very confused, and some of the medications can also cause them to act out.

Overall, there was a consensus among participants that the flagging system was highly effective and that along with the violence prevention policies and procedures of the hospital, it provided a comprehensive violence prevention program. When asked for suggestions to improve the efficacy of the program, participants stated that they highly endorsed the interventions. There were only a few suggestions for improvements, including colour coding patients at risk for violence on the EMR for higher visibility and adding prompts for nurses to complete additional assessments in the EMR after a violent incident is captured to continually screen for violence.

Discussion

Nurses are victimized at the highest rates because they spend the most time in contact with patients (Phillips 2016). The technology-enabled violence prevention system at HRH provides a clear, dependable and discreet process to alert nurses about patients with a history of violence and enable nurses to obtain immediate assistance in the event of a violent confrontation. The aim of this study was to provide a qualitative description of the experience of nurses regarding violence prevention technology at HRH.

Most nurses perceived the benefits of the HRH technology-enabled violence prevention system as providing the reassurance of safety and enabling pre-emptive measures to be taken to reduce the incidence of violence. One study participant had commented that the construction of larger patient rooms was also aided in the prevention of harm as multiple nurses or staff would be able to help a nurse who was experiencing patient-related violence. Many nurses observed that

violence prevention systems, whether HRH's technology enabled or otherwise, could not in fact "prevent" violence. The majority of the 11 nurses were resigned to violence as a known risk factor of their job and considered it unavoidable in light of various patient factors that induce violent behaviour.

The findings from this study are similar to others in which emphasis is placed on preventive actions versus reactive responses to violence (Lanctôt and Guay 2014; Papa and Venella 2013; Phillips 2016). Our findings confirmed the value that nurses place on being forewarned about violent patients, which in turn generated feelings of safety. This suggests that flagging strategies may be central to enabling nurses to feel prepared and safe to deal with violent patients. Nurses who feel confident and equipped to deal with violent patients may be in a better position to both circumvent violence using pre-emptive strategies and manage violence through de-escalation tactics. As suggested across a number studies, there are several negative consequences of exposure to violence in the workplace, including physical and psychological injury and illness and emotional trauma, such as fear and anger (Lanctôt and Guay 2014; Papa and Venella 2013; Phillips 2016). The ability to avoid violence and manage violent patients more effectively may reduce the impact of negative consequences associated with violence in the workplace.

Similar to other research, our findings suggested the need for violence prevention strategies to be coupled with internal policies, procedures and enhancements to the physical environment to ensure the safety of staff (Papa and Venella 2013; Phillips 2016). Nurses in this study viewed the personal panic alarm button and design of patient rooms as a reassuring measure of safety. Every employee at HRH is required, by policy, to wear the PSRS identification badge. The findings from our study affirm the need to provide staff with tangible safeguards that are anchored in definitive policy, signifying the commitment of the hospital to ensure a safer workplace.

Previous studies have identified nurses' acceptance of patient violence as an unavoidable consequence of providing care (Lanctôt and Guay 2014; Papa and Venella, 2013; Phillips 2016). Our study had similar results, with nurses reporting that they expected to experience violent behaviour from patients because of unavoidable circumstances, such as pain, dementia and anxiety. A possible explanation for this is the role that empathy plays in nursing practice. Although there are inherent risks with certain patient populations, we cannot become complacent and merely assent to violence as a component of nursing practice. Creating increased awareness by educating nurses about the boundary between empathy and safety may help shift this perspective.

Few studies have addressed the effectiveness of systems to prevent workplace violence (Phillips 2016). Our study provided the opportunity for nurses to consider the benefits and challenges of the technology-enabled violence prevention system at HRH. Given that very few violence prevention systems have been

evaluated in the literature, the opinions of nurses at HRH, who are primary users of this system, are important and can help inform modifications and enhancements to future systems. There were two notable suggestions to improve the violence prevention program provided by nurses who participated in this study. First, nurses suggested that the flagging symbol of patients at risk for violence should be more visible in the EMR and include a distinguishable colour-coded symbol. This is an important concern raised by nurses because the premise behind the flagging system in the EMR is to ensure that the risk of violence is identified prior to any interaction with the patient. If the flag is not highly visible, then potentially it could be missed and pose an unnecessary risk to nurses and other healthcare providers. As such, we are continuing to engage with nurses and our human factors engineering team to implement modifications to the EMR flagging symbol.

The second suggestion nurses provided was to add prompts in the EMR for nurses to complete additional assessments in circumstances where a violent incident had occurred. This was an interesting and important suggestion that had not been previously considered by the violence prevention system developers. At HRH and many hospitals, there is a system for documenting staff incident reports. However, this system is separate from the patient record. Integrating the circumstances of, responses to and outcomes of staff incidents of violence within the EMR may further support a proactive approach to managing violent patients and identifying the therapeutic interventions that best manage the unique needs of the patient and prevent harm to nurses or other caregivers.

Limitations

As a qualitative study, the small sample size provided insights for the subject matter and is not necessarily generalizable. In addition, the findings were based on data collected from face-to-face interviews, which may have resulted in respondents exhibiting social desirability bias. Finally, the present study did not make any conclusions about the effectiveness of the flagging system in decreasing the overall rate of violent incidents. Future evaluations of any violence prevention strategies should be assessed both quantitatively and qualitatively to gain a deeper understanding of its value and limitations.

Conclusions

Violence occurs in the workplace but should not be viewed as part of the job. Nurses recognize the risks associated with the compromised physical and psychological health of patients, which places them under stress and induces the potential for violence. However, appropriate, real-time tools embedded and enforced in policy are necessary supports to ensure that the risks related to violence in the workplace are minimized. Violence prevention tools, such as technology-enabled flagging systems and PSRS, are helpful to reassure safety and appropriately prepare nurses to avoid and manage violence.

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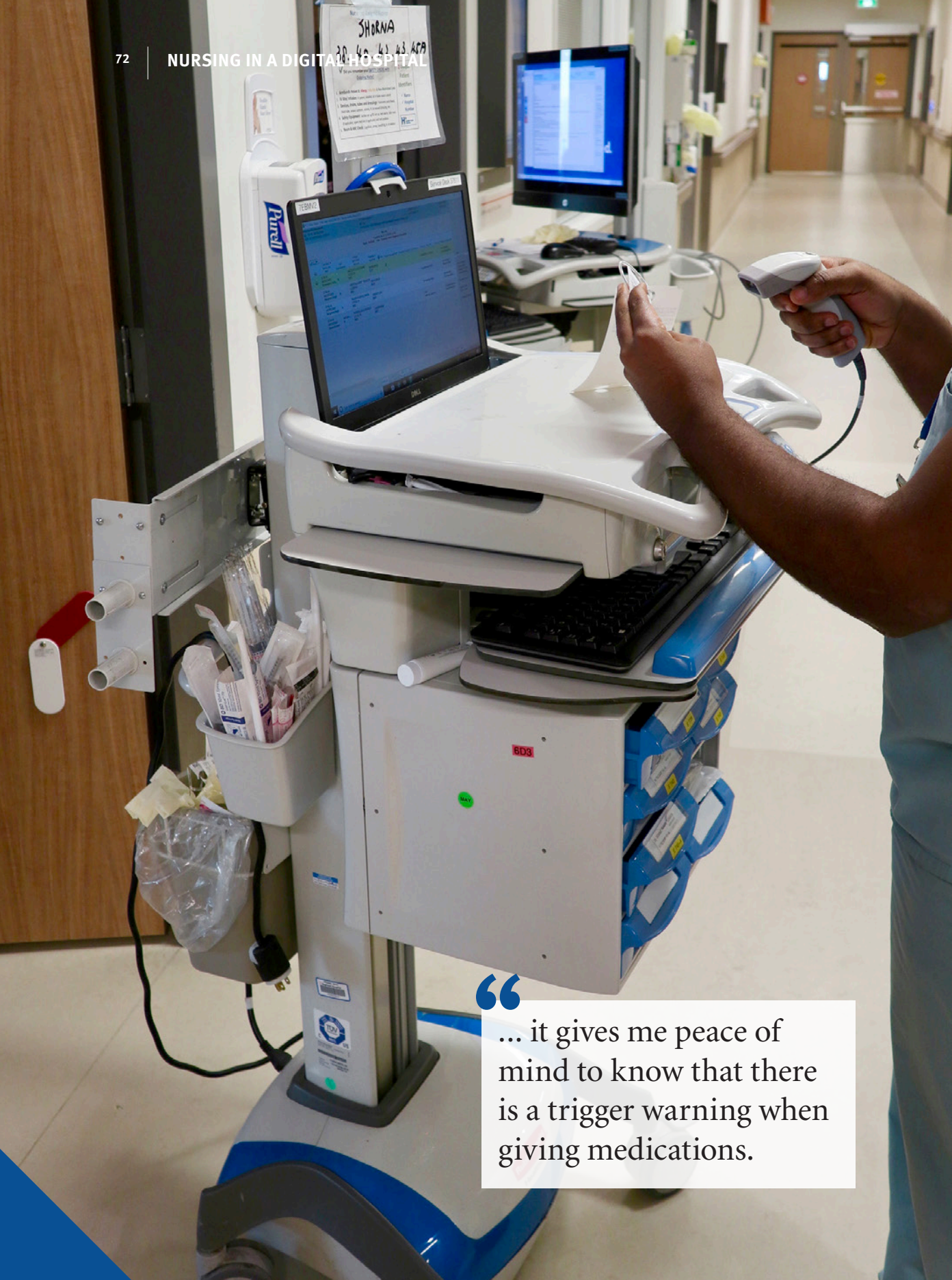

