Impact of smartphones in healthcare

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Smartphone Technology: Impact on Interprofessional Working Relations between Doctors and Nurses

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Abstract

Background: **For decades, the main communication technology in hospitals has been the paging system. In the era of digital communication, smartphones have been adopted by hospitals seeking to modernize processes and offer real-time, two-way communication to increase efficiency.**

Objective: **The aim of this study was to explore physicians' and nurses' perceptions of the impact of smartphones on communication and efficiency.**

Methods: **Mann-Whitney *U*-tests were used to compare differences in item scores between physicians and nurses on 17 questionnaire items relating to smartphone impact on interpersonal relationships and communication, efficiency and reliability. An open-ended question was used to elicit additional feedback.**

Results: **In total, 43 nurses and 27 physicians participated in the study. Nurses' ratings were significantly higher than physicians' on a number of questionnaire items, including the following: smartphones have a positive impact on efficiency (Mdn = 4.0 vs. 3.0, $U = 321.0$, $p = 0.027$, $r = .33$), smartphones increase my accessibility to physicians (Mdn = 5.0 vs. 3.0, $U = 277.0$, $p = 0.009$, $r = 0.42$) and smartphones reduce interruptions versus pagers (Mdn = 4.0 vs. 2.0, $U = 224.0$, $p > 0.0001$, $r = 0.47$).**

Conclusion: **The findings suggest that smartphone technology may reduce the locus of control for physicians, potentially limiting their ability to prioritize patients' needs and manage workflow efficiently.**

Introduction

The smartphone, a single handheld device, has replaced the use of pagers, cellphones and personal digital assistants in a growing number of hospitals (Al Thomairy et al. 2015). As a communication, clinical information and decision support tool, the smartphone has the potential to enhance care delivery and improve patient outcomes (Al Thomairy et al. 2015). Delivering care in the acute care hospital setting involves physicians, nurses and clinicians from a variety of disciplines, services and specialties. Effective communication and collaboration are essential for safe and high-quality patient outcomes and physician and nurse satisfaction (Bowles et al. 2016). In particular, effective communication between physicians, who have direct responsibility for their patients, and nurses, who monitor patients around the clock, is an essential component in providing highly reliable patient care (Bowles et al. 2016).

Pagers have been a useful method of communication between healthcare professionals, albeit now outdated and inferior to other tools (Webb et al. 2016). Pagers were at one time the dominant method of communication until recently, with the use of smartphones being adopted at a rapid pace (Webb et al. 2016). Pagers are a one-way communication tool, signalling that a callback is required (Przybylo et al. 2014). Therefore, a nurse who required collaboration with a physician was able to page the physician but would have to wait for a return response. Salehi (2018) suggested that ineffective communication, such as delayed callback, can compromise safe and effective patient care. According to Salehi (2018), "[S]afe and effective patient care demand interdisciplinary collaboration and communication among health care providers" (p. 1).

Humber River Hospital (HRH) implemented smartphone technology to support communication between nurses and physicians (Wels-Maug 2016). The smartphone technology used at HRH allows access to medical information and serves as a communication system between nurses and physicians (Przybylo et al. 2014; Wels-Maug 2016). Previous studies have examined different methods of communication, with findings that revealed the advantages and disadvantages of various communication methods and tools (Wu et al. 2013). The findings from one study that examined numerical and alpha-numerical pagers and smartphones revealed that when pagers were used, responses were often delayed or ignored and there were callback number errors, resulting in an inability to return calls (Wu et al. 2013). These deficiencies in the pager communication system created frustration among staff members (Wu et al. 2013). Although smartphones were found to reduce some of these issues, users found them highly disruptive as direct phone calls require an immediate response (Wu et al. 2013). Additionally, with the use of smartphones, all direct phone calls might be assumed to be urgent, resulting in frustrated users if they are interrupted during a task for a non-urgent matter (Wu et al. 2013). According to Ghahramanian et al. (2017), "In the domain of internal communications, disrupted communication between nurses and physicians can also hinder teamwork and consequently endanger the safety and quality of care" (p. 169). The aim of this study was to explore the perceptions of physicians and nurses regarding the impact of smartphones on communication and interprofessional relationships, as well as efficiency and reliability.

HUMBER RIVER HOSPITAL is one of Canada's largest community acute care hospitals, serving a population of more than 850,000 people in the north-west 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 bedside computer 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).

