

Mobile devices in medicine: a survey of how medical students, residents, and faculty use smartphones and other mobile devices to find information*

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Objectives: The research investigated the extent to which students, residents, and faculty members in Canadian medical faculties use mobile devices, such as smartphones (e.g., iPhone, Android, Blackberry) and tablet computers (e.g., iPad), to answer clinical questions and find medical information. The results of this study will inform how health libraries can effectively support mobile technology and collections.

Methods: An electronic survey was distributed by medical librarians at four Canadian universities to medical students, residents, and faculty members via departmental email discussion lists, personal contacts, and relevant websites. It investigated the types of information sought, facilitators to mobile device use in medical information seeking, barriers to access, support needs, familiarity with institutionally licensed resources, and most frequently used resources.

Results: The survey of 1,210 respondents indicated widespread use of smartphones and tablets in clinical

settings in 4 Canadian universities. Third- and fourth-year undergraduate students (i.e., those in their clinical clerkships) and medical residents, compared to other graduate students and faculty, used their mobile devices more often, used them for a broader range of activities, and purchased more resources for their devices.

Conclusions: Technological and intellectual barriers do not seem to prevent medical trainees and faculty from regularly using mobile devices for their medical information searches; however, barriers to access and lack of awareness might keep them from using reliable, library-licensed resources.

Implications: Libraries should focus on providing access to a smaller number of highly used mobile resources instead of a huge collection until library-licensed mobile resources have streamlined authentication processes.

INTRODUCTION

Since the advent of personal digital assistants (PDAs), mobile devices (PDAs, smartphones, and tablet computers) have been widely adopted by medical professionals [1–3]. These devices are quickly becoming one of the main tools for accessing clinical information, especially for younger health professionals and trainees [4–6]. Many medical resources of varying quality are available for these devices. Some are free and others are supported by advertising or have been developed by relatively unknown publishers, raising concerns about the quality of information [7, 8] and the influence of pharmaceutical companies on the content [9]. Other applications (apps) are expensive and offer purchasers limited opportunities to try out the apps in advance, a significant issue for some apps whose content is poorly adapted from a reference text and difficult to use on a small screen [7].

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 A supplemental appendix, supplemental Table 1, and supplemental Table 2 are available with the online version of this journal.

Health and academic libraries have provided services and institutionally licensed a selection of PDA and mobile information resources for years [1, 10, 11]. However, there are many challenges to providing information resources and services to library users that are unique to the mobile environment, including the availability of products that are usable on mobile platforms and can be institutionally licensed; authentication processes for accessing those products, which often depend on whether the content is accessed over wireless networks or downloaded to the device; and the variety of software platforms that need to be supported [10, 12, 13]. The process of using institutionally licensed mobile resources is more complicated than simply downloading an app or viewing a website.

Although PDAs have been around for over a decade, the introduction of the iPhone, iPad, and other smartphones and tablets has changed the type of information that can be easily accessed on mobile devices. These changes have been accompanied by an increase in published research on the use of mobile devices in medicine, both in the medical literature and the library literature. A 2012 literature review examined published research on "innovative roles of the smartphone in the field of internal medicine...[including] patient care, medical reference, and continuing education...[and] uses of the smartphone in medical education, communication, and research" [14]. The review found sixty research articles from 2007 to May

2012 that met the stated inclusion criteria. Despite this substantial number of studies, the authors concluded that more research is needed to understand how these devices are being used [14]. Three recent studies in the medical literature are particularly notable because they examined mobile device use for point-of-care information among medical students and professionals, a topic of interest for medical librarians. One study explored app use among residents in the United States [7]; another examined the use of mobile devices in medical education at the University of Alberta [15]; and a third surveyed smartphone use by medical students and junior doctors in the United Kingdom [16]. These studies indicated frequent use of mobile devices as reference and information management tools in clinical practice and medical training among faculty, students, and residents, with a trend toward higher use among newer professionals and trainees. However, these studies did not address some aspects of mobile device information use that are particularly important to librarians, specifically, the ways that users search for information and that libraries provide information resources. The results of these studies are also of limited value to health sciences libraries, as they focus on one specific user group or one institution and do not provide data on the full range of students and practitioners of medicine across all specialties served by a typical health sciences library.