> “... it gives me peace of mind to know that there is a trigger warning when giving medications.

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Experiences of Nurses Working in a Fully Digital Hospital: A Phenomenological Study

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WHAT WE LEARNED:

1. To our surprise, the study results indicate that in combination with previous exposure to many of the technologies at HRH, longer duration of employment at HRH was associated with a higher technology competency skills score. Generational cohort did not play a role in the perception of nurses' technology competency at HRH.

2. Not only should nurse leaders plan for sufficient time and exposure to technology, but they also need to ascertain the meaning of technology with respect to nurses' values to develop appropriate educational programs that support maximum adoption, regardless of the generational cohort.

3. Although the literature suggests that Generation X and Generation Y are technologically skilled, our findings did not concur with previous studies that baby boomers were less technologically skilled. At HRH, nurses in the baby boomer generation were no less technologically skilled and just as proficient with the technology as other generations.

Abstract

Background: With the increasing development and integration of information and communication technology (ICT) into hospitals, there remains a lack of understanding of the impact of these technologies on the hospital's largest core users: nurses. Humber River Hospital (HRH), one of the first hospitals to completely integrate technology across all hospital systems and workflows, has sought to understand how ICTs have transformed the clinical working environment.

Objective: The aim of the study was to achieve a deeper understanding of the lived experiences of nurses practising in North America's first digital hospital.

Methods: The methodological approach was informed by van Manen's hermeneutic phenomenological methodology. Data were gathered through in-depth semi-structured interviews with eight nurses at HRH. Thematic analysis was conducted using the van Manen and Colaizzi methods of data analysis.

Results: Six thematic categories that formed the nurses' lived experiences of working in a digital environment were identified: safety, time, teamwork, technology failures, patient responses and adapting.

Conclusion: Nurses at HRH identified six themes regarding their lived experiences working in a fully digital hospital that provide an insight into nurses' values and cause us to reflect on how we might use this information to further support nursing practice in the fully digital environment. Nurses at HRH seem to have normalized the nursing process within the fully digital environment. Technology appears to be viewed by nurses at HRH within the premise of nursing as an art, allowing patient responses to be acknowledged and incorporated into nursing workflows, and as a science, permitting safe care delivery. Overall, nurses perceived technology as being essential for patient safety and facilitating nursing practice. These findings offer insight into nurses' perception of ICTs, and as technological advancements continue to emerge, these findings will inform education, practice and policy.

The profession of nursing has had an ongoing relationship with technology, from telephones and typewriters in the 1900s to cardiac monitors and renal dialysis machines in the mid-20th century (Sandelowski 2000). Major technological advancements in the last decade have been credited with improving patient monitoring (Silow-Carroll et al. 2012), decreasing medication errors (Shah et al. 2016) and enhancing workflow efficiency (Gellert et al. 2015). With the increasing development and integration of information and communication technology (ICT) into hospitals, there remains a lack of understanding of the impact of these technologies on the hospital's largest core users: nurses. Humber River Hospital (HRH), one of the first hospitals in North America to completely integrate technology across all hospital systems and workflows, has sought to understand how ICTs have transformed the clinical practice environment for nurses.

There is a paucity of research that provides comprehensive data regarding the manner in which ICTs impact nursing care. Although several studies exist on the topic, most of the current literature has focused on physicians (Catan et al. 2015) or solely on critical care nurses working in intensive care units (Laerkner et al. 2015; Tunlind et al. 2015). Previous studies have revealed that nurses perceive ICTs positively because of improvements in accuracy, patient safety and ease of access (Rouleau et al. 2017). Studies have also suggested that nurses perceive technology as enhancing communication and collaboration (Burns et al. 2018) and facilitating everyday practice (Wikström et al. 2007). Conversely, various studies have reported negative perceptions of the impacts of technology. Tunlind et al. (2015) reported that nurses often found themselves prioritizing the troubleshooting of equipment due to device malfunctions that interrupted nursing care. Kiekkas et al. (2006) reported that nurses sometimes felt that technology increased stress and moved the focal point away from patients. The existing research has only provided a preliminary understanding of the impact of ICTs on nursing practice, and there is a lack of qualitative research examining nurses' experiences specifically in a high-technology environment.

The aim of this study was to examine the lived experiences of nurses practising in North America's first fully digital hospital by applying phenomenological research methods. Knowledge gained from the current research study will provide healthcare leaders with insight into how ICTs affect nursing practice and meanings that resonate with nurses in terms of integrating technology into their daily professional practice.

Methods

Design

This research is grounded in Heidegger's interpretive hermeneutic phenomenological philosophy drawn from van Manen (1990). Phenomenological inquiry is a systematic attempt to understand and describe a phenomenon in depth and arrive at the essence of participants' lived experience of a given phenomenon (Moustakas 1994), which makes it a highly suitable approach for this study. Interpretive hermeneutic phenomenology focuses on the subjective experience (van Manen 1990). The aim of this methodology is to gain a deeper understanding of the human experience through description and interpretation. Through a hermeneutic approach of analysis, the tenets of Heidegger's phenomenological philosophy provided the opportunity to explore nurses' emic perspective of their experience practising in North America's first fully digital hospital.

Participants and setting

Eight female and male nurses from all units of the organization volunteered to participate in the research study. Selection criteria included the requirement that nurses used ICTs in their nursing practice on a daily basis and were direct care providers. All nurses were required to have been previously employed at another acute care hospital, for the purposes of comparing their experiences to those in a non-fully digital acute care hospital setting. The participants had to have been employed at HRH for a minimum of three months to ensure sufficient experience with ICTs. The identity of the participants was concealed with a pseudonym so that no data could be tracked back to them.

Data collection

Van Manen's (1990) methodology was implemented by interviewing participants in depth and encouraging them to reflect on their experiences. A private room within the hospital was used to conduct the semi-structured interviews. Interviews took place in October and November of 2018, and open-ended interviewing was used to allow participants to provide information unique to their experiences. Each interview lasted from 30 to 60 minutes and was digitally recorded. Observation notes were recorded by the interviewer to document participant expressions and body language. Probing questions were asked by the interviewer to further explore points of interest. Based on the principles of phenomenology, prejudgments were acknowledged and set aside for the purpose of truly understanding the experiences of the participants (Valle et al. 1989).

Data analysis

The data analysis process drew on van Manen's (1997) and Colaizzi's (1978) phenomenological methodology. The method involved listening to all recordings to familiarize researchers so they acquired a sense of participants' experiences and then transcribing all digital recordings word for word (Colaizzi 1978). Following

transcription, extraction of thematic statements that contributed to participants' experiences that were of direct relevance to the phenomenon was undertaken using van Manen's (1997) highlighting approach. Meanings were derived from the statements, which were then organized into themes that were common across all participants. All themes were then integrated into an exhaustive description of the phenomenon (Colaizzi 1978). Finally, the validity of the phenomenological analyses was confirmed by asking participants to review the content to ensure that the interpretations accurately captured their experiences (Colaizzi 1978). Any new relevant data from the participants were then added to the analysis.