Methods

Study design and sample

A cross-sectional and descriptive study design was carried out at HRH. Survey participants consisted of two groups of clinicians: physicians and nursing staff, including part-time and

full-time staff. The inclusion criteria were nurses and physicians who were employed at HRH for at least 6 months, provided direct care to patients and used the hospital smartphone as part of their daily practice. Informed consent was obtained from all participants, and ethics clearance was granted by Veritas IRB, an external Research Ethics Board.

Data collection and instruments

Participant responses were collected between November and December 2019 through an online questionnaire. Relevant questionnaire items were compiled from a systematic review of the literature (Lo et al. 2012; Patel et al. 2016; Quan et al. 2013; Wu et al. 2011, 2015) for perceptions of smartphone use within a hospital setting. The questionnaire was reviewed by clinicians and modified based on their feedback. The final survey instrument was composed of 17 items relating to interpersonal relationships and communication, efficiency and reliability. Each item was measured using a 5-point numerical rating scale (1 = strongly disagree to 5 = strongly agree). The questionnaire also collected information about the participants' age, gender, years of work experience in their field and years of work experience at HRH. Additionally, participants were asked if they had any further information they wanted to provide about the hospital smartphone through an open-ended question contained in the questionnaire. Participation in the study was voluntary, and all responses were anonymous.

Data analysis

Participant demographic data were summarized using descriptive statistics. Inspection of the data using Kolmogorov–Smirnov tests showed that all measures were not normally distributed; therefore, non-parametric tests were used for analysis. A series of Mann-Whitney *U*-tests were used to compare differences in item scores between physicians and nurses. *P*-values were adjusted using the Benjamini-Hochberg procedure to address multiple comparison and reduce false positive results. A p-value < 0.05 was considered significant. Statistical analyses were conducted using SPSS version 25. Free text comments were analyzed thematically.

Results

Participant characteristics

Seventy participants completed the questionnaire, including 43 nurses and 27 physicians. Participant characteristics are presented in Table 1. The majority of nurse participants were female (86.0%) and between the ages of 25 and 34 years (39.5%). Most nurse participants had more than 10 years of experience in their field (55.8%) and over 10 years of experience working at HRH (34.9%). The majority of physician participants were male (88.9%) and between the ages of 35 and 44 years (48.1%). Most physician participants also had more than 10 years of experience in their field (55.6%) and over 10 years of working experience at HRH (44.4%).

Interprofessional relationships and communication

The results of the Mann-Whitney *U*-tests are presented in Table 2. The ratings of the nurses were higher than those of physicians on measures of interprofessional relationships and communication. Nurses' ratings were significantly higher than physicians' ratings on three of the five items: positive impact on interprofessional collaboration (Mdn = 4.0 vs. 3.0, $U = 336.5$, $p = 0.038$, $r = 0.29$), increasing accessibility to physicians (Mdn = 5.0 vs. 3.0, $U = 277.0$, $p = 0.009$, $r = 0.42$) and increasing accessibility to nurses (Mdn = 4.0 vs. 3.0, U = 307.0, $p = 0.021$, $r = 0.35$).

Efficiency

On measures of efficiency, nurses also generally rated the items higher than the physicians. Nurses' ratings were significantly higher than the physicians' ratings on three of the five items: positive impact on efficiency (Mdn = 4.0 vs. 3.0, $U = 321.0$, $p = 0.027$, $r = 0.33$), experiencing less "phone tag" than pagers (Mdn = 4.0 vs. 3.0, $U = 332.0$, $p = 0.034$, $r = 0.31$) and reducing interruptions versus pagers (Mdn = 4.0 vs. 2.0, $U = 224.0$, $p > 0.0001$, $r = 0.47$).

Reliability

On measures of reliability, nurses' ratings were significantly higher than the physicians' ratings on only two of the seven items: helping to convey the patient's status quickly (Mdn = 4.0 vs. 3.0, $U = 290.0$, $p = 0.021$, $r = 0.35$) and not experiencing a lack of response to messages (Mdn = 4.0 vs. 3.0, $U = 324.5$, $p = 0.034$, $r = 0.31$).

