

# The availability, functionality, and quality of mobile applications supporting medication self-management

Stacy Cooper Bailey,<sup>1</sup> Lisa T Belter,<sup>2</sup> Anjali U Pandit,<sup>2</sup> Delesha M Carpenter,<sup>1</sup> Eamon Carlos,<sup>2</sup> Michael S Wolf<sup>2</sup>

<sup>1</sup>Division of Pharmaceutical Outcomes and Policy, UNC Eshelman School of Pharmacy, Chapel Hill, North Carolina, USA

<sup>2</sup>Health Literacy and Learning Program, Division of General Internal Medicine, Feinberg School of Medicine at Northwestern University, Chicago, Illinois, USA

## Correspondence to

Dr Stacy Cooper Bailey, Division of Pharmaceutical Outcomes and Policy, UNC Eshelman School of Pharmacy, 2204 Kerr Hall, Campus Box 7573, Chapel Hill, NC 27599-7573, USA; [scbailey@unc.edu](mailto:scbailey@unc.edu)

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## ABSTRACT

**Objective** To systematically review mobile applications currently available to patients to support outpatient medication self-management.

**Methods** Three online stores were searched in March 2013 using nine distinct search terms. Applications were selected if they supported general outpatient medication self-management for adults; they were excluded if they focused on only one medication or condition, provided only a medication list or reference, only ordered refills, were written in a non-English language, or were for local pharmacy/hospital patients only. A multi-step review process was utilized by two independent reviewers to identify eligible applications. A standardized form was used to abstract data. User reviews were compiled from a subsample of applications and qualitatively coded to identify common criticisms.

**Results** 14 893 applications were initially identified. After the multi-step review process, 424 applications were deemed eligible for inclusion by reviewers ( $\kappa=0.85$ ). On average, applications were rated 2.8 stars (out of 5) from 107 reviews. Almost all provided medication reminders (91.0%), half enabled patients to create a medication history or log (51.5%), and 22% could email the log to a third party. Few helped patients organize their regimen (6.2%), check for drug interactions (2.8%), or identify pills (4.0%). User reviews (N=1091) from the subsample of 26 applications revealed common criticisms, including technical malfunctions, poor compatibility with certain medications, and absence of desired features.

**Conclusions** Hundreds of applications exist in the marketplace to support medication self-management. However, their quality, content, and functionality are highly variable. Research is needed to determine optimal capabilities, evaluate utility, and determine clinical benefit.

## INTRODUCTION

More than 90% of US adults own a cell phone and the majority of these adults (56%) report using a smartphone.<sup>1</sup> The rise and widespread adoption of this technology has created new avenues for communicating and searching for health information, delivering health messages and providing much needed support for health behaviors.<sup>2</sup> As a result, more than half of smartphone owners (52%) report using their mobile phones to search for medical information and nearly one in five smartphone users report downloading a mobile application to help manage their health.<sup>3</sup>

While mobile technology has been utilized to promote a number of health behaviors, from improving prenatal care to mental health, researchers have long recognized its unique potential to support patients' medication self-management.<sup>4-6</sup> Medication use is one of the most common health behaviors that patients perform on a daily basis to manage their health, yet it is often one of the most difficult, as it places demands on patients' memory, and organization and planning skills.<sup>7</sup> Mobile applications can help patients remember when and how much medication to take, and can also prompt patients to refill a prescription and help them recognize their pills to promote safe use.

Numerous research studies have been conducted to evaluate the effectiveness of using mobile technology to support medication self-management.<sup>8-10</sup> However, these studies often involve developing and evaluating one specific mobile-based intervention among patients within a research setting.<sup>10-12</sup> Less is known about the wide array of mobile applications that are publically available to patients to support everyday medication use. As nearly 10% of US adults have downloaded a mobile application to promote their health, it is essential to have a greater understanding of the availability, functionality, and quality of these applications.<sup>3</sup> Our study therefore sought to systematically identify, review, and characterize the features of currently available mobile applications to support outpatient medication self-management for adult patients.

## METHODS

### Search strategy

Three popular online mobile application stores (Google Play, iTunes, and Blackberry World) were searched in March 2013 using the following terms: *medication, prescription, drug, medicine, Rx, pharmacy, pill, dose, and medication management*. Search terms were purposively broad to capture a wide range of applications. Each term was searched separately in each store and a list of search results was compiled.