In addition to the above-mentioned studies, the health sciences library literature contained three recent studies that surveyed physicians and medical trainees regarding their use of library services on mobile devices. Chatterley and Chojecki reported that students were using specific clinical apps and were facing technical barriers to their use but completed their study before iPhones were available [5]. The studies by Bala and Gupta [17] and Bushhousen et al. [18] demonstrated that clinicians and students used their mobile devices for a wide variety of library services and other tasks, including clinical information use. All three studies were limited to specific geographic regions and did not take the use of tablets into account. To improve the provision of services and resources, it is essential that librarians learn more about medical information use on all types of mobile devices from a variety of user groups. The current study was designed to fill these gaps in knowledge through a multisite, cross-specialty examination of mobile device use in medicine, with a particular focus on questions that were important to librarians.

RESEARCH QUESTIONS

The research questions addressed by this project were:

- What is the extent to which medical trainees and faculty use their mobile devices when answering clinical questions and finding medical information?
- What are the facilitators and barriers to using mobile devices to find information related to medical studies and clinical work?

- How do health libraries support mobile users' clinical information needs?

METHODS

This study was a web-based survey with participants from four Canadian universities: McGill University, University of Alberta, University of Calgary, and University of Ottawa. At the time of the study, access to popular library-licensed resources such as UpToDate, Lexicomp, PEPID, and DynaMed varied at each institution, though each institution had access to at least one of the above resources. Each university library also had a specialized web page that facilitated access to library-licensed mobile resources.

The survey was developed by three health sciences librarians. Survey development was guided by the previous work of Chatterley and Chojecki [5]. The survey was pretested for face validity by two health sciences librarians at McGill University and the University of Alberta. The survey consisted of fourteen items (Appendix, online only).

Each university involved in the study received ethics approval from its respective institutional ethics board. An email invitation with a link to a web survey hosted at McGill was sent to prospective participants via departmental email discussion lists, personal contacts, and a link to the survey on relevant internal websites. The front page of the survey explained the project in more detail, explaining that the survey was being conducted "in order to know how you are using your mobile device," and provided information regarding the ethics approval for each institution. The survey was open and data were collected from January 2012 to April 2012. Two reminder emails were sent.

The target population was medical trainees, graduate students, and faculty members (including both full-time faculty who may or may not have clinical responsibilities and clinical instructors) from the four medical training university centers. Specifically, undergraduate or graduate students (including medical residents) in a degree program offered through a medical faculty at one of the four institutions involved in the study or a faculty member or instructor associated with a medical faculty at one of the four institutions were included in the study.

Descriptive statistics were collated and summarized using SPSS 19 [19].

RESULTS

User groups and device ownership

There were 1,210 individuals who responded to the survey, which is an estimated response rate of 6%–8%. (Due to the diverse composition of the 4 medical faculties involved in the study, the exact number of potential respondents could not be accurately determined, but the authors estimated it to be 15,000–20,000 individuals.) Most participants reported owning a mobile device (1,120, 92.6%). Those who did

Table 3
Frequency of use by user group (n=1,069)

How often do you use your mobile device to access medical resources?	1st- or 2nd-year undergraduate medical student	3rd- or 4th-year undergraduate medical student	Medical resident	Graduate student (other than medical resident)	Faculty member	Other	Total
More than once a day	44 (26.8%)	55 (59.1%)	241 (77.0%)	13 (14.6%)	146 (38.5%)	9 (29.0%)	508 (47.5%)
Once a day	13 (7.9%)	10 (10.8%)	24 (7.7%)	5 (5.6%)	46 (12.1%)	2 (6.5%)	100 (9.4%)
Several times a week	42 (25.6%)	23 (24.7%)	28 (8.9%)	14 (15.7%)	75 (19.8%)	6 (19.4%)	188 (17.6%)
Several times a month	35 (21.3%)	2 (2.2%)	11 (3.5%)	13 (14.6%)	28 (7.4%)	3 (9.7%)	92 (8.6%)
Once a month	10 (6.1%)	0 (—)	3 (1.0%)	6 (6.7%)	16 (4.2%)	2 (6.5%)	37 (3.5%)
Less than once a month	9 (5.5%)	0 (—)	1 (0.3%)	11 (12.4%)	19 (5.0%)	4 (12.9%)	44 (4.1%)
Never	11 (6.7%)	3 (3.2%)	5 (1.6%)	27 (30.3%)	49 (12.9%)	5 (16.1%)	100 (9.4%)