Written feedback from participants

Of the total sample, 32 participants (45.7%), including 14 physicians and 18 nurses, provided responses to the open-ended question regarding the hospital smartphone. Comments from nurse participants were strongly focused on technical issues. Poor reception and poor battery life were the most frequently mentioned concerns, which included dropped calls, muffled voice sounds and battery life that did not last through their shift. Nurses also reported "alarm fatigue," touch sensitivity issues and frozen or unresponsive screens. Nurses stated that their experience would be ameliorated if technical issues were resolved as the smartphones provided the benefit of having a direct line of communication to the physician. One nurse commented:

> [The smartphone] can be a great resource if it had less technical difficulties, better battery life and less steps in

TABLE 1.
Demographic data and characteristics of survey participants

	Total (%) (*n* = 70)	Nurse (%) (*n* = 43)	Physician (%) (*n* = 27)
Gender			
Female	40 (57.1%)	37 (86.0%)	3 (11.1%)
Male	28 (40.0%)	4 (9.3%)	24 (88.9%)
Gender diverse	2 (2.9%)	2 (4.7%)	0 (0.0%)
Age group			
18–24	1 (1.4%)	1 (2.3%)	0 (0.0%)
25–34	18 (25.7%)	17 (39.5%)	1 (3.7%)
35–44	24 (34.3%)	11 (25.6%	13 (48.1%)
45–54	15 (21.4%)	10 (23.3%)	5 (18.5%)
55–64	9 (12.9%)	4 (9.3%)	5 (18.5%)
65–74	2 (2.9%)	0 (0.0%)	2 (7.4%)
75+	1 (1.4%)	0 (0.0%)	1 (3.7%)
Years of experience			
1 to < 3 years	5 (7.1%)	3 (7.0%)	2 (7.4%)
3 to < 5 years	9 (12.9%)	5 (11.6%)	4 (14.8%)
5 to < 10 years	17 (24.3%)	11 (25.6%)	6 (22.2%)
10+ years	39 (55.7%)	24 (55.8%)	15 (55.6%)
Length of time at HRH			
6 months to < 1 year	5 (7.1%)	4 (9.3%)	1 (3.7%)
1 to < 3 years	7 (10.0%)	5 (11.6%)	2 (7.4%)
3 to < 5 years	16 (22.9%)	11 (25.6%)	5 (18.5%)
5 to < 10 years	15 (21.4%)	8 (18.6%)	7 (25.9%)
10+ years	27 (38.6%)	15 (34.9%)	12 (44.4%)

> the sign in process. Overall, it has improved communication with physicians and getting orders in a more timely manner.

Comments from physician participants were mostly unfavourable and were strongly focused on increased interruptions and disruption to their workflow. Physicians stated that having to immediately answer calls was time consuming and potentially disruptive to patient care. Physicians also indicated that the increased accessibility that the smartphone provided had resulted in an increase in non-urgent calls from other health professionals. As a result, many physician participants indicated a stronger preference for the paging system than the smartphone. One physician commented:

> Highly interruptive technology for physician: real-time communication where the nurse controls when and how is very difficult for physicians and disrupts patient care.

TABLE 2.
Mann-Whitney *U*-test comparing the ratings of nurses and physicians on measures of interprofessional collaboration and communication, efficiency and reliability of smartphones within the hospital

Questionnaire item	Median		*n* (nurses/ physicians)	*U*	r[§]	Benjamini-Hochberg adjusted *p*-value
	Nurses	Physicians				
Interprofessional relationships and communication						
1. The hospital smartphones have a positive impact on interprofessional collaboration	4.0	3.0	39/26	336.5	0.29	0.038*
2. The hospital smartphones increase communication	4.0	3.0	39/27	392.5	0.22	0.092
3. The hospital smartphones do not decrease face-to-face communication	3.5	3.0	38/27	494.0	0.03	0.793
4. The hospital smartphones increase my accessibility to physicians	5.0	3.0	39/27	277.0	0.42	0.009*
5. The hospital smartphones increase my accessibility to nurses	4.0	3.0	38/27	307.0	0.35	0.021*
Efficiency						
6. The hospital smartphones have a positive impact on efficiency	4.0	3.0	38/27	321.0	0.33	0.027*
7. The hospital smartphones speed up my daily work tasks	4.0	3.0	38/27	389.5	0.21	0.112
8. The hospital smartphones do not bog me down with non-urgent messages	3.0	3.0	38/27	360.5	0.26	0.070
9. The hospital smartphones result in less "phone tag" than pagers	4.0	3.0	38/27	332.0	0.31	0.034*
10. The hospital smartphones reduce interruptions versus pagers	4.0	2.0	36/27	224.0	0.47	0.000**
Reliability						
11. The hospital smartphones do not experience frequent technical issues	3.0	3.0	37/27	449.0	0.09	0.507
12. The hospital smartphones help convey the patient's status quickly	4.0	3.0	36/27	290.0	0.35	0.021*
13. The hospital smartphones are beneficial for communicating complex issues	4.0	3.0	38/27	370.5	0.24	0.077
14. I do not frequently experience a lack of response to my messages[a]	4.0	3.0	37/27	324.5	0.31	0.034*
15. Responses to my messages[a] are sufficiently detailed	3.0	3.0	36/27	348.5	0.25	0.077
16. I do not frequently experience a delayed response to my messages[a]	3.0	3.0	36/27	379.5	0.19	0.138
17. The receiver is able to realize that my messages[a] require urgent attention	4.0	3.0	37/27	366.5	0.23	0.089

