Major article

Review and analysis of existing mobile phone applications for health care–associated infection prevention

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Background: The expanding number of mobile health applications (apps) holds potential to reduce and eliminate health care–associated infections (HAIs) in clinical practice. The purpose of this review was to identify and provide an overview of the apps available to support prevention of HAIs and to assess their functionality and potential uses in clinical care.

Methods: We searched 3 online mobile app stores using the following terms: *infection prevention*, *prevention*, *hand hygiene*, *hand washing*, and specific HAI terms (*catheter-associated urinary tract infection* [CAUTI], *central line–associated bloodstream infections*, *surgical site infection*, and *ventilator associated pneumonia* [VAP]).

Results: Search queries yielded a total of 2,646 potentially relevant apps, of which 17 met our final inclusion criteria. The areas of focus were CAUTI (n = 1, 5.9%), VAP (n = 1, 5.9%), environmental monitoring (n = 2, 11.8%), and hand hygiene (n = 2, 11.8%); the remainder (n = 11, 64.7%) were focused on >1 area (eg, multiple infection prevention bundles, infection prevention guidelines). Almost all of the apps (70.6%) had a maximum of two functions.

Conclusion: Mobile apps may help reduce HAI by providing easy access to guidelines, hand hygiene monitoring support, or step-by-step procedures aimed at reducing infections at the point of clinical care. Given the dearth of available apps and the lack of functionality with those that are available, there is a need for further development of mobile apps for HAI prevention at the point of care.

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Mobile phones are typically carried on the person, turned on, and allow for bidirectional communication and on-demand access to information.[1,2] As a result they have been recognized as potentially valuable tools to support health care at the point of care.[3] The World Health Organization's Global Observatory for eHealth defines mobile health (mHealth) as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices."[4] mHealth applications (apps), developed to run on smartphones, can be used to deliver scientific evidence to health care providers in their clinical settings.[5] In the United States, approximately 65% of adults own smartphones, making the use of

mobile apps for the provision of health care a feasible delivery platform. A recent report suggests that there are >40,000 health care–related apps available.[6] Health care–related apps have been designed to promote behavior change, support self-management of chronic diseases,[7] and offer health care providers easy access to health care information at the point of care.[8]

This is particularly relevant for health care–associated infections (HAIs), a growing and high-priority problem in the United States that have devastating emotional, financial, and medical consequences.[9] These infections cost the U.S. health care system billions of dollars each year, lead to the loss of tens of thousands of lives, and result in significant morbidity.[9] In response, the U.S. Department of Health and Human Services has identified the reduction of HAIs as an agency priority goal, and there is growing consensus that the goal in the United States should be the elimination of HAIs.[10]

Mobile apps can support dissemination and uptake of evidence to reduce and ultimately eliminate HAIs. There is concern, however, that many apps are being developed without scientific knowledge to advance the delivery of care.[11] In fact, many apps are being used

by or recommended to patients and health care providers with little understanding of their functionality or ability to integrate data into health care systems.[6] Given the surge in health-related apps, the widespread use of mobile devices, and the urgent need to reduce and eliminate HAIs, this review seeks to explore the apps that are currently available for HAI prevention. The purpose of this article is to identify and provide an overview of the apps available to support prevention of HAIs and to assess their functionality and potential uses in clinical care.

MATERIAL AND METHODS

Search and screening strategy

In July 2014, we used the terms *infection prevention*, *prevention*, *hand hygiene*, *hand washing*, and *handwashing* to search the Apple iTunes Store, Android Google Play Store, and Amazon Appstore. In addition, the search terms *catheter-associated urinary tract infection* (CAUTI), *central line—associated bloodstream infections*, *surgical site infection*, and *ventilator-associated pneumonia* (VAP) were used to identify apps focused on infection prevention bundles. Each term was searched in each of the app stores listed.

The apps were eligible for inclusion if they were focused on or included sections on prevention of HAIs. The apps were excluded if they (1) were not focused on infection prevention (eg, apps for diabetes or hair loss prevention), (2) were not focused on HAI prevention (eg, apps for diagnostic or treatment support only), (3) solely functioned as a game, (4) were developed to sell a product, (5) were written in a non-English language, (6) were a duplicate, or (7) were a lite version of another app that was available.