not report owning a mobile device were not given the option to continue with the rest of the survey, so no demographic information is available for this group. Of the 1,092 participants who provided demographic information, 169 were preclinical undergraduate medical students (15.5%), 93 were clinical undergraduate students (8.5%), 316 were medical residents (28.9%), 92 were graduate students (8.4%), 382 were faculty members and clinical instructors (35.0%), and 36 selected "other" (3.3%). (Please note that throughout the results and discussion, the term "graduate students" refers to graduate students who are not medical residents.) The breakdown of participants by institution was: McGill University, 349 (32.1%); University of Alberta, 214 (19.7%); University of Calgary, 268 (24.6%); and University of Ottawa, 257 (23.6%). Medical residents, other graduate students, and faculty members came from a broad range of medical specialties, with the largest groups coming from internal medicine (124, 15.8%), family medicine (87, 11.1%), surgery (77, 9.8%), basic sciences (73, 9.3%), and pediatrics (63, 8.0%). Overall, the sample was representative of the combined population of the 4 universities, but it was not representative when the results were broken down by each institution (for example, University of Alberta had a higher proportion of residents in comparison to other population groups, while McGill had more medical students).

Apple products were the most commonly owned devices, with 71.8% of participants owning an iPhone or iPod Touch and 42.1% owning an iPad (Table 1, online only). A substantial number of participants reported owning both a smartphone and a tablet (41.8%), including more than 50% of both residents and faculty members.

Information searching on mobile devices

Across all user groups, the most commonly reported uses of mobile devices were finding drug information (73.5%), performing clinical calculations (57.9%), and taking notes (51.6%) (Table 2, online only). However, a substantial portion of respondents also used these devices to search for journal articles (46.5%) and read journal articles (50.2%). Medical students and residents used their devices for a broader range of activities than other groups; over 50% of the 3rd- and 4th-year students and residents reported using their mobile devices to find drug information, find clinical practice

guidelines, read point-of-care information, do clinical calculations, or perform differential diagnoses. More than 50% of residents reported using their devices for all listed activities. The only categories in which over 50% of faculty reported using their mobile devices were taking notes, finding drug information, and searching and reading journals.

Participants frequently used their mobile devices to access medical resources (Table 3): 47.5% of all participants reported using their mobile devices for this purpose more than once a day. Residents and medical students in their clinical clerkships were the most frequent users of mobile devices for this purpose: 77.0% of residents reported greater than daily use; a cumulative total of 93.6% used them at least several times a week or more; and 59.1% of medical students in their clinical clerkship (3rd- or 4th-year undergraduates) used them more than once a day, while 94.6% used them at least several times per week or more. Graduate students other than medical residents were the most infrequent users, with only 14.6% reporting greater than daily use and 30.3% never using their devices to access medical information.

As part of the survey, participants were asked to provide details about the last time that they used their mobile device to find medical information. To not limit potential responses, this section of the survey used open-ended questions, and the authors coded the answers for analysis. When participants were asked which resource they last selected to use, the 10 most frequently mentioned resources were: UpToDate (20.9%), Medscape/eMedicine (12.8%), PubMed (9.9%), Lexicomp (9.8%), Epocrates (8.7%), Google (8.5%), a medical calculator such as MedCalc or QxMD (7.7%), journals or journal articles (7.7%), DynaMed (5.8%), and PEPID (4.6%). Eighteen percent of resources were only mentioned once, representing a long tail of less common information sources. A few (3.2%) participants also stated that they used the web or the Internet, without specifying in greater detail which sites or resources they used. Table 4 shows the top 10 resources mentioned.

Participants were asked to list their favorite resources. Participants were free to enter any resource they liked, and the responses were coded by authors. The 10 most frequently mentioned favorite resources were: UpToDate (18.9%), Epocrates and Medscape/eMedicine (tied at 11.5%), Lexicomp (10.3%), PubMed (6.9%), DynaMed, (5.7%), PEPID (5.3%), a medical

Table 4

Top ten resources most frequently mentioned

Last used (n=846)	# of mentions	Listed as favorite (n=736)	# of mentions
UpToDate	177 (20.9%)	UpToDate	139 (18.6%)
Medscape/eMedicine	108 (12.8%)	Epicates	85 (11.4%)
PubMed	84 (9.9%)	Medscape/eMedicine	85 (11.4%)
Lexicomp	83 (9.8%)	Lexicomp	76 (10.2%)
Epicrates	74 (8.7%)	PubMed	51 (6.8%)
Google	72 (8.5%)	DynaMed	42 (5.6%)
Medical calculator	65 (7.7%)	PEPID	39 (5.2%)
Journals/journal articles	65 (7.7%)	Medical calculator	37 (5.0%)
DynaMed	49 (5.8%)	Micromedex	13 (1.7%)
PEPID	39 (4.6%)	General web/Internet	12 (1.6%)

Participants could select more than 1 option, so totals do not add up to 100%.

calculator (5.0%), Micromedex (1.8%), or the general web or Internet (1.6%). Only 3 participants listed Google as a favorite resource (0.3%).