[a] Refers to messages of a callback location and time. *Statistically significant at $p < 0.05$. **Statistically significant at $p < 0.001$. [§]A common effect size statistic for the Mann–Whitney test is r, which is the Z value from the test divided by the total number of observations. As written here, r can vary from 0 to nearly 1.

These issues suggested that smartphones could have the potential to negatively impact interprofessional relationships. Some physicians indicated that these issues could be improved if the smartphone had voicemail capabilities, which would allow physicians to answer a call if they were free to but also to identify priorities based on the urgency of the voice message. Additionally, a directory listing on the smartphone that provides the physician with the phone number of the nurse providing care to their patient for that day was considered critical for successful team communication.

Discussion

Our study revealed that nurse participants rated smartphones as having a positive impact on interprofessional collaboration and accessibility to physicians and other nurses – significantly higher than physician participants did. Previous research has suggested "that physicians and nurses have fundamentally different perceptions and interpretations of interprofessional collaboration" (Bowles et al. 2016: 655). In part, this may account for the significant difference in nurses' versus physicians' perceptions of the impact of smartphones in our study. Similar to previous studies, our findings suggested that smartphone interruption in the process of physician care delivery was a major source of frustration (Ghahramanian et al. 2017; Wu et al. 2013). Nurses are on the sending end of smartphone technology, so their positive perceptions, particularly as they relate to accessibility to physicians, are not surprising. Nurses' unilateral control of the smartphone communication functionality might create pressure between physicians and nurses, which may compromise interprofessional relationships. According to Henkin et al. (2016), "Collaboration between physicians and nurses is essential for providing quality health care, and breakdown in this area is a major root cause of sentinel events" (p. 201). Interruption during the process of physician care because of smartphone communication has been identified in other studies as an erosion of patient-centredness (Al Thomairy et al. 2015; Webb et al. 2016). As suggested by Wald et al. (2014), concerns from the medical community are centred on the impact technology may have on the physician–patient relationship. Physician perceptions of this interference in their relationship with patients may have contributed to their lower rating of the positive impact of smartphones on interprofessional collaboration. Modifications to the smartphone technology that enable physicians to prioritize return calls and minimize workflow disruption need to be considered to foster and sustain effective interprofessional collaboration.

For the variables we explored in relation to efficiency, nurse participants rated smartphones higher than physicians did on positive impact on efficiency, experiencing less phone tag than pagers and reduced interruptions versus pagers. Again, these findings are not surprising given that the smartphone technology at HRH provides nurses with the unilateral control for the timing of calls based on their practice and workflow needs. Our findings align with other research suggesting that smartphones might pose more of a hindrance than a help to physicians (Al Thomairy et al. 2015; Webb et al. 2016). Conversely, the results from this study are contrary to other findings from previous research suggesting that smartphones improved the speed of communications between hospital clinicians and medical colleagues, improved time management and enhanced the ability to better coordinate care (Al Thomairy et al. 2015; Salehi 2018; Webb et al. 2016). Our findings suggest that smartphone functionality may not be configured to meet the workflow needs of physicians. Al Thomairy et al. (2015) suggested that smartphones have different operating systems that are open and thus encourage application development. Achieving efficiency by using smartphone technology, from the physicians' perspective, will require modifications to the software and applications. Potentially, a two-way communication feature that enables clinicians to exchange information and make decisions in the moment could increase efficiency. This might be accomplished through a secure text messaging function that is integrated with the patient electronic medical record. In this way, both physician and nurse needs are met through the automated process of requesting and delivering orders during the communication exchange between them.