Rigour of the study

To ensure that rigour was achieved, Lincoln and Guba's (1985) criteria for creditability, transferability, dependability and confirmability were evaluated in the qualitative process. Credibility was addressed by recruiting diverse individuals, taking into consideration age, years of experience and hospital unit. To ensure transferability, in-depth descriptions of nurses' lived experiences were sampled across several hospital units. Dependability was ensured by closely following data analysis procedures of the in-depth descriptions and transcription of nurses' lived experiences. Lastly, confirmability was achieved by ensuring that the research team's biases were not introduced (to maintain openness to the information provided by the participants) and by putting them aside throughout the research process.

Ethical considerations

Institutional review board (IRB) approval was obtained from the IRB committee of HRH. All participants were provided with detailed written and verbal information about the study prior to their participation. Assurances were given that participation was voluntary and that the participants would be able to withdraw at any time, without prejudice. Anonymity was emphasized, and the participants' identities were not used in data storage. All participants signed and received a copy of the informed consent.

Findings

Six themes provided the basis for describing the experiences of nurses working in a digital hospital: safety net, time, teamwork, technology failures, patient responses and adapting to a new environment. The themes are described and illustrated with comments from the participants.

Safety net

Safety was perceived as a highly valued impact of technology. In particular, nurses viewed the technological interventions for preventing medication errors, smartphone devices that provide call bell notifications and bed exit alarms as extremely important to their practice. All research participants had positive reactions to the role of safety in technological interventions:

> Safety is huge. To know that we have the technology in place to help support the care that we are providing – it acts like a safety net.
>
> Say, for example, we have a patient that is high risk for falls. We do have the capability of putting on a bed alarm, and if that patient is trying to get out of bed, it will ring an alarm and it will also go to our phones. So it allows us time to get to that patient versus the patient is already on the ground, we have no idea that that patient was even attempting to get up out of bed and it's kind of too late. So safety has been huge with the implementation of technology.
>
> Sometimes if you are in a hurry and you accidentally scan the wrong medication, then it will prompt you. You can
>
> identify your errors.
>
> … it gives me peace of mind to know that there is a trigger warning when giving medications.

One participant stated that safety may be compromised with automation from technology,

> … sometimes because [data from the vital signs machine is] automatically transferred to the [electronic medical record], some nurses might bypass the interpretation [of the data] because it's just numbers on a screen.

Time

Nurses described conflicting feelings about technology with regard to time. Participants commented on receiving call bell alerts on their smartphone, as well as on time spent documenting care delivery in the electronic medical record. Participants viewed technology as both time saving and time consuming:

> It does help us to prioritize; we are not having to run back and forth between the main nursing station and the patient [be]cause everything is at hand. So it does save a lot of time. And I think … the biggest thing that's improved our patient care is time.
>
> If I am doing something in a patient's room and another patient is ringing the call bell, I don't have to leave and run to the nursing station to find out what they are requesting [and] then go back to my patient's room. I can manage my time.
>
> I've seen other people struggle between managing time with technology and taking care of patients.
>
> You do have to find time between patient care and documentation … Things can easily pile up with all the documentation.

Teamwork

One of the more unexpected themes to emerge from the study participants' experiences was the promotion of collaboration with other nurses through technology. Participants described receiving support from other nurses when they experienced issues or problems with technology:

> My colleagues are usually the best people to ask if I am having any issues.

> My colleagues and managers are always willing to help ... Whenever we have new technology, there's always good training that is provided.

Technology failures

System glitches and planned downtimes were described by nurses as one of the disadvantages of working in a fully digital hospital:

> It's technology, so sometimes it fails or it has glitches. So we have to learn how to work with it …, like when we have downtimes … It's hard to remember what it's like to work without [technology], so that has actually been a struggle.

> Anytime that there is a breakdown with one of the devices, you also have to solve the technical issues on top of your regular nursing duties.

Participants also stated that some technology was difficult for older patients to learn:

> … the phones don't look like a phone, they look like a remote, so patients don't really know that it's a phone.

> It sort of puts on the nurses the need to help support patients [to use the technology], so if the patient needs to make a phone call, the nurse has to be in [the patient's room] to dial the number.

Patient response to nurses using technology

Nurses stated that most patients who came into the hospital appreciated that the nurses were using advanced technology to deliver care:

> The patients really appreciate it; they know that we are providing them with safe care.

One nurse also explained that having all the information about patients at their fingertips helped to build a better relationship with their patients:

> With technology, I don't have to leave the room to get an answer to a patient's question. If I leave the room, I might be stuck somewhere with something important. But it's hard to explain that to the patients, so technology has helped us a lot.

However, many nurses also stated that there were generational differences in patients that influenced their level of comfort with the digitalization of hospital processes:

> 98% of patients are good with the technology. Everybody has a smartphone or iPad and computer, so they love it. But there are some seniors who have not used technology, so there is a little bit of a challenge, like a generational gap.

> I think it allows us more time with our patients because we are not having to be running back and forth to get things for our patients. But also I find with the older population, they tend to get a little bit frustrated because they don't understand how technology works; it's just not part of their era. So we do spend a little more time with them to explain to them how the call bell works.

Adapting to a new environment

When asked about the challenges associated with adjusting to a fully digital environment, all nurses stated that adjustment was rapid. Most nurses stated that they learned to use the technology within two to three weeks:

> Because I come from a generation where I've always sort of had technology at hand and I've grown as technology improved over the years, it wasn't a huge impact for me personally … I just sort of picked it up and I figured it out.

> It wasn't a huge impact on me personally.

> As time went on and we were using it every day, we just sort of got used to it.

One nurse said that she had become so comfortable using technology that they were unwilling to consider other employment opportunities:

> I love [working with technology]; that's why I don't want to leave Humber.

Discussion

The aim of the current study was to examine the lived experiences of nurses practising in North America's first fully digital hospital by applying Heidegger's interpretive hermeneutic phenomenological philosophy. The concept of *Dasein* portrays a living being through the activity of *being there* and in the context of *being with others*, as well as lived experience and everyday ordinariness. Based on these tenets, the meaning of nurses' everyday existence, practising in a fully digital hospital, was explored (Horrigan-Kelly et al. 2016). There is a paucity of research regarding nurses' experiences of practising in a fully digital hospital, and to date, this is the first study of its kind.

Several themes emerged from the study: safety, time, teamwork, technology failures, patient responses and adapting. Participants of the study commented positively about technology in relation to safety. Nurses predominantly viewed the

fully digital practice environment as a safety net, thereby supporting nurses and providing them with safeguards in care delivery. Safety is at the core of nursing practice. Nurses' perception of a work environment with protections in place to maximize safe care delivery is an essential component of maintaining and sustaining professional practice and achieving consistently positive patient outcomes.

As noted earlier, one interesting interpretation involved a study participant's caution regarding the automation function of technology and the potential for safety to be compromised. A potential safety concern was articulated in relation to data from the vital signs machine that is automatically transferred to the electronic medical record. The experience of the study participant was that the interpretation of the vital signs data might be bypassed by nurses "because it's just numbers on a screen" in its tabular format. Technology does not replace the fundamental nursing process by which patients are assessed, assessment data are interpreted and monitored and therapeutic interventions are implemented. We reflect on how this acute observation highlights the interface and interconnection between nursing clinical reasoning and technology. Our interpretation is that this nurse perceives that the technology can provide time and technical efficiencies in the collection and documentation of patient vital signs but does not replace the kind of pathic knowledge nurses must constantly reflect upon to reframe their cognitive picture of patients and generate a sense of something being wrong (Errasti-Ibarrondo et al. 2019; van Manen 2007). For nurse leaders, reflexivity is required to understand the real impact on nurses when implementing technology. Although designed to save lives, technology may, in fact, overwhelm staff, for example, with alarm fatigue (Jones 2014).

Participants of the study perceived technology as both time saving and time consuming. The efficiency of delivering nursing care and ability to prioritize patient care needs were regarded as time saving. Timely access to information, enabled through technology, was experienced by nurses as contributing to efficient and effective time management and leading to improved care delivery. Nurses stated that the time-consuming aspect of technology was related to electronic documentation, which could "easily pile up." Balancing the time spent taking care of patients and documenting nursing actions was experienced as a possible "struggle" by some study participants. The distribution of time spent caring for patients versus time spent documenting care has long been a challenge for nurses in the paper world and continues to be acknowledged as such in the electronic environment. As key nursing processes transition to the electronic world (e.g., medication barcode scanning instead of signing medication administration records, independent double check of high-alert medications, electronic documentation), nurse leaders should consider whether true opportunities for efficiencies can be found. For example, implementation of the barcode medication

scanning technology at HRH represented a safety net for nurses and patients (to prevent errors), but it may also have represented an efficiency gained for nurses as they no longer needed to sign off individual medications in a paper chart; the scans are automatically populated into the electronic medical record with dates, times and patient and nurse data.