Finally, participants were asked how many medical resources or apps they had purchased for their mobile device: 44.8% had not purchased any resources, 36.6% had purchased 1–4 resources, 12.8% had purchased 5–10 resources, and 5.7% had purchased more than 10. Third- and fourth-year undergraduate medical students and medical residents reported purchasing more resources than did other groups: 70.5% of third- and fourth-year undergraduate students and 73.1% of residents had purchased 1 or more resources, while 27.3% and 29.9%, respectively, had purchased more than 5. Graduate students purchased the fewest number of medical resources, with 75.9% not having purchased any.

Barriers and facilitators to access

Two survey questions explicitly addressed barriers to using mobile devices for study and practice. One was a qualitative question asking participants what did not work well in their last information retrieval and

the other a multiple choice question with an option for comment. Table 5 shows barriers to access by user group.

In the multiple choice question, "Wireless access in the hospital or clinic" was reported as the main barrier to using mobile devices for information seeking, with 70.7% of participants recognizing it as being a problem. Wireless access was broadly recognized as a problem among all groups, but particularly among clinical undergraduate students (90.1%) and residents (77.2%). Fewer graduate students found it to be a problem (58.7%). At the time of this survey, the Canadian hospitals and clinics associated with these universities did not have WiFi access, and some hospitals had dead spots in cellular network coverage.

"Knowing what resources were available" (55.8%) and "lack of time" (26.3%) were the other most commonly reported barriers to access, among all groups. Other barriers included "understanding how to use the resources" (20.8%), "technology problems" (20.7%), or "complicated installation process" (18.3%).

In the qualitative responses, WiFi or cellular data coverage was again reported as one of the most

Table 5

Barriers to access by user group (n=921)

What are the barriers you have encountered when accessing medical resources on your mobile device?	1st- or 2nd-year undergraduate medical student	3rd- or 4th-year undergraduate medical student	Medical resident	Graduate student (other than medical resident)	Faculty member	Other	Total
Wireless access in the hospital or clinic	88 (63.8%)	73 (90.1%)	217 (77.2%)	37 (58.7%)	223 (66.2%)	13 (61.9%)	651 (70.7%)
Knowing what resources are available	91 (65.9%)	41 (50.6%)	144 (51.2%)	34 (54.0%)	193 (57.3%)	11 (52.4%)	514 (55.8%)
Understanding how to use the resources	37 (26.8%)	13 (16.0%)	52 (18.5%)	13 (20.6%)	74 (22.0%)	3 (14.3%)	192 (20.8%)
Technology problems	32 (23.2%)	19 (23.5%)	63 (22.4%)	11 (17.5%)	60 (17.8%)	6 (28.6%)	191 (20.7%)
Complicated installation process	32 (23.2%)	18 (22.2%)	68 (24.2%)	9 (14.3%)	39 (11.6%)	3 (14.3%)	169 (18.3%)
Do not have permission to install software (e.g., corporate Blackberry)	13 (9.4%)	5 (6.2%)	18 (6.4%)	3 (4.8%)	43 (12.8%)	2 (9.5%)	84 (9.1%)
Lack of time	37 (26.8%)	23 (28.4%)	52 (18.5%)	18 (28.6%)	107 (31.8%)	5 (23.8%)	242 (26.3%)
Other barriers	13 (9.4%)	6 (7.4%)	30 (10.7%)	10 (15.9%)	47 (13.9%)	3 (14.3%)	109 (11.8%)

Participants could select more than 1 option, so totals do not add up to 100%.

significant barriers to using mobile devices during the participants' last information retrieval. Participants commented on slow loading times, intermittent Internet connections, and inability to access needed information as a result of this problem. Several comments expressed a high level of frustration about this issue:

"Incomplete WiFi access in hospital very frustrating and almost makes it not worthwhile to carry around a mobile device because of limited geographical areas it can be used in."

Participants also commented on the screen size of most smartphones and technical limitations of most mobile devices (e.g., touchscreen keyboards, no printing, unable to view certain websites or file formats). One respondent summarized it with the following statement: "Slow to load, hard to read, clumsy to search."

