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A Review and Analysis of Existing Mobile Phone Applications for HAI Prevention

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Abstract

Background—The expanding number of mobile health applications (apps) holds tremendous potential to reduce and eliminate healthcare 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 three 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 (CLABSI), 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%), hand hygiene (n=2, 11.8%), and the remainder (n=11, 64.7%) were focused on more than one area (e.g., multiple infection prevention bundles or infection prevention guidelines).

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.

Keywords

mobile apps; healthcare associated infections; mHealth technology

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INTRODUCTION

Mobile phones are typically carried on the person, turned on, 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 healthcare 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 healthcare providers in their clinical settings (5). In the U.S. approximately 65% of adults own smartphones making the use of mobile apps for the provision of healthcare a feasible delivery platform. A recent report suggests that there are more than 40,000 healthcare-related apps available (6). Healthcare-related apps have been designed to promote behavior change, support self-management of chronic diseases (7) and offer healthcare providers easy access to healthcare information at the point of care (8).

This is particularly relevant for healthcare associated infections (HAIs), a growing and high-priority problem in the U.S. that have devastating emotional, financial and medical consequences (9). These infections cost the U.S. healthcare 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 U.S. 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 healthcare providers with little understanding of their functionality or ability to integrate data into healthcare 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 manuscript 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, the Android Google Play Store, and the Amazon Appstore. In addition the search terms catheter-associated urinary tract infection (CAUTI), central line-associated bloodstream infections (CLABSI), surgical site infection (SSI), 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 above.

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

App Selection, Data Extraction, and Assessment of App Functionality

Initially, two study team members (SI, THJ) 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 (RS) and majority rule was used to determine subsequent inclusion. 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 (e.g., Apple or Android), targeted end-user (administrator, provider, or patient), primary focus (e.g., HAI prevention or included HAI prevention content), content area (e.g., CAUTI, CLABSI), 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 seven functionality categories and four subcategories of data use described in the 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 (e.g., provides specific instructions on how to prevent HAIs rather than information/education only)
- Record: captures user entered data
- Display: graphically displays user entered data and provides an output (e.g., displays reports/data/inputted info, prior observations)
- Guide: provides guidance based on user entered information (e.g., offers a diagnosis, or recommends a consultation with a physician/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 (e.g., 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 and so 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. The majority of apps were excluded because they were non-infection prevention related (n=1,711), a game (n=640), or not available in English (n=295).

Descriptive Characteristics

Table 1 lists the included apps and their associated characteristics. The areas of focus were: CAUTI (n=1, 5.9%), VAP (n=1, 5.9%), environmental monitoring (n=2, 11.8%), hand hygiene (n=2, 11.8%), and the remainder (n=11, 64.7%) were focused on more than one area (e.g., multiple infection prevention bundles or infection prevention guidelines). Most apps (n=12) were developed for providers, with 3 that could be used by a patient and 2 targeting administrators or healthcare facility environmental control specialists. The mean and standard deviation (S.D.) user rating score was 4.06 (0.76) on a scale of 1–5 (5 being the highest score) for those with user rating reported. Download data were reported for 12 apps. The cost of the apps ranged from free to \$27.06. However, upon downloading free app we found some with components requiring fee for access (e.g., AACN Bedside .99c/reference tool). The HAI prevention information for VAP and CAUTIs were within the free practice alerts.

Functionality

Figure 2 illustrates the single functionality of almost all of the apps. Nearly all of the apps had the function to *Inform* (n=16). The one app that did not have the functionality to *Inform* was specifically designed to collect data (EcoLab EnCompass). Nine had the function to *Instruct*, 5 had *Record*, and 3 had *Display* user entered data. Seven of the apps had two or more functionalities. Only one app had 4 functionalities. None of the apps had more than 4 functional capabilities.

Sub-categories of Record Function

Of the 5 apps that had the function to *Record*; all had *Collect Data*, 3 (iScrub Lite, Safe Injection Practices and Ventilator Bundle Checklist) had *Share Data*, and 2 (Safe Injection Practices and Ventilator Bundle Checklist) had *Evaluate Data* sub-category functions. Data was shared by sending observations, tallies, or summaries by email and evaluated by calculating percentages of meeting a requirement or not.

Themes of User Reviews

Seven of the apps included written feedback from users (range 2–17 comments). Table 2 lists examples of online reviewer comments and themes. An example of an online reviewer comment related to usability was “The app is great. It just keeps crashing and requires re install every few days.” A number of reviews were posted related to the cost of the app. One reviewer posted, “Totally disappointed. App is free but all the information to use at the bedside is 99 cents.” A common concern by online reviewers related to the app content was related to unclear content updated frequently, for example “unsure if this app will provide frequent updates or not...considering the nature of the content, frequent content updates are essential.”