Data extraction, app selection, and assessment of app functionality

Initially, 2 study team members (S.I., and a research assistant) reviewed the titles of each of the apps and excluded apps from further review that clearly did not meet eligibility criteria. Next, the team members independently reviewed the full marketing descriptions of each of the remaining apps. Discrepancies were reviewed by a third team member (R.S.), and majority rule was used to determine subsequent inclusion. The apps meeting eligibility criteria were downloaded for further evaluation.

A standardized form was created to extract app characteristics using REDCap (Research Electronic Data Capture), which is a secure, Web-based application designed to support data capture for research studies.[12] Each app was assessed for platform where available (eg, Apple, Android), targeted end user (eg, administrator, provider, patient), primary focus (eg, HAI prevention, included HAI prevention content), content area (eg, CAUTI, central line—associated bloodstream infection), user rating and number of people contributing to the rating, date of last update, range of the number of downloads where available, cost to download, and users' reviews.

To assess app functionality, we adapted and used the 7 functionality categories and 4 subcategories of data use described in the IMS Institute for Healthcare Informatics report.[6] We downloaded each app and assessed whether it had the following functionality:

- Inform: provides information in a variety of formats (text, photo, video).
- Instruct: provides instructions to the user (eg, provides specific instructions on how to prevention HAIs rather than information or education only).
- Record: captures user-entered data.
- Display: graphically displays user-entered data and provides an output (eg, displays reports, data, or inputted info; prior observations).
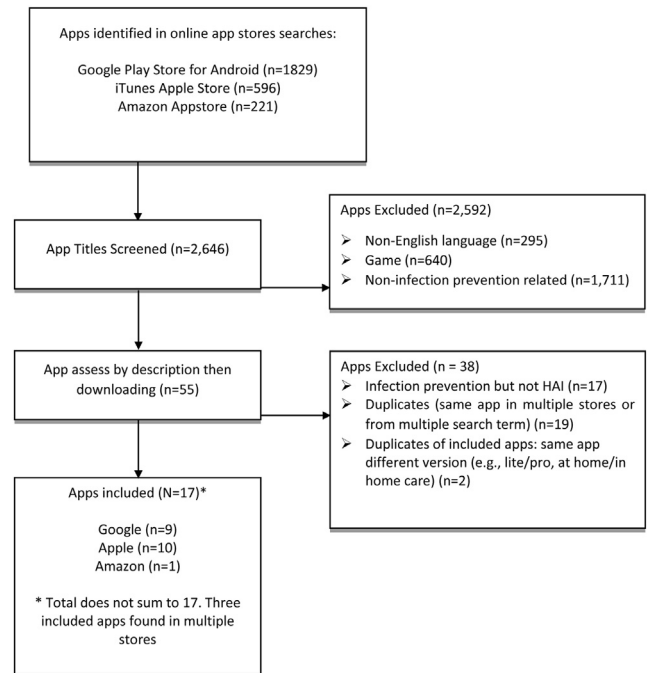
Fig 1. Screening process flowchart. *HAI*, health care—associated infection.

- Guide: provides guidance based on user-entered information (eg, offers a diagnosis or recommends a consultation with a physician or a course of treatment, having function to enter search terms to obtain information or diagnostic criteria was not considered a guide functionality).
- Remind/alert: provides reminders to the user.
- Communicate: provides communication between providers, patients, consumers, caregivers, and/or administrators.

If the app was identified to have a record function it was assessed for having the following subcategories:

- Collect data: able to enter and store health data on individual phone.
- Share data: able to transmit health data.
- Evaluate data: able to evaluate the entered health data by patient and provider, provider and administrator, or patient and caregiver.
- Intervene: able to send alerts based on the data collected or propose behavioral interventions or changes (eg, alert to contact provider or alert that monitoring for VAP prevention checklist is overdue).

Finally, we assessed online reviewer comments for themes related to the apps' usability (ability of the app to meet the end users' needs),[13] cost, and content. This step was included because, after a thorough review of the literature, no studies on the effectiveness or usability of HAI prevention apps were identified; therefore, this was a qualitative approach for evaluating the apps. Descriptive statistics were calculated for each functionality.

RESULTS

Our searches yielded a total of 2,646 potentially relevant apps, of which 17 met our final inclusion criteria. Figure 1 provides an overview of the selection process and categories for exclusion. Most apps were excluded because they were noninfection prevention