Participants were trying to access journals or other licensed resources, which required obtaining a serial number or logging into the resource through a proxy server, virtual private network (VPN), or a personal account. One participant explained how these technical problems often compound to make mobile resources overall more difficult to use:

"Small screen, the fact that many medical sites are not modified to be compatible with iphone, and slowness of internet with constant need to log-in makes more complex searches difficult — cannot usually get to online resources in a timely fashion."

Despite these barriers, 91.3% participants said they were successful in finding the information they needed, while 5.7% said they were relatively successful. Only 2.9% reported being unsuccessful in their searches for information. This level of success is impressive considering that more than a quarter of participants (26.6%) reported spending less than a minute on their search for information, and 92.6% spent a few minutes or less.

Participants were also asked to describe what worked well in their information retrieval. Many participants indicated that the speed and convenience of access afforded by smartphones was very beneficial:

"So fast, so easy. I can read articles or check notes during rounds or during a quick break."

"I got the information right away as opposed to intending on looking it up at home and actually never getting to it."

Participants also commented on the fact that concise, well-organized information was important. The presence or lack of Canadian drug information in the drug resources was also commonly a reason for using or not using a resource. Having an efficient search function, offline access to information through an app, and a usable, mobile-enabled interface were also important features:

"Having apps/products that are already downloaded on your phone so that you don't always have to have access to

the internet. iPhones are convenient because they are always on you (vs having to find a desktop computer)."

Library-specific barriers and facilitators

Only 43.0% of participants knew that the library offered mobile resources to its users. Of those participants who were aware of these resources, only 67.5% had used those resources, although 96.8% of those individuals who had used them expressed that they had found having access to those resources useful.

Clinical undergraduates (65.5%) and medical residents (62.3%) were more aware of mobile resources offered through the library than other participants, and graduate students were the least aware of these resources (17.7%). A higher proportion of clinical undergraduates (80.4%) and medical residents (78.1%) reported using these resources compared to other groups.

Those participants who had used mobile resources through the library were almost uniformly pleased with them, regardless of whether they were students, residents, faculty members, or instructors. Qualitative comments revealed that ease of access, breadth of resources, reliability and authority of information, and cost savings were important:

"Easy access to medical information. Lighter than carrying books around."

"Having a variety of resources allows for a more comprehensive overview of each given topic."

"They are very expensive apps, so getting access from the university library is incredibly helpful."

Barriers to accessing library resources were largely related to finding and retrieving full-text journal articles and authentication for licensed resources:

"Actually accessing the journal/article via the online library resources. Too many steps involved to go from pubmed search result to actually downloading the PDF to my iPad."

"I keep meaning to get the code for pepid and did use it years ago but keep getting distracted and then when I want to use it I'm in the middle of clinic and can't stop to apply for the code."

Library support for mobile users

Most participants got support for their mobile devices from friends (62.9%) or colleagues (38.3%), with only 4.7% choosing the library as a place to get support. When asked what support they would like the library to provide, the most popular answers were "online how-to guides specific to your institution" (64.3%), "hands-on workshop on how to use medical resources on mobile devices" (42.7%), and "drop-in troubleshooting assistance" (39.2%). Table 6 shows desired library support by user group.

In qualitative responses for this question, participants commented that they wanted more communication about mobile-optimized resources available through the library:

Table 6
Desired library support by user group (n=929)

What support would you like the library to provide?	1st- or 2nd-year undergraduate medical student	3rd- or 4th-year undergraduate medical student	Medical resident	Graduate student (other than medical resident)	Faculty member	Other	Total
Hands-on workshops on how to use mobile devices	16 (11.8%)	9 (11.1%)	38 (13.6%)	16 (24.6%)	73 (21.2%)	6 (26.1%)	158 (17.0%)
Hands-on workshops on how to use medical resources on mobile devices	75 (55.1%)	37 (45.7%)	94 (33.6%)	27 (41.5%)	158 (45.9%)	6 (26.1%)	397 (42.7%)
Drop-in troubleshooting assistance	60 (44.1%)	32 (39.5%)	113 (40.4%)	27 (41.5%)	125 (36.3%)	7 (30.4%)	364 (39.2%)
Online how-to guides specific to your institution	92 (67.6%)	51 (63.0%)	175 (62.5%)	35 (53.8%)	232 (67.4%)	12 (52.2%)	597 (64.3%)
More resources	25 (18.4%)	30 (37.0%)	94 (33.6%)	8 (12.3%)	50 (14.5%)	7 (30.4%)	214 (23.0%)
None	6 (4.4%)	5 (6.2%)	20 (7.1%)	11 (16.9%)	31 (9.0%)	1 (4.3%)	74 (8.0%)
Other	11 (8.1%)	3 (3.7%)	23 (8.2%)	4 (6.2%)	35 (10.2%)	1 (4.3%)	77 (8.3%)

Participants could select more than 1 option, so totals do not add up to 100%.