Participants in the study stated that support and collaboration from peers and management at HRH are widely available for problem solving technical issues and that training is robust and ongoing. Teamwork, fostered by the shared goal of overcoming encounters with technological difficulties, was a positive outcome of nurses experiencing technology issues or problems in the fully digital practice environment. From a change management perspective, this is a very encouraging by-product, which highlights the organizational culture that is receptive to change. We did not anticipate this positive outcome related to interprofessional collaboration. Upon reflection, the culture at HRH demonstrates resiliency, which allows for the continuous improvements that are essential in an environment where evidence-based practice is valued and technology is fully integrated.

Nurses described "system glitches and planned downtimes" as the singular hindrance of practising in a fully digital hospital. However, nurses said that regardless of the disadvantage of experiencing technical glitches and scheduled downtimes, the fully digital practice environment brought opportunities for learning and enhanced resilience. Nurses also experienced the burden of needing to remove themselves from direct nursing care to assist elderly patients with customer services such as making a telephone call because "… the phones don't look like a phone; they look like a [television] remote [control]." What we can draw from this observation is that nurses may need to be vigilant about assessing how new technologies may impact patients as much as they impact staff. As organizations transition to become increasingly digital and technologically advanced, these reflections remind nurse leaders that in addition to nursing clinical assessments, patient technology orientation must be incorporated into workflows. Nurse leaders must recognize that for technology to serve the purpose for which it was intended, direct care nurses need the time and space to interact with patients and families. That interaction needs to be built into the workflow process for nurses. Technology is not a substitute for therapeutic communication and patient education.

Nurses stated that the use of technology was appreciated by most patients and represents to them the provision of safe care. The formation of stronger therapeutic relationships with patients, as a result of the fully digital practice environment, was also shared by one study participant. As expressed by the research participant,

technological resources allow nurses to stay with patients in their room to answer questions, thereby avoiding being sidetracked with other matters, as often occurs when required to leave the room to obtain information in response to patient questions (e.g., searching for a paper chart). The need to both assist patients with the technology in their room and provide patient health information using the inpatient room technology was described by nurses as fostering the potential for nurses to have more time at the bedside.

Most of the research participants described adjusting to a fully digital practice environment at HRH as swift, with limited negative impact. Everyday use and the passage of time were considered the primary factors that permitted ease of technology integration into nursing practice. One nurse stated that the level of comfort achieved with using technology in the clinical environment makes it impossible to consider employment in a hospital that is not fully digital. We can appreciate that this reluctance to leave HRH may represent how deeply the digital environment and multiple technologies have become interwoven into nursing practice to provide safe, high-quality care. We parallel this experience with the seamlessness of smartphone technology in today's world, which has made information so accessible that for some it is impossible to return to the world of printed encyclopaedias.

Overall, the research participants reflected positively on ICTs in this technology-enriched environment. With the identified themes of safety net, time, teamwork, technology failures, patient responses and adapting as part of the nurses' lived experience, we continue to reflect on how these themes provide an insight into nurses' values and how we might use this information to further support nursing practice in the fully digital environment. The themes identified in this study led us to believe that nurses view technology within the premise of nursing as an art and a science. The science permits safe care delivery, and the art allows patient responses to be acknowledged and incorporated into nursing workflows. Nurses at HRH seem to have normalized the nursing process within the fully digital environment. In fact, no study participant identified bypassing technology use in their daily work, and some nurses perceived the inability to practise in a healthcare environment where clinical practice is not completely electronically integrated.

We thought about how HRH introduces technology using a system of criteria based on the strategic priorities of the hospital. At HRH, the highest safety and quality are top priorities, and the introduction of enhanced or new technology is based on meeting this criterion first. It appears to us that this approach must resonate with nurses at HRH given the high value they place on safety, as identified in this study.

Limitations

A limitation of the study was that the participants' ages were mainly between the early twenties and the late thirties. To gain a full understanding of nurses' experiences in the digital hospital environment, further study is required with older participants. Another potential limitation when using face-to-face interviews was social desirability bias. Attempts were made to minimize this bias by having an interviewer who was unfamiliar with the nursing staff and creating an environment that respected the respondents' privacy.

Conclusion

The current study permitted examination of the lived experiences of nurses practising in North America's first fully digital hospital. Using tenets from Heidegger's hermeneutic phenomenological philosophy, the meaning of nurses' everyday existence, practising in a fully digital hospital, was explored. Unveiling the lived experiences of nurses practising in a fully digital clinical environment can contribute to enhancements in training, education, knowledge and the practice of nursing as it relates to technical competency. Similar to previous studies, nurses perceived technology positively because of improvements in accuracy, patient safety, ease of access, communication and collaboration (Burns et al. 2018; Rouleau et al. 2017). The current study found that nurses' negative perception of technology was in relation to glitches and scheduled downtimes. However, nurses in the fully digital practice environment found opportunities for learning and enhanced resilience. In opposition to the findings from Kiekkas et al. (2006), whereby nurses reported that they sometimes felt that technology increased stress and moved the focal point away from patients, the current study found that technology was experienced as fostering the potential for nurses to have more time at the bedside with patients. An additional finding from the current study was the perception of teamwork that was generated by overcoming encounters with technological difficulties through the collaboration and support of peers and management.

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> “...technology adoption across Generation Y, Generation X, and baby boomer nurses was not influenced by the era in which they had been socialized to computerization.

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Generational Differences in Hospital Technology Adoption: A Cross-Sectional Study

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WHAT WE LEARNED:

1. To our surprise, the study results indicate that in combination with previous exposure to many of the technologies at HRH, longer duration of employment at HRH was associated with a higher technology competency skills score. Generational cohort did not play a role in the perception of nurses' technology competency at HRH.
2. Not only should nurse leaders plan for sufficient time and exposure to technology, but they also need to ascertain the meaning of technology with respect to nurses' values to develop appropriate educational programs that support maximum adoption, regardless of the generational cohort.
3. Although the literature suggests that Generation X and Generation Y are technologically skilled, our findings did not concur with previous studies that baby boomers were less technologically skilled. At HRH, nurses in the baby boomer generation were no less technologically skilled and just as proficient with the technology as other generations.

Abstract

Background: The advancement of technological change within healthcare means that it is essential for nurses to have the necessary technological skills to deliver safe and efficient nursing care. Few studies have examined whether generational differences affect the adoption of technology within the healthcare system.

Aim: The primary purpose of this study was to explore predictors that influence the adoption of technology.

Methods: In this cross-sectional study, nurses were asked to rate their level of competency on 20 key skills related to clinical technological devices (CTDs) in a self-administered questionnaire. Participants' demographic data and level of proficiency related to personal computer skills were also collected. Multiple linear regression analysis was used to examine whether demographic characteristics and personal computer skills predicted higher scores related to CTDs.

Results: Sixty-three nurses completed the questionnaires. Overall mean score for skills related to CTD was high at 3.74 (SD = 0.75) out of 5. Length of employment at the hospital and previous exposure to the technology used at the hospital ($\beta = 0.06$, $p = 0.021$; $\beta = 0.054$, $p = 0.011$, respectively) were the only variables significantly associated with higher CTD skills scores. Generational cohort, gender, years of nursing experience and self-rated proficiency related to personal computer skills were not related to higher CTD skills scores.

Conclusion: The results of this study emphasize that consistent exposure to technology enhances its adoption. Generational cohort did not play a role in the perception of nurses' technology competency at Humber River Hospital.

In the midst of rapid technological advancement, nurses are confronted with adopting a computerized system to deliver and document nursing care. This trend has led hospitals to critically evaluate the manner in which staff are prepared to practise in the changing healthcare environment. As Humber River Hospital (HRH), a large community hospital in Toronto, leverages the latest technology to enhance patient care, nurses, the primary technology users, will need to be equipped to meet this challenge.

