

Smartphone Applications in Dentistry: A Database and Characterization of Apps

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Abstract

Background: Smartphone applications (apps) in oral healthcare have become very common but little is known. The purpose of this study was to characterize the features of oral healthcare related smartphone apps.

Methods: The term “dental” was searched in the Apple App Store and Android Google Play Store between March 1 and May 1, 2018. Data elements such as the app’s name, developer, cost, year released, app store category, target user, and purpose were recorded to an Excel database. Statistical analysis was carried out with descriptive statistics and linear regression.

Results: A total of 250 apps met inclusion criteria with significantly more Apple apps (n = 159, 64%) than Android apps (n = 91, 36%). More Android apps (40%) were for doctors’ clinical use than Apple apps (17%). More Apple apps (28%) were for the general public than Android apps (19%). A significant upward linear trend was found between launch year and the number of new apps.

Conclusion: Apps for the general public provide oral health information about common conditions and procedures and supplement direct dental care. Apps for clinicians provide clinical and management tools such as chairside clinical information, scientific references, office management, communication with patients and communication with other dentists.

Practical Implication: Dentists need to understand smartphone apps potentially influence our patients, the general public, and dentists. It is imperative that they provide a leadership role in standardizing the apps, validating contents, and ensuring safe use.

Keywords: App; Application; Smartphone; Mobile App; Dental Apps; Phone Apps

Introduction

In 2019, more than 265.9 million U.S. people were estimated to use a smartphone (a mobile phone with dedicated operating system (OS) and more advanced computing capabilities) at 81% of cell phone market penetration [1,2]. Among U.S. smartphone users in 2019, 51.1% used an Android OS device, a market leader [3]. Globally, Android is also the most popular operating system of smartphones at the market share of 84.2% in 2018 [4]. The number of apps in each app store (a marketplace open to all smartphone users and software developers) is consistent with the market share of their respective systems, with the Android Google Play Store being the largest store with 2.47 million apps in the first quarter of 2019 [5]. Apple’s App Store is the second-largest app store with 1.8 million apps.

Literature in medicine addressed smartphone apps that are intended to benefit patients, the general public, and healthcare professionals. Some studied smartphone apps' effectiveness related to smoking cessation, pain management, melanoma detection and traumatic injury [6-9]. Others evaluated apps' contents across platforms. In 2011, Chomutare., *et al.* compared apps that are intended to manage diabetes across four online app stores: App Store (iPhone), Google Play (Android), App World (BlackBerry) and Ovi (Nokia/Symbian) and found that the contents provided in the apps may not be fully consistent with evidence-based clinical guidelines. They also found that personalized education is an underrepresented feature in diabetes smartphone apps [10]. In 2013, Bender., *et al.* performed a search of the keyword "cancer" across the same four smart phone platforms: iPhone, Android, Blackberry, and Nokia, and conducted a systematic review of literature from MEDLINE, Embase® and the Cochrane Library [11]. The authors found that there are hundreds of cancer-focused apps promoting behavior change, monitoring symptoms, and providing interventions but there was a lack of evidence in their utility, effectiveness, and safety.

Likewise, in oral healthcare, there are many potential benefits of using apps. Using smartphone apps may improve the quality of doctor-patient communication, operating efficiency in a dental office, and oral health outcomes. Several studies have investigated the use and effectiveness of particular smartphone apps in a variety of settings, including at-home use, chairside use, and teledentistry. In 2015, Underwood., *et al.* conducted a study on a health app called "Brush DJ" which is to motivate users to improve their oral hygiene routine [12]. Of 189 responses, 88% reported that the app motivated them to brush their teeth longer, and 79% reported that their teeth felt cleaner when using this app. In 2016, Petruzzi., *et al.* studied WhatsApp to share clinical oral medicine information [13]. Clinical images and related questions were submitted through the app by clinicians and patients to be evaluated by oral medicine specialists. A preliminary clinical impression was determined and the patients were later presented for a clinical exam, when a definitive diagnosis was made. It was found that the telemedicine impression agreed with the pathologic assessment for 82% of the cases. Although there are still many limitations in using smartphone apps as a reliable clinical tool, telecommunication technology is taking a step towards improving oral health in the general population and benefit patients from rural or poorly served areas.

However, little is known about a comprehensive outlook of smartphone apps in oral healthcare.

Purpose of the Study

The purpose of this study was to characterize the market of dental and oral health apps in the United States across the two major platforms: Android Google Play Store and Apple App Store.

Methods

The initial plan included a list of search terms of "dental," "oral," "oral healthcare," and "dentistry." However, one search term "dental" resulted in an extensive and comprehensive list of apps, thus it was determined that the search was limited to "dental." This resulted in more than 400 apps in Apple App Store only. Between March 1 and May 1, 2018, Investigator 1 (CF) searched the Apple App Store on an iPhone 7 and Investigator 2 (ZZ) searched the Android Google Play Store on a Samsung Galaxy Note 4. The two investigators met regularly to calibrate each other. The search was considered "complete" after more than 50 apps in a row were in a language other than English.

Inclusion and exclusion criteria

The selection criteria was to include apps that are related to dentistry or oral healthcare delivery open to clinicians and the public. Exclusion criteria included non-dental related apps, non-educational games just using dental theme, exam preparation apps (dental or non-dental), dental offices' practice apps only for particular private use, and apps in a language other than English.