"Send out a newsletter with a list of available apps and how to install them (make installation easier!)"

"Provide a list and email info about where to find these resources."

DISCUSSION

While previous studies have explored a single institution [5, 15, 17, 18] or a limited user group—residents and attending physicians [7], or medical students and junior doctors [16]—this study provides multisite, multiple user group, cross-country data on mobile device use in medicine. This study also reveals the searching habits of this population in more detail than previous studies [5, 17, 18].

Mobile device ownership reported in the survey was 92.6%, higher than earlier surveys but consistent with previously reported trends in mobile ownership [5, 7, 15, 16]. As predicted in a previous study on PDAs, smartphones have achieved widespread adoption among medical professionals [5].

It is clear that mobile devices are well suited for use in clinical practice, where clinicians and students often have to find patient care information quickly. While valued by all clinicians, mobile devices appeared to be most heavily used by those in an active clinical trainee role. Across all the data, third- and fourth-year undergraduate students (i.e., those in their clinical clerkships) and medical residents, as compared with other participant groups, used their mobile devices more often, used them for a broader range of activities, and purchased more resources for their devices. A higher percentage of this group wanted the library to provide more resources or wanted the hospital to provide WiFi access. Intuitively, this pattern of use makes sense: students and residents are still learning and still need to look up a vast amount of information.

It is less clear what role mobile devices play in other academic information-seeking contexts. Graduate students (i.e., medical science students who are not

training for clinical work) used their mobile devices for information seeking much less frequently than other groups did. Because many graduate students are focused on research and are not necessarily practicing clinicians, they demand instant information less and in-depth literature searching and reading more. As many participants commented, the small screen and touchscreen keyboard of these devices do not lend themselves to complex searching. Although iPads and tablet computers do function as a device for reading portable document format (PDF) files and other documents, a small proportion of graduate students reported owning one. The authors suspect that the low rate of ownership of iPads and tablet computers among graduate students is because individuals in that group have less disposable income than many clinicians and faculty members.

The top three uses of mobile devices (finding drug information, making clinical calculations, and taking notes) were consistent with earlier surveys [5, 15], but a much larger number of participants reported using mobile devices to search for and read journal articles than in a previous survey regarding PDAs: approximately half of the participants in this study used their devices to search for journal literature, whereas only three out of fifty-three students in a previous study did so [5]. This trend is not surprising when considering that the screen quality, processing power, and usability of mobile devices have increased dramatically in the past few years, removing some of the barriers to journal access. Searching for and reading PDF journal articles on tablet computers such as the iPad, which are much more suited to such a purpose, accounts for some of this increase, although a substantial portion of participants also used their smartphones for the same purpose.

UpToDate was most frequently ranked as participants' favorite resource and was most frequently mentioned as the last-used resource in a search for information. However, many of the resources mentioned were free ones such as Medscape and Epocrates (which both have easily downloadable

app versions), medical calculators (many of which are free or inexpensive), and PubMed (which has a mobile-optimized website).

There were differences between what participants identified as their favorite information resource and what they actually used the last time they searched for clinical information. Participants named clinical point-of-care tools as their favorite resources, and indeed, these resources appeared to be used frequently. However, Google, PubMed, and journals or journal articles were more frequently listed as the last-used resource in practice but were mentioned less often as a favorite resource. In fact, the survey indicated that Google or the general web was used in 11.7% of participants' last information-seeking encounters, but they were barely mentioned as a favorite resource (2.0%). Journal articles were also used more frequently, despite a large number of complaints about reading non-optimized web pages and PDF articles on a small screen.

One possible explanation for these differences is that many participants default to Google as a search option when they do not have the time to log into library-licensed resources or to download an appropriate app to answer a particular question. This explanation is supported by the fact that most participants spent less than a few minutes on their search, and qualitative comments indicated that accessing particular resources was problematic. Google is easily accessible through mobile web browsers, and PubMed, Medscape, and other free resources generally rank quite high in Google search results, especially when the query contains specialized terminology. Often, the top results in Google are actually PubMed records for journal articles, which could also account for the higher use of journal articles.

As a result of often cumbersome access to resources, many participants appeared to be "satisficing" in their search [20], choosing convenience and speed over finding better quality information. One student explicitly recognized this dilemma:

"I would have ideally liked to go through my school's library's reputable clinical/point-of-care resources - however, I was asked to look up information for a particular patient and due to the lack of time, could not."