Studies have shown that health information technology interventions have a direct impact on patient safety outcomes (Kutney-Lee and Kelly 2011; Waneka and Spetz 2010). Nurses' adoption of newly introduced technologies is essential to delivering efficient nursing care and reducing medication administration errors, infection rates, stroke incidence and mortality (Brenner et al. 2016). Yet, as of 2019, although the Canadian Association of Schools of Nursing outlines entry-to-practice competencies specific to nursing informatics (https://www.casn.ca/2014/11/nursing-informatics-entry-practice-competencies-registered-nurses/), nursing baccalaureate programs in Ontario may be reviewing opportunities for health information technology courses as part of their required course curriculum. To address this gap in knowledge and ensure the ongoing success of computerized system integration, HRH has incorporated extensive on-site healthcare technology training into staff orientation of new hires.

Recent investigations in other fields have suggested that generational cohort membership, years of experience and degree of comfort with technology are all factors that affected the successful adoption of technology (Gilakjani 2013; Hezaveh et al. 2014; Wood et al. 2005;). Research studies have highlighted differences in the ease with which technology is adopted on the basis of generational cohort. For example, Generation Y or millennials (born between 1981 and 2000) are most likely to be adept at using technology and have integrated technology into their daily life (Cekada 2012). Generation X'ers (born between 1965 and 1980) are generally considered to be technology literate as they were introduced to digital technology through the workforce (Cekada 2012). Finally, baby boomers and the silent generation (born between 1946 and 1964 and 1933 [and] 1945, respectively) have not grown up with technology and tend to be classified as "digital immigrants" (Cekada 2012).

The lack of experience using technology was also cited as a barrier to learning and using technology. In a study of teachers' information and communication technology adoption in Italy, researchers found that technical skills and competency level affected teachers' use of technology for educational purposes (Peralta and Costata 2007). Lastly, newly graduated nurses would be expected to experience a

slower adoption of health information technology as they are not only tasked with learning new technologies but also building their clinical knowledge and managing workload demands (Hezaveh et al. 2014).

There is limited knowledge regarding the effects of generational differences in nurses' adoption of health information technology (Gagnon et al. 2012). Training and education leaders must possess an understanding of the unique learning needs of its multigenerational staff and develop innovative teaching strategies to ensure successful adoption of technology among all staff members. The primary aim of this study was to investigate whether generational differences influenced technology adoption by nurses. The secondary aim of this study was to explore predictors that influence the adoption of technology. The results of this study will enable HRH to adjust its teaching philosophy to meet the identified learning needs of its workforce.

Methods

Development of training

HRH integrated health information technology training into the orientation session for all incoming nursing staff. The two-week in-person training was delivered by three staff and focused on improving technological competence using a variety of teaching strategies, including didactic instruction, problem-based learning, case studies, simulation room training and computer laboratory exercises. Online learning modules were available through the staff portal of the hospital website for staff to provide additional resources and a broader range of learning tools for new hires.

Study design and sample

A cross-sectional survey was conducted between October and November 2018. Permission to carry out the study was obtained from the Institutional Review Board at HRH, and informed consent was obtained from all participants. Participation in the study was voluntary, and subjects were assured of the anonymity of their responses. All eligible nurses were invited to complete either an online or paper-based anonymous questionnaire. Participants were considered eligible for inclusion if they had been employed at HRH for a maximum of 12 months, used technology in their nursing practice on a daily basis and provided direct care to patients.

Data collection

Data were collected through a self-administered questionnaire. Participants were asked to rate their level of competency for each of the 20 key skills related to clinical technological devices (CTDs) at HRH using Benner's (1984) stages of clinical competence (novice, advanced beginner, competent, proficient, expert). A sixth

option of "not applicable" was provided. A composite score was created for each participant by averaging the competency ratings for the 20 items related to CTD skills, with higher scores reflecting greater competence. The CTD skills scale demonstrated high internal consistency with a Cronbach's alpha of 0.96.

The questionnaire also collected information about participants' age group, gender, years of experience as a nurse and length of time working for HRH. Age group values were converted to generational cohort variables to explore generational differences. Additionally, participants were asked to rate their level of proficiency related to personal computer skills on a five-point Likert-type scale (1 = novice to 5 = expert) and whether they had previous exposure to the technology used at HRH on a four-point Likert-type scale (1 = no, none to 4 = yes, many).

Data analyses

Descriptive statistics were computed for each of the variables analyzed. The associations between independent variables (generational cohort, female gender, years of experience as a nurse, number of months employed at HRH, personal computer skills and previous exposure to the technology used at HRH) and CTD skills scores were first evaluated using simple linear regression analyses. Next, multiple linear regression with backward elimination (probability for removal, $p > 0.1$) was performed with all independent variables entered simultaneously to determine the most significant factors associated with high CTD skills score.

Regression assumptions of linearity, multicollinearity, normality of residuals and homoscedasticity of residuals were assessed, and all assumptions were met. Collinearity diagnostics were examined to assess multicollinearity of variables, and no multicollinearity was present in the final model. All statistical analyses were performed with SPSS version 25. A p value of < 0.05 was considered statistically significant.

Results

Participant characteristics

In total, 63 (30.7%) of the 205 eligible nurses completed the questionnaire. Descriptive statistics are presented in Table 1. The majority of participants were female (88.5%) and millennials (80.4%). Nearly one third (31.1%) of participants had between one and three years of nursing experience, and many did not have any previous exposure to the technology used at HRH (41.8%). The median duration of employment at HRH for participants was 8.5 (SD = 4.1) months.

Most participants rated their level of proficiency in personal computer skills highly, with 35.7% identifying as "competent," 41.1% identifying as "proficient" and 17.9% identifying as "expert"; none identified as "novice," and only 5.4% identified as "advanced beginner."

Table 1. Characteristics of participating nurses.

Characteristic	*n*	%
Age	*N* = 61	
19 to 29 years (Generation Y/millennials)	22	36.1
30 to 39 years (Generation Y/millennials)	27	44.3
40 to 54 years (Generation X)	9	14.8
55 to 69 years (baby boomers)	3	4.9
70+ years (traditionalist/silent generation)	0	0
Gender	*N* = 61	
Female	54	88.5
Male	7	11.5
Years of nursing experience	*N* = 61	
< 1 year	15	24.6
1 to < 3 years	19	31.1
3 to < 5 years	6	9.8
5 to < 10 years	8	13.1
10+ years	13	21.3
Proficiency related to personal computer skills	*N* = 56	
Novice	0	0
Advanced beginner	3	5.4
Competent	20	35.7
Proficient	23	41.1
Expert	10	17.9
Previous exposure to technology used at HRH	*N* = 55	
No, none	23	41.8
Yes, a few	10	18.2
Yes, some	9	16.4
Yes, many	13	23.6

Factors associated with higher perceived CTD score

Overall, the mean CTD skills score for all participants was 3.74 ($SD = 0.75$) out of 5. The results from the simple linear regression analyses between potential predictors and CTD skills score are presented in Table 2. Longer duration of employment at HRH, previous exposure to the technology at HRH ("many" compared to "none") and greater proficiency in personal computer skills ("proficient" and "expert" compared to "advanced beginner"/"competent") were significantly associated with a higher CTD skills score. In the final multiple regression analysis, only longer duration of employment and previous exposure to the technology at HRH ("many" compared to "none") were associated with a higher CTD skills score ($R^2 = .25$, $F[2,10.33]$, $p < 0.001$). Self-rating of

"proficient" and "expert" in personal computer skills (compared to "advanced beginner"/"competent") was not associated with higher CTD skills score in the final model.

Table 2. Linear regression of CTD skills and potential predictors.

Characteristic	Simple regression		Final multiple regression $N = 55$	
	β (95% CI)	*p* value	β (95% CI)	*p* value
Duration of employment at HRH	0.07 (0.02 to 0.11)	**0.009**	0.06 (0.01 to 0.10)	**0.021**
Generation				
Generation Y/millennials	Reference			
Generation X	-0.38 (-0.95 to 0.18)	0.181		
Baby boomers	-0.88 (-1.95 to 0.19)	0.107		
Female gender	-0.37 (-0.96 to 0.21)	0.209		
Years of nursing experience				
< 1 year	0.27 (-0.30 to 0.83)	0.352		
1 to < 3 years	0.18 (-0.36 to 0.72)	0.509		
3 to < 5 years	0.23 (-0.54 to 1.01)	0.552		
5 to < 10 years	0.05 (-0.67 to 0.78)	0.882		
10+ years	Reference			
Proficiency related to personal computer skills				
Advanced beginner/competent	Reference			
Proficient	0.51 (0.11 to 0.91)	**0.005**		
Expert	0.74 (0.22 to 1.25)	**0.012**		
Previous exposure to technology used at HRH				
None of them	Reference			
A few of them	-0.14 (-0.67 to 0.40)	0.617		
Some of them	0.35 (-0.21 to 0.90)	0.220		
Many of them	0.63 (0.13 to 1.12)	**0.014**	0.54 (0.13 to 0.95)	**0.011**

Note: Unstandardized regression coefficients are reported.