### Selection criteria

Applications were deemed eligible for inclusion if they supported general outpatient medication self-management for adult patients. Applications were excluded if they: (1) were not designed specifically for medication use (ie, general calendars or alarms), (2) focused exclusively on one medication (ie, oral contraceptives) or one medical condition (ie, asthma, diabetes), (3) provided only a method of

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listing medications prescribed without any further support, (4) were designed solely for ordering medication refills, (5) provided only medication reference materials (ie, guides or indexes), or (6) were written in a non-English language. Local hospital and pharmacy-based applications were excluded as their use is generally restricted to a limited number of patients and customers in their immediate geographic area. Mobile applications for the three largest chain pharmacies (Walgreens, CVS, Rite Aid) and pharmacy benefit management organizations (ie, Express Scripts) were included as these are utilized by a broader audience.

### Selection methodology

To select appropriate mobile applications, two study team members (SCB, LTB) first performed a title review of the search results and excluded applications that clearly did not meet eligibility criteria. This included games, music, and applications that were irrelevant to the review (eg, Dose of Humor, Equine Drugs). This review was conducted independently; only those applications that were deemed ineligible by both team members were excluded from further review. Next, two study authors (SCB, LTB) independently reviewed the full descriptions of each of the remaining applications; any applications that either did not fulfill selection criteria or did not provide enough information to determine eligibility were excluded. A  $\kappa$  score was calculated to determine agreement between reviewers; discrepancies were reviewed by a third study author (AUP) and majority rule used to determine subsequent inclusion. This resulted in a final list of eligible applications for data abstraction and analysis. Figure 1 provides an overview of the application selection process and provides the number of mobile applications remaining after each stage of review.

### Data extraction and analysis

A standardized form was utilized by three study authors (LTB, SCB, AUP) to abstract information from each eligible application in a consistent manner. The form included questions concerning: platform (Android, iOS, Blackberry), number of installs,

star ratings, cost, most recent update, and application features and capabilities. Data was imported into STATA V.12; descriptive statistics were calculated for each variable.

### Subset analysis

To gain a deeper understanding of application quality and functionality, user reviews were examined for a subset of mobile applications. To select the subset, eligible iPhone and Android applications that appeared within the top 10 results from the search strategy described above were identified. The assumption made was that patients would be more likely to download and use these applications than others that appeared later in the search results or were only available on less commonly utilized platforms or devices. User reviews for these applications were sorted by 'most helpful' and the top 75 consumer reviews per application were entered into an Excel spreadsheet. Two study authors (SCB, DMC) examined these reviews and coded user criticisms based on a list of pre-identified themes.

### RESULTS

A total of 14 893 applications were returned from the initial search of the three online stores (n=4500 from Google Play, n=1354 from BlackBerry World, and n=9039 from iTunes). This included duplicates of applications that were available in multiple platforms (ie, on both Android and iOS) as well as applications that appeared multiple times as results from different search terms. While Google Play reported retrieving more than 1000 results for each search term, a maximum of 500 results were displayed by the search engine. Only these 500 records were therefore reviewed by the study authors.

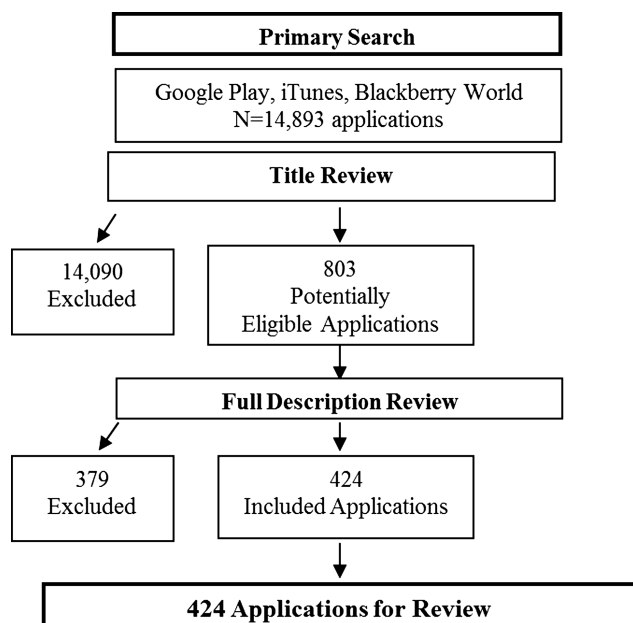
After removing duplicates and performing the title review, a total of 803 potentially eligible applications remained. After the full description review, 406 applications were identified as eligible by both reviewers, 323 were considered ineligible by both reviewers, and 74 applications received discordant ratings ( $\kappa$  score of 0.85). After the third author review, 18 of the 74 applications were deemed eligible for inclusion, for a total of 424 applications.

### Application characteristics

Of the 424 applications included in this review, 35.9% (152) were from Google Play, 59.7% (253) were from iTunes, and 4.5% (19) were from Blackberry World. A total of 45 applications were available in both a free and paid version and 59 applications were available on more than one platform or device (ie, Android and iOS, or iPhone and iPad), leaving a total of 308 unique applications. As applications often perform differently depending on platform or device, all applications were included in subsequent analyses.