Participants were aware of better resources, but the convergence of several different barriers (time, access, knowing the resources) kept them from using these more reliable resources. Most participants reported being able to find a satisfactory answer within a minute or two, but it might not be the most authoritative or most accurate answer.

The convenience, accessibility, and overall utility of mobile devices are a result of their compact size and portability, yet those same aspects are also points of frustration for many users. Many participants expressed dissatisfaction with the screen size, touch-screen typing, and slow loading time (which is a symptom of both poor network connections and less

powerful mobile processors). One resident mentioned the limitations of the technology, while also explicitly acknowledging what the technology allowed:

"Small screen can make some websites cumbersome. That being said, it is absolutely amazing to have this technology on hand."

This juxtaposition of negative and positive features of mobile devices and/or resources often appeared in the qualitative comments.

Implications for librarians

While health sciences libraries are facilitating the use of various medical mobile resources by providing access to expensive licensed resources, authentication to library-licensed resources remains the most significant barrier to access. Each library-licensed mobile resource has a different method of authentication, and busy clinicians or students will often give up before they have figured out how to access the resource. The authors were surprised to learn that so many participants were reading journal articles on their mobile devices, especially considering the need to authenticate through proxy servers or VPNs to access the articles. Streamlining the process to access library-licensed resources, including journal articles, removes a huge barrier to the use of these resources.

The fact that so many clinicians and students are using free resources on a regular basis and are using such a wide variety of resources raises questions about where libraries should be investing time and money in regard to mobile resources. The qualitative comments demonstrate that medical information seekers turn to the library for reliable mobile resources, yet it is difficult for the library to connect users to these resources. One potential strategy for libraries is to focus on providing access to a smaller number of select, highly used mobile resources instead of trying to offer access to a huge collection of mobile resources. In this way, libraries could focus on these select resources until library-licensed mobile resources have a more streamlined authentication process.

By removing the access barriers to library-licensed resources, it will be easier to promote these resources. Even though the majority of people surveyed did not know about library-licensed mobile resources, the survey demonstrated that they appreciated and needed this content. One clear area for improvement for libraries is the active promotion of mobile device resources that are available through the library, particularly to faculty members and clinical instructors. Presumably, undergraduate medical students and medical residents are more aware of these resources because the librarians are often more involved in teaching these students, whereas librarians often have less contact with teaching faculty. Creating online guides and actively promoting these guides to faculty members and students through email, social media, and other electronic means might

be one way of increasing the visibility of mobile resources available through the library. Targeted hands-on sessions for specific medical mobile resources are another important way of raising awareness among all user groups. These hands-on sessions are more difficult to plan, with the question of which devices the instructor will demonstrate and how the instructor will address the different versions of devices that users bring to the workshop. Increased promotion and hands-on workshops would also address two of the major barriers to access ("knowing what resources are available" and "knowing how to use resources") and encourage more students and faculty to use library-licensed resources on their mobile devices.

Limitations of the study

One limitation of this study was the small response rate. While the authors were pleased to receive 1,210 responses, this number represents 6%–8% of the possible respondents out of the estimated 15,000–20,000 medical students and physicians in the 4 institutions. The 1,210 participants were more likely to be interested in mobile device use in medicine and might not represent the average user. However, the authors still feel that the pool of participants provided useful data for health sciences libraries involved in mobile device resources. Another limitation was the fact that this survey was only administered in English. Due to the logistical challenges of data collection and analysis in two languages, a French survey instrument was not developed. Therefore, the survey results might not represent the usage patterns of Francophone members of the Canadian medical community.

CONCLUSION

The results from this survey demonstrate that medical students, medical residents, clinical instructors, and faculty are using their mobile devices to answer clinical questions in a variety of ways. The portability and increasing power of these devices has facilitated wider adoption, but slow or nonexistent wireless Internet connections and library authentication problems still arise as major complaints. These problems do not seem to prevent medical trainees and faculty from regularly using mobile devices for their medical information searches; however, barriers to access and lack of awareness might be keeping them from using the most appropriate resources to efficiently answer their questions. Libraries want to help their users find the best resources for their information needs, whether the resources are free or licensed by the library. Unfortunately, libraries and vendors have not yet succeeded in facilitating effective access on mobile devices. By better understanding this group's mobile device habits, health libraries across North America can begin targeting their services and resources to this ever-expanding population of mobile users. The familiar challenges of access to and promotion of resources hold true to mobile resources, but libraries

and vendors need to think of new solutions appropriate to the mobile environment.