DISCUSSION

Despite the national attention, need, and financial incentives for preventing HAIs and the vast number of mHealth apps on the market, our results indicate that there are few to support HAI prevention. Of those apps that are available, the functionality of the apps is very narrow and limited to providing information. The apps identified in our review may help reduce HAIs by providing easy access to guidelines, supporting hand hygiene monitoring, listing step-by-step procedures to reduce infections at the point of clinical care or providing specific healthcare facility layout instructions to minimize HAIs. The limited number and functionalities of HAI prevention apps suggests that these apps are at the early stage of development, providing easier access to established protocols and guidelines. Or these findings, along with relatively few downloads reported for many of apps, suggests that they have not yet been readily adopted or integrated into broader healthcare systems.

As mHealth tools are increasingly used by healthcare professionals it is important that they be usable, accessible, and have the functionalities to support the end user needs within a given healthcare setting. Added fees to access tools within a free app or fee for updated versions may be barriers to acceptance and adaption of some of the HAI prevention apps, as suggested by online reviewer comments and noted by authors when these apps were downloaded. Users must also be assured that the information provided in an app is maintained up to date. Although assessing online reviewers’ comments has its limitations the review did serve to highlight some important issues. For example, the ease of access to a large volume of information and being able to document HAI prevention data such as hand hygiene behavior, using the app discreetly without others knowing, and being customizable to the healthcare setting.

Challenges to Identifying Apps

There were a number of challenges in identifying apps, which may also be a reason for relatively low consumer downloads and ratings. If the apps are not easily accessible then this is a barrier to using the technology. The lack of advanced search functions in all of the mobile app stores made it challenging to identify apps. For example, narrowing the search to medical apps overrode the prior search term and all medical category apps were retrieved. The app searches in Google Play could not be ordered by relevance, nor were apps explicitly labeled as game, education, medical, or other type, such as within the Apple Store. Additionally, many of the apps had minimal marketing descriptions making it difficult to identify if an app could be used for promoting HAI prevention. We also identified that when searches were conducted from an iPhone, a total count of apps retrieved from a search was displayed, whereas no total count was provided from the online web-based searches and manual counting was required. In Google Play, when the search term was general, results included a maximum of 250 apps. The Amazon Appstore, being a mainly consumer platform, required the word “app” be added toward the end of the search term used to find apps and not consumer products such as books. Amazon Appstore is shared with Android apps, and there was a high percentage of overlap in the apps identified.

Recommendations for Clinicians and Developers

Currently there are limited apps with limited functionalities available for HAI prevention. The apps included in this review are mostly a compilation of guidelines and not specifically developed for HAI prevention. Given the current apps that are available and the content that is contained within, there is a great opportunity for the integration of patient-centered outcomes research evidence into mHealth tools for HAI prevention. At the same time, new mHealth tools should be developed with greater functionality, including: record, share, evaluate and intervene on data entered into the app. Ultimately, collaboration between infection prevention specialists and app developers will likely yield the greatest end products and be the most likely to affect changes in outcomes. Examples of potential areas for development may include providing feedback to administrators on environmental safety checks, tailored reminders about HAI prevention and incorporating existing evidence into the development of mobile apps.

In addition, there has been limited testing of apps for measuring changes in outcomes, such as HAIs prevented. Given the critical numbers of HAIs in the U.S. and the potential power of mHealth, rigorous research is needed to assess the efficacy of such apps in actual healthcare settings. Better understanding of their impact, usability, accuracy, and functionality is needed prior to widespread adoption into complex healthcare systems. Enhanced social marketing, including appropriate terms in app descriptions, and having advanced search functions within the online stores could promote increase usage.

Limitations

Our study has a number of limitations to consider. First, although nearly 3,000 apps were reviewed, advanced search functions were limited within each of the app stores and therefore it is possible that potentially eligible apps may have been missed. We attempted to overcome this limitation by conducting multiple searches using broad and narrow search

terms and searching within the most prominent smartphone app stores. Second, many apps were identified in languages other than English; therefore, some apps aimed to promote HAI prevention may be available in other languages.