Discussion

The results of this study indicate that, contrary to the study's hypothesis, nurses' generational differences did not influence technology adoption. In contrast and to our complete surprise, the findings indicated that in combination with previous exposure to many of the technologies at HRH (compared to none), longer duration of employment at HRH was associated with a higher CTD skills score. Additionally, a greater number of years of work experience as a nurse was also not associated with a higher CTD skills score.

The findings from this study revealed that technology adoption across Generation Y, Generation X, and baby boomer nurses was not influenced by the era in which they had been socialized to computerization. These findings are in opposition to other studies that suggest technology adeptness was influenced by generational cohort, with Generation Y being the most adroit and baby boomers the least proficient (Czaja et al. 2006). In alignment with findings from the current research, some studies have suggested that older generational cohorts are increasingly adopting technological skills generally ascribed to millennials (Morris and Venkatesh 2000).

Previous studies have found that a lack of confidence with computer skills may be a barrier to nurses' adoption of technology (Hogarty et al. 2003; Peralta and Costata 2007). However, the results of this study indicated that only nurses' previous exposure to HRH technology and longer duration of employment at HRH were associated with a greater level of perceived technological skills competency. This evidence is consistent with a similar study by Litchfield and Matteis (2016) that identified adequate time for practice using technology in the delivery of nursing curriculum as necessary to strengthen the adoption of technology.

Implications

The findings from this study suggest that nurses, regardless of generational cohort, require sufficient time and consistent exposure to computerized systems of nursing care delivery and documentation to enhance adoption. This is an important finding given that previous studies suggest that younger generations, Y and X, are naturally more technically skilled and adaptable. Although this inference may still be true, upon reflection, our results instead highlight the assumption that older generations are not technically proficient. Our study found that each generation of nurses employed at this completely digital hospital is adaptable and functioning appropriately within nursing workflows that integrate multiple technologies. Healthcare organizations can be reassured based on our findings, that across the spectrum of generational cohorts that may exist in their organization, all nursing staff are capable of technology adoption and proficiency over time.

The results from the current study may help ensure that training across all generational cohorts of nurses supports consistent exposure to technology and is sufficient in duration to maximize adoption. Our study provided an excellent opportunity to reflect on the meaning of technology and its adoption into nurses' professional practice. Education to socialize nurses to the concepts of nursing informatics and provide them with the opportunity to ponder the meaning of technology may be accomplished through the application of Mezirow's

transformative learning paradigm. Not only is sufficient exposure and duration necessary, but we also need to provide nursing staff with the space and opportunity to capture the meaning of the new technological changes to their own nursing practices (Christie et al. 2015).

One of the most important discourses that occurs at HRH when designing education for nurses practising in the fully digital environment is associated with the following questions: "How does this tool impact my practice?" and "How do I explain what I am doing with this tool to my patients?" The responses to these two questions will direct the nature of the education and training that are necessary to support nurses' adoption of new and enhanced technology. Nurse leaders need to support staff and educators to surface any dilemmas that arise based on the responses to these questions as these questions will reveal the values nurses espouse. These values will inevitably support or pose challenges for nurses in their adoption of the technology (Christie et al. 2015). For example, if nurses' most important value is safety, then adoption of technology should be positioned against the safety aspects of the initiative. In fact, our phenomenological analysis of nurses' experience in the digital hospital environment has provided HRH with the key terminology that we need to use to frame our conversation (i.e., safety, time, teamwork, technology failure, patient response and adoption) when designing education for new and enhanced technology integration to maximum uptake and adoption (Burkoski et al. 2019). The experience of nurses at HRH may support the opportunity for other organizations introducing and expanding on their digital platform to develop more robust and meaningful educational programs.

Limitations

There are limitations that must be taken into account when interpreting the results presented in this study. The small study sample size provided insights into the issue of generational learning and adoption of technology. The findings may be considered hypothesis-generating observations. Second, there was no representation of nurses from the silent generation and only a few nurses from the baby boomer generation, which may have resulted in sample bias. Additionally, the results are based on self-reported data, which may be subject to reporting and social desirability bias. As well, given the cross-sectional design of the study, causality cannot be inferred. Finally, the present study did not take into account psychosocial factors such as self-efficacy and perceived usefulness of technology (Buchanan et al. 2013), which may have an impact on technology adoption.

Conclusion

Nurses' adoption of newly introduced technologies is essential to delivering safe, high-quality care. Previous studies have highlighted differences in the ease with which technology is adopted on the basis of generational cohort. Contrary to this study's hypothesis, the results indicate that nurses' generational differences did not influence technology adoption. In contrast, the findings from this study indicated that in combination with previous exposure to technologies at HRH, longer duration of employment at HRH was associated with a higher CTD skills score. This is an important finding because previous studies suggest that younger generational cohorts are naturally more technically skilled and adaptable. The findings from the current study may support improved training that, regardless of generational cohort, ensures that nurses receive sufficient time and exposure to computerized systems of nursing care delivery and documentation to enhance adoption.

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> Recognizing the power of information technology

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the northwest Greater Toronto Area.

The multi-site hospital currently operates out of its Wilson Avenue acute care site and Finch and Church Street reactivation care centres with a total of 722 beds, just over 3,800 employees, approximately 700 physicians and over 1,000 volunteers.

Affiliated with the University of Toronto and Queen's University, Humber River Hospital is North America's first fully digital hospital. Part of Humber River Hospital's digital infrastructure includes completely automated laboratory services, robots sorting and mixing medications, electronic health records, tracking systems for patients undergoing surgery that update families through their cellphones and patient computer bedside terminals – all varieties of technologies that automate information, eliminate paper and provide a connected experience for patients, staff and families.

Humber River Hospital was awarded Accreditation with Exemplary Standing in 2018 and since its opening in 2015 has received numerous awards and accolades for technological advancements and innovation (www.hrh.ca).

Optimizing Nursing Practice through Integration of Best Practice Guidelines into Electronic Medical Records

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WHAT WE LEARNED:

1. Embedding the RNAO BPGs into the EMR at HRH permitted forcing functions to be established that increase evidence-based practice integration and reduce practice variation, ultimately contributing to the delivery of highly reliable care.
2. The digital infrastructure at HRH has enabled the creation of monitoring dashboards with RNAO BPG-specific process indicators (nursing-sensitive indicators) that facilitate the measurement of patient outcomes and provide an opportunity for improving nursing practice.

Abstract
A commitment to best practice guidelines (BPGs) is crucial for ensuring the safety of patients. Recognizing the power of information technology, Humber River Hospital has integrated BPGs into the electronic medical record (EMR) infrastructure. The large-scale implementation institutes a uniform standard of care and ensures adherence to BPGs through a forcing function designed to require nurses to complete and document the necessary assessments. The initiative strengthens the audit process and provides the opportunity to identify long-term trends. The implications of the quality improvement initiative are discussed. Due to the widespread use of EMRs, the replication of this initiative is economically feasible in other healthcare settings.

Electronic medical records (EMRs) have been implemented in the hospital environment for electronically storing patient data since 2006 (Chang and Gupta 2015). The value of EMRs is its capacity to influence patient health outcomes (Olchanski et al. 2017). There are a seemingly endless number of possible applications for EMRs, including performance monitoring and generation of customized reports (Bird et al. 2003). To date, EMRs have not been effectively harnessed to optimize nursing practice (Leapaldt 2016).

Several studies have indicated that nurses do not routinely assess patients for potential adverse outcomes such as fall risk and pressure injury (Gunningberg and Ehrenberg 2004; Stephenson et al. 2015). These adverse events are judged to be highly preventable, with some studies finding that 40% of falls (McMahon et al. 2014) and 43% of pressure injuries were preventable (Downie et al. 2013). Performing risk assessments regularly and in a timely manner can greatly reduce the risk of adverse events to patients (Arfanis and Smith 2012; Doran et al. 2014). One step to achieving this is for nurses to be prompted to complete the necessary assessments through the EMR. Based on the Health Belief Model of "cues to action" construct (Hochbaum et al. 1952), the EMR at Humber River Hospital (HRH) was specifically designed to prompt nurses to implement risk assessments and interventions using the Registered Nurses' Association of Ontario's (RNAO) best practice guidelines (BPGs).