Mobile devices will have an ever-growing presence in medical education and the practice of medicine, and libraries must be aware of the impact that these devices have on library services and the ways in which users search for information. Future studies could explore medical students' and physicians' mobile information searching habits from a qualitative perspective or investigate how other health students and professionals use mobile devices in their clinical work.

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REFERENCES

- Burnette P. Mobile technology and medical libraries: worlds collide. *Ref Lib.* 2011;52(1-2):98–105.
- Garrity C, El Emam K. Who's using PDAs? estimates of PDA use by health care providers: a systematic review of surveys. *J Med Internet Res.* 2006 Apr-Jun;8(2):e7. Epub 2006/07/27.
- Jackson and Coker Research Associates. Apps, doctors, and digital devices [Internet]. The Associates; 2011 [cited 30 Jan 2013]. <<http://www.jacksoncoker.com/physician-career-resources/newsletters/monthlymain/des/Apps.aspx>>.
- Leon SA, Fontelo P, Green L, Ackerman M, Liu F. Evidence-based medicine among internal medicine residents in a community hospital program using smart phones. *BMC Med Inform Decis Mak.* 2007 Feb 21;7:5. Epub 2007/02/23.
- Chatterley T, Chojecki D. Personal digital assistant usage among undergraduate medical students: exploring trends, barriers, and the advent of smartphones. *J Med Lib Assoc.* 2010 Apr;98(2):157–60. DOI: <http://dx.doi.org/10.3163/1536-5050.98.2.008>.
- Ahead of the curve: Canadian doctors leap on the mobile bandwagon. *Future Pract* [Internet]. 2012 Nov;11–4 [cited 29 Jul 2013]. <http://www.cma.ca/multimedia/CMA/Content_Images/Inside_cma/Future_Practice/FP_nov2012.pdf>.
- Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. *J Med Syst.* 2012 Oct;36(5):3135–9. Epub 2011/11/05.
- Mosa AS, Yoo I, Sheets L. A systematic review of healthcare applications for smartphones. *BMC Med Inform Decis Mak.* 2012;12(1):67.
- Wilson D. Drug app comes free, ads included. *N Y Times* [Internet]. 2011 [cited 29 Jul 2013]. <<http://www.nytimes.com/2011/07/29/business/the-epocrates-app-provides-drug-information-and-drug-ads.html>>.
- Carney S, Koufogiannakis D, Ryan P. Library services for users of personal digital assistants: a needs assessment

- and program evaluation. *Portal Lib Acad.* 2004 Jul;4(3):393–406.
11. Burnette P, Dorsch J. From novelty to necessity: impact of the PDA experience on medical libraries. *Ref Lib.* 2006;45(93):83–98.
 12. Kim B, Ball M. Mobile use in medicine: taking a cue from specialized resources and devices. *Ref Lib.* 2011;52(1–2):57–67.
 13. Mihlrad L, Glassman NR. Institutional access to mobile resources. *J Electron Resour Med Lib.* 2012;9(1):77–86.
 14. Ozdalga E, Ozdalga A, Ahuja N. The smartphone in medicine: a review of current and potential use among physicians and students. *J Med Internet Res.* 2012 Sep-Oct;14(5):e128. Epub 2012/09/29.
 15. Wallace S, Clark M, White J. 'It's on my iPhone': attitudes to the use of mobile computing devices in medical education, a mixed-methods study. *BMJ Open.* 2012 Aug 24;2(4):ii:e001099.
 16. Payne KB, Wharrad H, Watts K. Smartphone and medical related app use among medical students and junior doctors in the United Kingdom (UK): a regional survey. *BMC Med Inform Decis Mak.* 2012 Oct 30;12:121. Epub 2012/11/01.
 17. Bala A, Gupta BM. Perceptions of health professionals regarding use and provision of LIS through mobile technologies. *DESIDOC J Lib Inf Technol.* 2010 May;30(3):7–12.
 18. Bushhausen E, Norton HF, Butson LC, Auten B, Jesano R, David D, Tennant MR. Smartphone use at a university health science center. *Med Ref Serv Q.* 2013; 32(1):52–72. Epub 2013/02/12.
 19. Corporation IBM. *IBM SPSS statistics for Windows.* 19.0 ed. Armonk, NY: IBM Corporation; 2010.
 20. Simon HA. Rational choice and the structure of the environment. *Psychol Rev.* 1956 Mar;63(2):129–38.

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