Nurses in this study rated the use of smartphones to help convey patients' status quickly and the infrequency with lack of response to messages higher than physician participants did. A significant benefit of the smartphones and their implementation at HRH is that they provide an alarm system to nurses with the ability to view critical lab results and various telemetry readings. This display of clinical information permits nurses to prioritize their activities based on the urgency of patients' needs. A similar function has not been implemented for physicians except for assigned code physicians. The issue of alarm fatigue must be considered if smartphone application is enhanced to include this function. Alarm fatigue results from excessive and misleading alerts, which distract and desensitize clinicians from responding appropriately (Jones 2014). Achieving the right balance of alarm notification can be challenging.

Smartphone "messages" at HRH refer to a callback location and time versus a voicemail message. Not surprisingly, nurses stated that they do not frequently experience a lack of response to their messages, likely because, as previously described, the smartphone technology at HRH provides nurses with unilateral control for the timing of calls based on their practice and workflow needs. Physicians' rating of not frequently experiencing a lack of response to their messages was lower than that of nurses. Possibly, as the primary receiver of

calls, without voicemail functionality, physicians are more compelled to respond immediately to messages to avoid the risk of failing to intervene in urgent circumstances. Our findings suggest that physicians' smartphone technology at HRH has reduced the locus of control for physicians, potentially limiting their ability to prioritize, organize and gain workflow efficiency. Our findings highlight the need to balance the degree of control that clinicians have over their information and communication needs to enable prioritization of patients' needs and manage workflow efficiently.

Several limitations should be considered when interpreting the results of the study. The study outcome was limited to nurses' and physicians' perceptions of smartphone technology; patient perceptions were not obtained regarding disruptions to patient care. Survey administration by hospital staff may have resulted in reporting and social desirability bias occurring. A single-site setting and comparatively small sample size present further limitations in this investigation.

Conclusion

The smartphone has the potential to enhance care delivery and improve patient outcomes (Al Thomairy et al. 2015). Smartphone technology used at HRH allows access to medical information and serves as a communication system between nurses and physicians. Effective communication and collaboration are essential for safe and high-quality patient outcomes and physician and nurse satisfaction (Bowles et al. 2016). Our study revealed that nurse participants rated smartphones as having a positive impact on interprofessional collaboration and accessibility to physicians and other nurses – significantly higher than physician participants did. Possibly, nurses' unilateral control of the smartphone communication functionality may contribute to pressures between physicians and nurses, which may compromise interprofessional relationships. To foster and sustain effective interprofessional collaboration, smartphone technology needs to enable physicians to prioritize return calls and minimize workflow disruption. Our findings also suggested that smartphone functionality might not be configured to meet the workflow needs of physicians. Potentially, a two-way communication feature that enables clinicians to exchange information and make decisions in the moment could increase efficiency. A significant benefit of the smartphones and their implementation at HRH is that it provides an alarm system to nurses with the ability to view critical lab results and various telemetry readings. If this functionality is to be broadened for physician use, then the issue of alarm fatigue must be considered. Finally, our study highlighted the need to balance the degree of control that clinicians have over their information and communication requirements to enable prioritization of patients' needs and manage workflow efficiently.

What We Learned:

1. Similar to previous studies, our findings suggest that smartphone interruption in the process of physician care delivery was a major source of frustration, potentially contributing to physicians' lower rating of positive impact of smartphones on interprofessional collaboration.

2. Nurse participants rated smartphones higher than physicians did on positive impact on efficiency, experiencing less "phone tag" than pagers and reduced interruptions versus pagers. These findings are not surprising given that the smartphone technology at HRH provides nurses with the unilateral control for the timing of calls based on their practice and workflow needs.

3. Our findings suggest that smartphone technology at HRH has reduced the locus of control for physicians, potentially limiting their ability to prioritize, organize and gain workflow efficiency. These findings highlight the need to balance the degree of control that clinicians have over their information and communication needs to enable prioritization of patients' needs and efficiently manage workflow.

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