The RNAO BPG Program

Funded by the Ministry of Health and Long-Term Care and developed by RNAO, BPGs provide a systematic, evidence-based approach to improve practice and patient health outcomes and are critical to advancing nursing care excellence (Grinspun 2001, 2015, 2016, 2018; Grinspun and Bajnok 2018; Grinspun et al. 2001, 2014, 2018). RNAO supports healthcare facilities in the implementation and evaluation of multiple clinical and healthy work environment BPGs over a three-year period through the Best Practice Spotlight Organization (BPSO) candidacy process (RNAO 2012). To advance the implementation of RNAO BPGs further, Nursing Quality Indicators for Reporting and Evaluation (NQuIRE) was launched by RNAO in 2012. NQuIRE was established to enable quantitative impact analysis of BPGs on nurse, patient and organizational outcomes (Grinspun et al. 2015; Lloyd 2012). NQuIRE is a data system of nursing-sensitive quality indicators derived from RNAO BPGs that track the progress of BPSOs across multiple indicators. NQuIRE includes indicators that are classified into three categories based on Donabedian's framework: structure indicators (measuring organizational characteristics), process indicators (measuring nursing activities) and outcome indicators (measuring patient outcomes) (Donabedian 2005; VandeVelde-Coke et al. 2012). HRH is committed to implementing five RNAO BPGs across the three-year BPSO pre-designate phase, including pressure injuries, pain management, care transition, fall prevention and delirium, dementia and depression.

Aim

The aim of this article is to describe the development of HRH's innovative EMR-based approach to screening patients at risk for adverse outcomes, using RNAO BPGs that were implemented in the first year of the BPSO pre-designate phase.

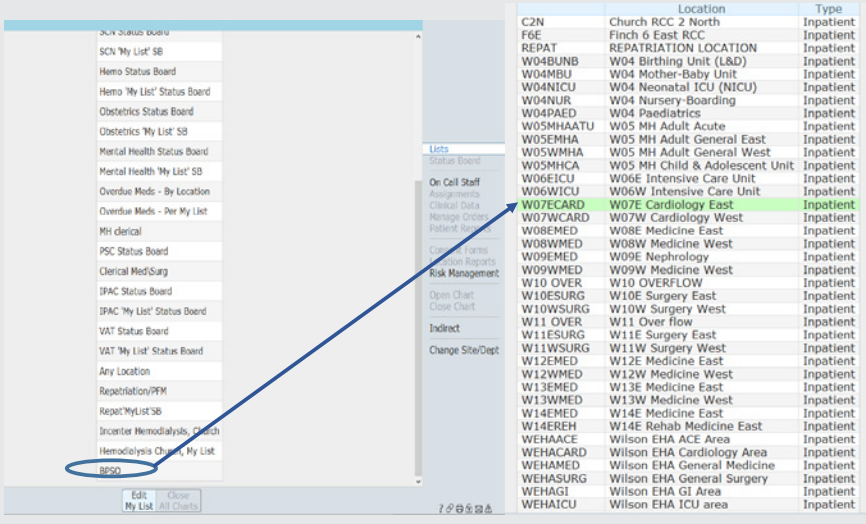
Program Description

In January 2018, a multidisciplinary team was established to integrate BPGs into the EMR. The BPG Task Force was composed of several staff members from the Evidence Based Practice Integration, and Information Services departments. The team assembled to develop and identify RNAO BPG elements to be embedded into the EMR. The BPG Task Force evaluated and modified existing risk assessments to ensure alignment with RNAO BPGs and achieve optimally effective and efficient nursing documentation within the EMR. NQuIRE process indicators, such as risk assessment completion upon admission, and outcome indicators, such as the number of hospital-acquired pressure injuries, were selected for each BPG and added to the nursing documentation page.

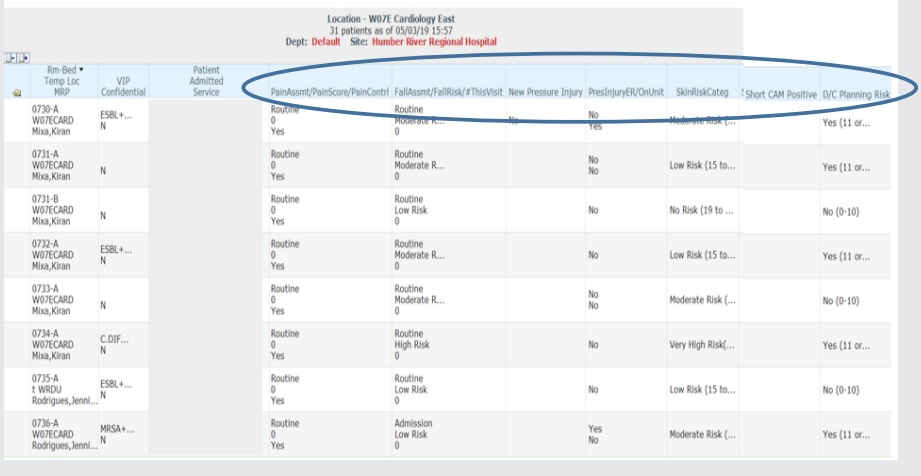
Figure 1. Patient status board.

How to find the BPSO Status Board documentation related to Pain, Falls Risk, Pressure Injury, Discharge Risk and CAM.

Select IP/OP Clinical Menu → select Clinical Status Board→ select Lists



Select BPSO status board (at the very bottom) and choose a unit

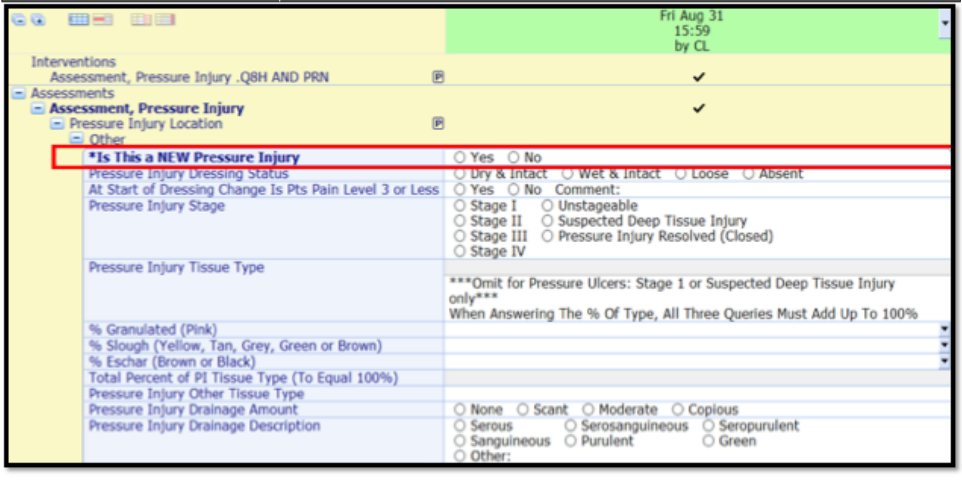


A careful analysis of the clinical workflow was conducted prior to EMR integration to determine how and when the assessments should be displayed. Members from the Information Services department then designed and configured the IT architecture to ensure optimal data capture and functionality. All relevant assessments, based on predefined criteria, for each patient were populated in the nurses' task list within the EMR. Accompanying information to support the uptake of

BPG interventions, such as how often the assessment should be completed, the time frame between assessments and whether the assessment is overdue and for how long, were also integrated into the EMR. Finally, a clock icon was built to appear next to nursing assessments that require completion in order of priority. This signalling function was constructed to enable nurses to easily visualize which assessments are most appropriate. The project was initiated in January 2018, and hospital-wide implementation took place in July 2018.

To monitor for RNAO BPG implementation adherence, the BPG Task Force developed enhancements to the patient status boards. A snapshot of the current state for every patient, in relation to the assessment (nursing activity) and the outcome (patient-specific outcome), was created (Figure 1). *Forcing function* elements were embedded in the EMR, requiring nurses to document, for example, whether a new pressure injury (hospital acquired) was identified or not to proceed to the next nursing activity. Upon successful completion of the necessary risk assessment, the nursing activity is designated as completed on the BPSO Status Board. If the patient has a new pressure injury (hospital acquired), then another forcing function occurs whereby a series of therapeutic nursing interventions based on the RNAO BPGs are triggered. Figure 2 provides an example of the EMR pressure injury screening with forcing functions.