Reviewers' comments can include potentially confounding factors (e.g., dissatisfied customers, competitors, the app developers themselves, marketers, etc). Nonetheless, assessing user feedback may be a helpful method to gain a preliminary understanding of an app's usefulness, robustness, affordability and functionality. Finally, there are mobile medical apps which are not available directly to consumers through the mobile marketplace (e.g., Apple iTunes store). We did not include Blackberry apps in our review as the market penetration is low with only 3% of the market share (14); which was a decrease from the previous year (15). Given the restricted access to these apps, we did not include them in our review and did not assess whether there are any HAI prevention apps developed outside the mobile marketplace.

CONCLUSION

This review identified apps that may aid in the prevention of HAIs and outlined their functionality. Current apps may help reduce HAIs by providing easy access to guidelines, supporting hand hygiene monitoring, or listing step-by-step procedures to reduce infections at the point of clinical care. However, those we identified are limited in number and functionality. In addition, there were apps that appeared to be useful based on the full marketing descriptions, but once downloaded had limited coverage of HAI prevention and likely minimal benefit to healthcare providers for this topic. Collaboration between infection prevention specialists and app developers to enhance further HAI focused app designs or improve upon those which exist. Increasing the functionality to include feedback or tailored reminders for HAI prevention measures are options to consider. Adoption of these apps could be enhanced through social marketing as well as including appropriate terms in the description of the apps and advanced search functions within the online stores for easier identification by potential end-users. Foremost, research is needed to assess efficacy of the apps to prevent HAI within various healthcare settings and to determine usability issues from the end-user's perspective.

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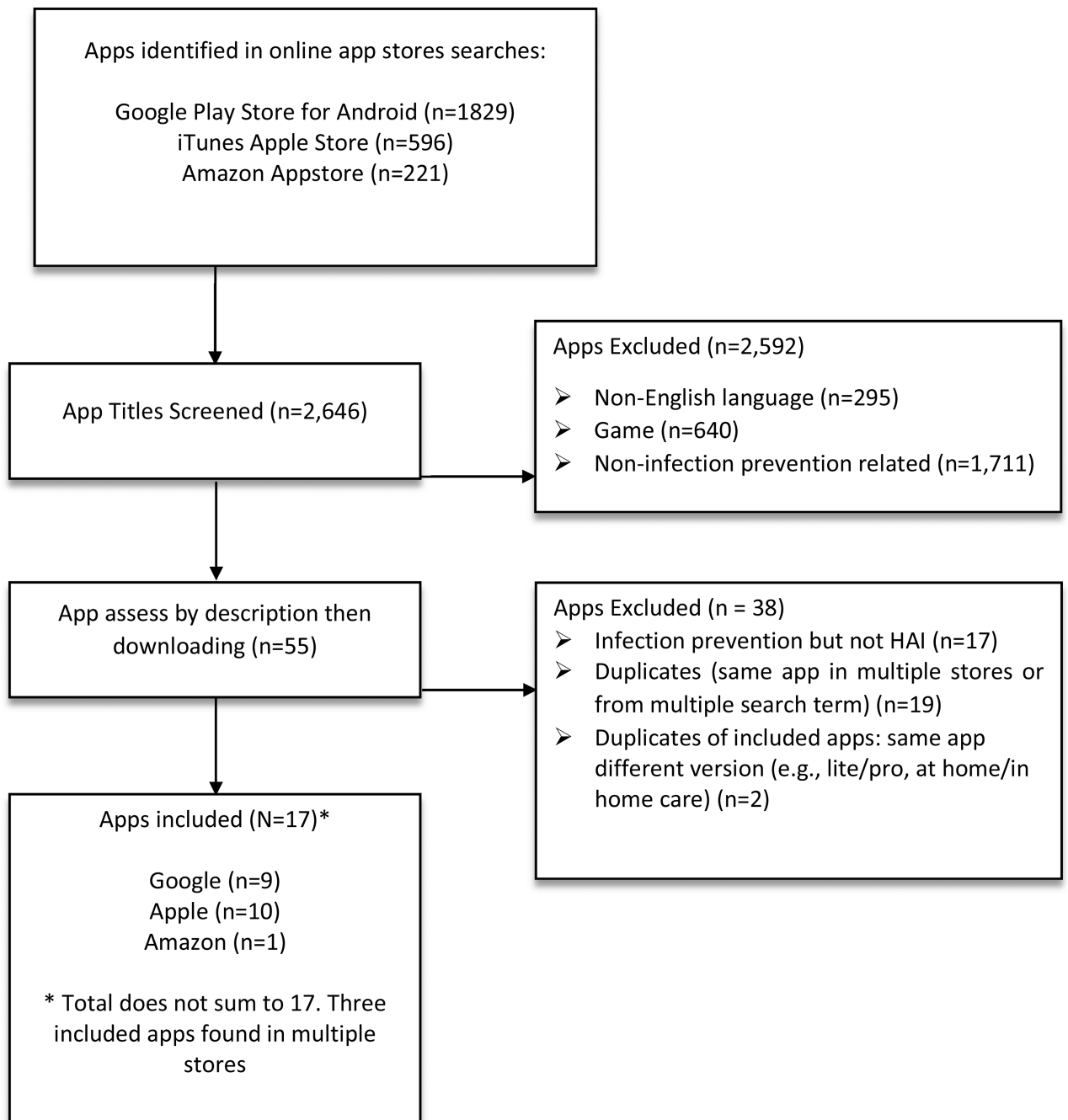