Of the 260 applications with customer ratings, the average rating was 3.5 stars; 8.1% of rated applications had fewer than two stars and 41.2% had four or more stars. The mean number of reviews for rated applications was 1615 (range 1–21 665). More than half (57.8%) of applications were free to download. Of the 175 applications that were not free, the average cost was \$2.91 (range \$0.99–99.99). Only Google Play provided information on the number of installations per application; approximately one-fifth (19.7%) of Android applications had been downloaded fewer than 100 times and 17.1% had been downloaded on more than 10 000 occasions.

In terms of features, almost all applications provided a medication reminder or alert (91.0%) and half (51.5%) enabled users to create a medication history, list, or log. Almost a quarter of applications (22.0%) were capable of exporting and/



**Figure 1** Mobile application search and review process.

or emailing patients' medication information to a third party, such as a healthcare provider. One in five applications (21.8%) was designed to manage medications for multiple users, such as family members. Some applications provided refill assistance to patients; 15.1% had pharmacy refill reminders, 8.3% were able to order refills, and 5.7% included a pharmacy locator. Some applications provided visual aids, such as photos of pills, to support medication use (17.7%), fewer helped patients organize medication regimens (6.2%), identify pills in their regimen (4.0%), or check for drug interactions (2.8%). Table 1 provides an overview of the characteristics of the 424 eligible applications.

### Subset analysis

A total of 26 applications were identified for the subset analysis. Four applications included in the subsample were available in both platforms, leaving 22 unique applications. As applications often perform differently depending on platform, user reviews from both versions were included in the review. On average, subset applications were favorably reviewed, receiving a rating of 3.9 stars (range 1–5). The mean number of reviews for rated applications was 381 (range 9–5132); 18 of the applications had fewer than 75 written user reviews. Nearly three-quarters (73.1%) of applications were free to download; those that were not had an average cost of \$2.13 (range \$.99–\$3.99).

Compiling the top 75 most helpful user reviews from these applications resulted in a total of 1091 user reviews. Given the popularity of the applications, approximately half of the reviews (56.3%) were positive or general comments (eg, 'Great app').

The remaining comments revealed common challenges with available medication management applications. Of the 476 reviews providing negative or constructive criticisms, the most common complaint (N=195 reviews) was related to technical difficulties, as applications frequently 'crash', 'freeze', malfunction after an operating system upgrade, or otherwise fail to perform as designed. Another common theme in user reviews was the absence of desired features (N=164). While consumers varied in which capabilities were lacking, some of the features requested included: additional notification/sound features for alarms, improved/expanded visual images of medications, ability to create a historical log of medication taken, ability to export/print/email the log for providers and family, improved screen colors/greater color contrast, ability to note expiration dates and future refills, area to add notes to describe symptoms or irregularities, place to document laboratory results, and ability to add other user profiles for family members.

Beyond these concerns, users also noted that applications often failed to work for all the medications in their regimens (N=53). For example, many applications were not designed to work with oral contraceptives, drugs taken 'as needed' (also known as PRNs), over the counter medicines, or tapered doses, which may require varying doses and/or dosing frequencies. Other users criticized application alarms and notifications (N=78), suggesting they were either too loud or not loud enough, did not provide snooze options, or failed to work when phone screens were off. Other less common concerns included: difficulty entering medications into the application or finding a medication in the application database (N=34), a poor user interface and design (N=34), difficulty syncing between devices (N=16), problems related to registration and login (N=61), and data safety and security concerns (N=9).

**Table 1** Key characteristics of eligible mobile applications (N=424)

Characteristic	
Platform, % (n)	
Android	35.9 (152)
iOS	59.7 (253)
Blackberry	4.5 (19)
Number of downloads, % (n)	
1–100	19.7 (30)
100–1000	32.2 (49)
1000–10 000	30.9 (47)
10 000–100 000	13.8 (21)
100 000–10 000 000	3.3 (5)
Rating, mean (SD)	2.8 (1.7)
Number of reviews, mean (SD)	107.4 (1118.2)
Cost of app, mean (SD)	\$1.20 (\$5.20)
Number of free apps, mean (SD)	58.0 (242)
Application features, % (n)	
Medication alert/reminder	91.0 (386)
Medication history, list or log	51.5 (218)
Exports medication history	22.0 (93)
Manages profiles for multiple users	21.8 (92)
Uses visual aids	17.7 (75)
Pharmacy refill reminder	15.1 (64)
Drug reference or education	10.9 (46)
Orders refills	8.3 (35)
Organizes drug regimen	6.2 (26)
Pharmacy locator	5.7 (24)
Provides drug cost and savings information	5.2 (22)
Identifies pills	4.0 (17)
Checks for drug interactions	2.8 (12)