Figure 2. EMR pressure injury screening.



Implications

Implementation science has taught us that much more is required for nurses to integrate evidence-based practice successfully in their work environment than the availability of RNAO BPGs (Grinspun et al. 2018). Support and resources at the micro, meso, and macro levels are essential for optimizing and sustaining uptake of evidence (Grinspun et al. 2018). In addition to the robust implementation

framework developed by RNAO, technology has been identified as an important enabler of evidence-based practice integration (Wilson and Bajnok 2018). HRH, with its fully digital landscape, has leveraged technology to maximize evidence-based practice integration.

One of the most significant components of the digital infrastructure that has been established for RNAO BPG integration is the forcing function. By definition, a forcing function is "an aspect of a design that prevents the user from taking action without consciously considering information relevant to that action" (Papantoniou et al. 2002). The EMR at HRH is designed to force conscious attention on RNAO BPG assessments and interventions, making it easy to deliver evidence-based care. Additionally, the forcing function of the EMR at HRH creates a hard stop that cannot be bypassed unless nurses change their actions to align with the RNAO BPGs (Institute for Healthcare Improvement 2016). At HRH, the key benefit being leveraged through the technology is decreased nursing practice variability.

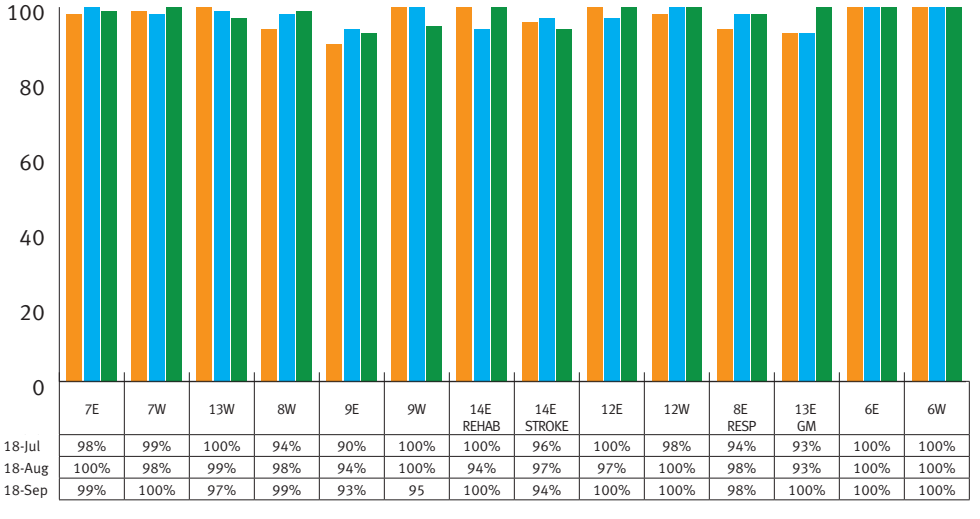
Integration of RNAO BPGs into the EMR can provide both short- and long-term benefits for nursing practice, as well as patient outcomes and organizational performance. In the short term, data collection through the EMR facilitates monthly reporting of process and outcome indicators data for submission to the NQuIRE data system. Clinical leaders have readily available access to BPSO status reports that serve as internal and external benchmarking tools. Ongoing review and analysis of BPSO data provide the opportunity to identify and address challenges in current practice across the hospital. Figure 3 provides a sample of the data (which are posted on quality dashboards on the hospital units), across the units, for the completion of risk assessment of pressure injury upon admission.

Timely follow-up with nurses who have not completed the necessary BPG assessments is made possible through performance reports generated by the system. Clinical leaders can then assist nurses in closing the gap between best practice and current practice so that patients can receive optimal care. Real-time identification and coaching are essential for elevating and sustaining RNAO BPG integration. For nurses, the integration of RNAO BPGs into the EMR is essential for monitoring patient progress over time and informing decisions regarding therapeutic interventions.

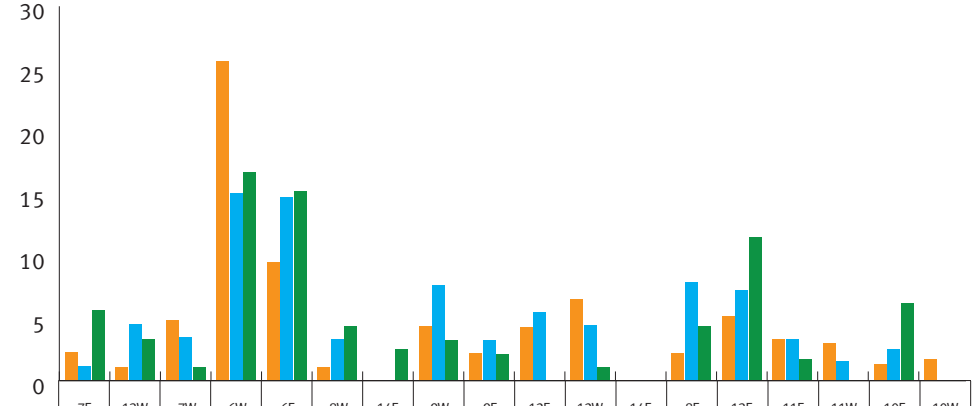
The long-term benefits of the EMR system design for RNAO BPG implementation provide the most exciting opportunity for care transformation. Impending upgrades to the IT system will provide minute-by-minute updates of patient status through a clinical analytic dashboard. The ability to predict potential adverse outcomes by identifying and analyzing patterns and changes in patient status will further enhance the potential for every patient to consistently receive the safest and highest quality care.

Figure 3.

Pressure injury risk assessment completion and hospital-acquired pressure injuries for July 2018-September 2018.



	7E	7W	13W	8W	9E	9W	14E REHAB	14E STROKE	12E	12W	8E RESP	13E GM	6E	6W
18-Jul	98%	99%	100%	94%	90%	100%	100%	96%	100%	98%	94%	93%	100%	100%
18-Aug	100%	98%	99%	98%	94%	100%	94%	97%	97%	100%	98%	93%	100%	100%
18-Sep	99%	100%	97%	99%	93%	95	100%	94%	100%	100%	98%	100%	100%	100%



	7E	13W	7W	6W	6E	8W	14E STROKE	9W	9E	12E	12W	14E REHAB	8E RESP	13E GM	11E	11W	10E	10W
18-Jul	2.31	1.09	4.81	25.6	9.49	1.1	0	4.33	2.19	4.31	6.52	0	2.24	5.18	3.35	2.99	1.31	1.7
18-Aug	1.18	4.52	3.48	15.05	14.71	3.34	0	7.65	3.26	5.48	4.46	0	7.86	7.22	3.36	1.59	2.55	0
18-Sep	5.62	3.33	1.11	16.69	15.15	4.39	2.51	3.24	2.12	0	1.09	0	4.34	11.52	1.74	0	6.23	0

Conclusion

RNAO BPGs provide the building blocks for nursing practice optimization. The EMR infrastructure has allowed HRH to be able to support nursing practice on a large scale and to advance improvements in patient outcomes. Both nurses and clinical leaders recognize the value of adherence to BPGs. As a result of this intervention, nurses are provided with evidence-based assessment tools at their fingertips and the ability to quickly and consistently assess patients. Clinical leaders will be able to identify trends, improve health care quality and readily make informed clinical decisions. As well, the data generated from this initiative can be analyzed to assess improvement in patient safety outcomes. Digitalization of BPG documentation overcomes many of the challenges related to paper-based

BPG auditing, including the reduction of documentation time, minimization of workflow disruption and collection of researchable data. The EMR has facilitated point-of-care nursing adherence to BPGs and provided a source of rich data that can be gathered and analyzed to gain knowledge of the impact of nursing interventions on patient safety and outcomes. Future studies could further explore the long-term benefits of such an initiative. Furthermore, the rapidly expanding use of EMRs around the globe means that this is an economically viable and technically feasible option for adoption and integration of RNAO BPGs in other hospital settings to consistently increase adherence to RNAO BPGs and optimize clinical practice and results for safe and high-quality care for patients, as well as organizational effectiveness and performance.

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