Figure 1.
Screening Process Flowchart

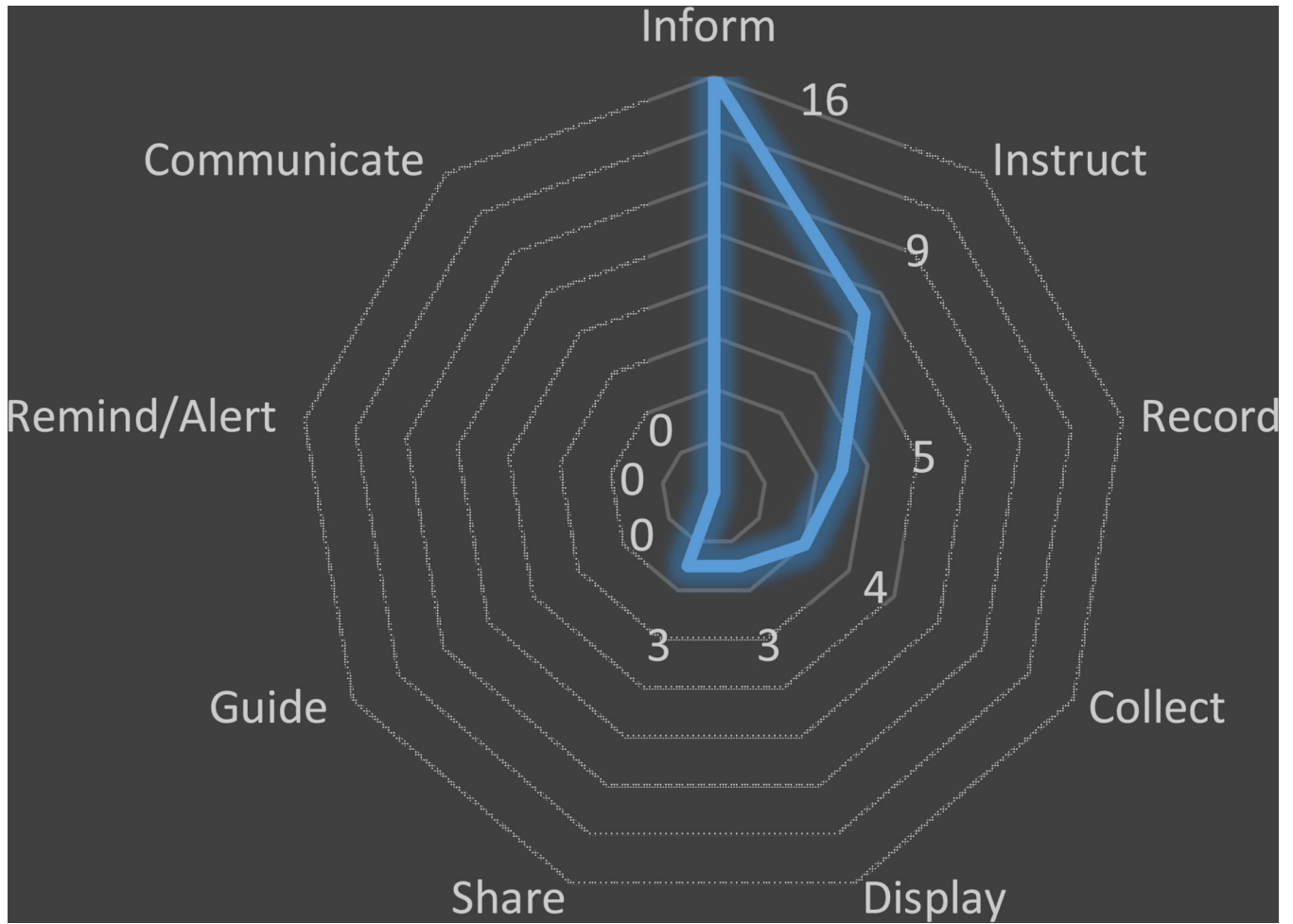


Figure 2.
Functionality of Included Apps

Table 1

Overview of Applications for Healthcare Associated Infection Prevention

App Name	Cost (\$)	Platform	Rating (#rating)	Downloads*	Targeted End-User	App Focus/Features
AACN Bedside	Free ^{\$}	Google	2.7 (16)	++++	Provider	Provide guidelines for multiple HAI and complications, section on CAUTI
AscensionP FP	Free	Google	-	++	Provider	Provide guidelines for 10 core areas including prevention of CAUTI, CLABSI, SSI, and VAP
Bugs and Drugs	27.06	Google	4.9 (7)	++	Provider	Inform on proper antimicrobial use, section on infectious disease prevention
Ecolab EnCompass	Free	Apple	-		Administrator	Record the cleanliness of rooms in a hospital setting, for future HAI preventive
Guideline Central	Free	Google, Amazon	4 (206)	+	Provider	Provide guidelines for multiple infections (including infection prevention), diseases and conditions in healthcare facilities
Handwash Counter	Free	Apple	-		Provider, Patient	Track handwashing instances to promote infection prevention and better hand hygiene
Health Facility Guidelines Pro	3.01	Google	4.7 (3)	++++	Administrator	Support design of healthcare facility, section on infection prevention
Infection Control Pocketbook	Free	Apple	4.5 (9)	++++	Provider	Provide guidelines for infection control and prevention for healthcare providers
Infection Prevention	9.61	Google	-	+	Provider, Patient	List precautions associated with preventing numerous infections
Infection-Guide	10.99	Google, Apple	-	+	Provider	Provide guidelines on infection control and prevention for healthcare providers
Infections	Free	Apple	3.5		Provider	Provide guidelines for antimicrobial prescribing, section on infection prevention
iScrublite	Free	Apple	3.5		Provider	Track hand-hygiene compliance to prevent HAI from unwashed hand
Med Procedures – A la Carte	Free ^{\$}	Apple	-	+	Provider, Patient	Provides step-by-step guidelines for medical procedures
Preventing Infection at Home	Free	Google	3.9 (8)	++++	Provider	Provides toolkit for application of standard infection control precautions for community healthcare staff