### DISCUSSION

Hundreds of mobile applications are available to consumers to help manage outpatient medication use, and this landscape is rapidly changing on a daily basis. Our results indicate, however, that the quality and content of these applications varies greatly. The average star rating for applications that received a rating was 3.5, with 107 out of the 424 applications scoring four or more stars. This suggests that while consumers consider certain applications to be of high quality, many others are suboptimal and in need of improvement. Technical malfunctions may be one of the primary reasons for negative reviews, as consumers reported that many applications are prone to crash, freeze, or perform inconsistently. This can be particularly problematic if medication reminders are erratic or incorrect; patient reliance on such reminders could lead to non-adherence or unsafe medication use. Addressing these concerns is essential if mobile applications are to become widely used, constructive tools for supporting patient medication self-management.

In terms of content, almost all applications in this review included medication alerts or reminders. Yet other features, such as the ability to document medication use and to share medication history with others, were less universally available. This is unfortunate, as user reviews indicate that such features are desired by patients and could not only improve their medication use, but also their communication with providers and family members involved in their care. Our review also indicates that many applications are unable to support complex or varying regimens. As patients are increasingly being prescribed a greater number of medications, ensuring that mobile applications are able to provide assistance with drugs that have varying doses or frequencies is essential.<sup>13</sup> Along the same lines, helping patients

organize a complex regimen and check for drug interactions may become increasingly important as multiple medication are prescribed; these capabilities are rarely available in applications in the marketplace today.<sup>7, 14</sup>

Despite these limitations, anecdotal evidence from this review suggests that many consumers find medication management applications to be tremendously beneficial. Of the 1091 reviews analyzed in our subsample, many were positive, with some users reporting that applications were ‘lifesaving’. While research studies to rigorously evaluate the effects of mobile technology on health outcomes are ongoing, such user reviews highlight the promise of mobile technology as a means of promoting positive health behaviors and improving health. Additional research is needed to determine the optimal content and features of applications to support medication self-management.

While the focus of our review was on publically available, mobile applications designed to support medication use, we should note that many novel devices have recently emerged that utilize mobile and innovative technologies to improve consumers’ medication self-management. Technologically-enhanced medication caps, organizers, and delivery systems are currently available to notify patients of when medications should be taken by providing visual cues (ie, a glowing cap or digital display) or by calling or texting a patient, their family, or their provider when a medication has not been taken as directed.<sup>15–17</sup> These devices may be able to provide enhanced support to patients through tangible as well as phone-based reminders and address some of the criticisms expressed in user reviews. Additionally, since the time of our review, new mobile applications have emerged that incorporate novel strategies, such as gaming techniques or rewards systems, for promoting and incentivizing medication self-management.<sup>18</sup> These innovative approaches and devices deserve further investigation.

There are limitations to this review that should be noted. First, applications are created, updated, and/or discontinued on a daily basis; the dynamic nature of mobile application development means applications included in this review may no longer be available, new applications have likely been added to stores, and new features and upgrades to existing applications have likely occurred since this review was conducted. Second, authors relied on information presented in the full descriptions of each application to determine application functions and capabilities. It is possible that applications had features that were not listed in the full description or, conversely, that advertised features were not present or functional in the actual product. We also used customer reviews and star ratings as quality indicators. Consumers who provide reviews may differ systematically from users who do not; it is therefore possible that these findings are not representative of the opinions of all consumers. Only a subsample of applications and their user reviews were able to be evaluated in greater depth, further limiting our generalizability. While utilizing information presented in the full descriptions and consumer reviews is suboptimal, it is likely to mirror the process patients would engage in when determining which application to download or purchase. Finally, we have limited background knowledge with which to understand the applications in this review. It is unclear how many of these applications were developed, how developers approached a patient’s perspective to medication management, and what the original intent was in the design process. This information might have helped to explain some application problems and constraints.

Despite these limitations, our review is, to our knowledge, the first comprehensive review of currently available mobile

applications supporting general outpatient medication use. We used rigorous scientific methods to systematically identify and characterize available applications. Our results can directly inform the future development and testing of mobile applications by providing information on currently available—and desired—features of mobile applications. Similarly, findings can provide valuable guidance to clinicians and patients considering the use of mobile applications. Given the variability in application content and quality, it is essential to ensure that patients are using well functioning applications that fulfill their unique needs for medication support.

## CONCLUSIONS

Mobile applications may help facilitate safe and appropriate medication use by providing reminders for when medications should be taken, notifying patients when refills are necessary, and assisting in the creation of medication histories. This review provided a comprehensive overview of the functionality and quality of currently available mobile applications to support outpatient medication use. Additional research is needed to determine the utility of these applications and to improve the design, content, and features from a patient perspective.

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