Safe Injection Practices	Free	Apple	-		Provider	Monitors, assesses, and catalogs injection practices within a healthcare facility, provides safe injection practice guidelines
Urinary Catheter Care	2.99	Google	4(2)	+	Provider	Provides urinary catheter care guidelines, section on infection prevention
Ventilator Bundle Checklist	Free	Apple	-	+	Provider	Prevention of VAP

^{\$} cost for additional components within free app;

-: Not reported; +: 1-50; ++: 50-500; +++: 500-1000; ++++: 1000-5000 CAUTI = catheter-associated urinary tract infection, CLABSI = central line-associated bloodstream infection, SSI = surgical site infection, VAP = ventilator-associated pneumonia.

Table 2

Examples of Reviewer Comments and Themes

App	Rating (#rating)	# of comments	Sample Reviewer Comments	Themes
AACN Bedside	2.7(16)	8	Free but all the information to use at the bedside is\$.99. Not a lot of money but it is the point of the matter	Cost
			Lot of spelling mistakes	Content
Bugs and Drugs	4.9(7)	2	The app is great. It just keeps crashing and requires re-install every few days	Usability
Guideline Central	4(206)	17	Really no need to purchase anything extra. Thousands of guidelines in summary form make this a great app for students. Good for a quick refresher.	Content
			Outdated and crashes	Usability
			Major improvements, but for a price New app update: it removed everything we previously had access to for free.	Cost, Content
Infection Control Pocketbook	4.5(9)	3	This is a very practical App for doctors, nurses, and anyone else working in healthcare. A must have.	Content
iScrublite	3.5	3	Love it SO MUCH we now need an updated version!	Content
			I am trying to move my infection prevention department towards using technology to help us do our job better. I think this app will be a step in the right direction. This is a perfect example of using technology to save lives! This app is easily customizable to the demographics of your hospital!!	Usability
Urinary Catheter Care	4(2)	2	Great help This app is great. With me not dealing with this every day it has become my best resource. Thank you	Content

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