Creating database

Data elements such as the app’s name, developer, cost, year released, app store category, user group (audience), and app function were entered to an Excel database. Among these elements, app function was determined by the investigators. The data element of geographic location was not included in the database because many apps did not state explicitly the target geographic location nor provided the developer’s address including country. Some apps had a target audience in a country different from the country where it was developed. Information was collected based on the app store description of the applications and its screenshots when provided. Websites of the apps were examined only if the app had unclear store descriptions.

Cleaning up duplicates

For each Apple App Store and Google Play Store lists, duplicates were identified by using the “Duplicate Values” feature in Excel. The spreadsheet was then manually reviewed for duplicates that were missed due to capitalization or spacing discrepancies. These duplicate apps were removed. Some apps looked very similar but they were not considered duplicates unless the name and developer were the same.

Only eleven identical apps were on both Apple and Android platforms and were counted for each platform. The data were manually reviewed to confirm that all apps fulfilled inclusion criteria.

Characterization of apps

Authors re-categorized app user groups based on app store descriptions or by inferring from the developer’s description. This approach was necessary because sometimes store descriptions were not complete and accurate. User groups included clinical (dentists, hygienists, students) and laypersons (patients, the public). The apps were categorized into the following by app function and users: (1) Doctor only (clinical), (2) Doctor only (management), (3) Doctor-Doctor both, (4) Doctor-Patient both, (5) Patient only, and (6) General Public (Table 1).

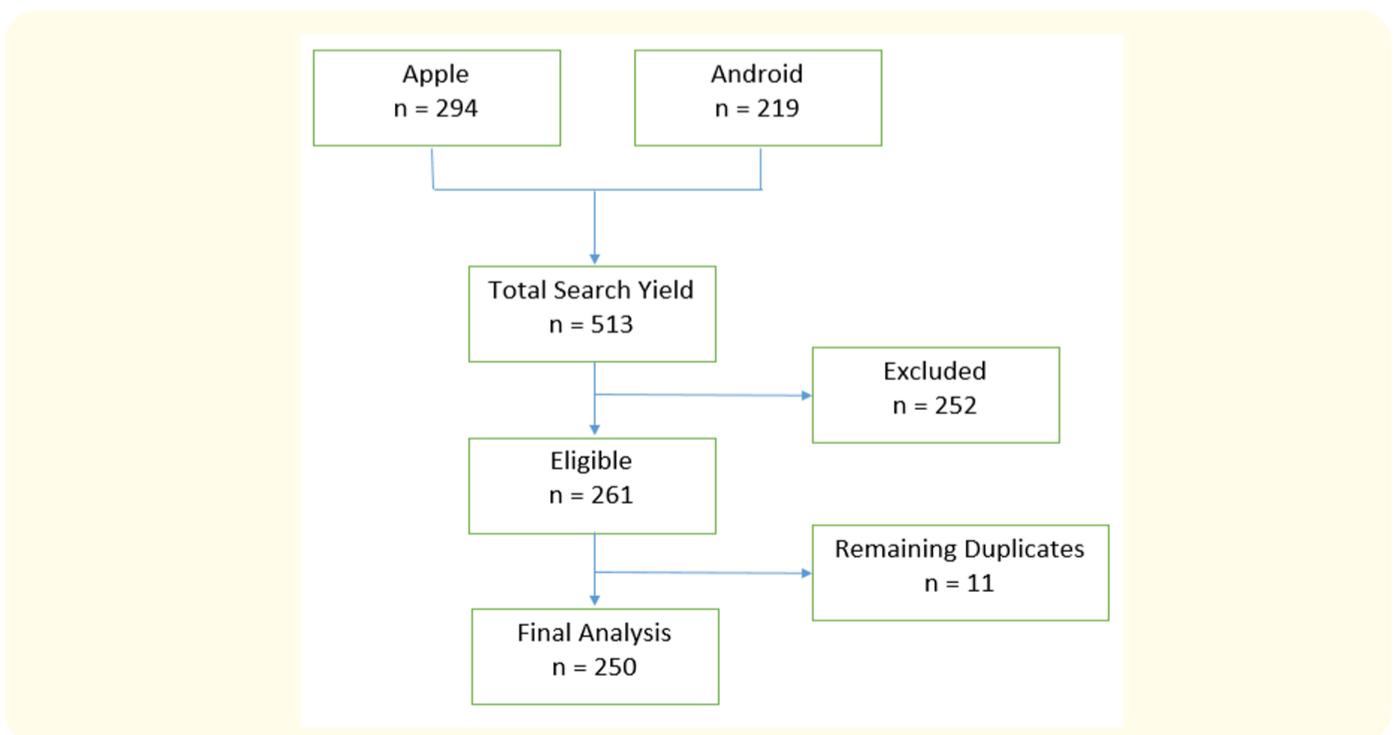
Authors determined apps to be interactive when “two-way” flow of information happens while using the app: receiving customized information, communicating between app users. Authors determined apps not to be interactive when only “one-way” flow of information happens. Categories such as business, education, health and fitness, and medical were based on what is indexed in the app stores.

Statistical methods

Smartphone application characteristics were summarized using descriptive statistics. A linear regression was used to determine the growth in the number of smartphone apps by year. Comparisons were made between different features of applications (platform, app functions, cost, categories, user groups etc.) using Chi-squared tests or Fisher’s Exact tests where appropriate. A significance level of 0.05 was used. All analyses were performed in SAS EG v.6.1/SAS 9.4 (SAS Institute, Cary, NC).

Results

A total of 250 smartphone applications were included in the analysis (Figure 1). Of these, 159 for Apple platforms and 91 for Android, indicating significantly more Apple apps than Android apps (64% vs. 36%, p-value < 0.0001).



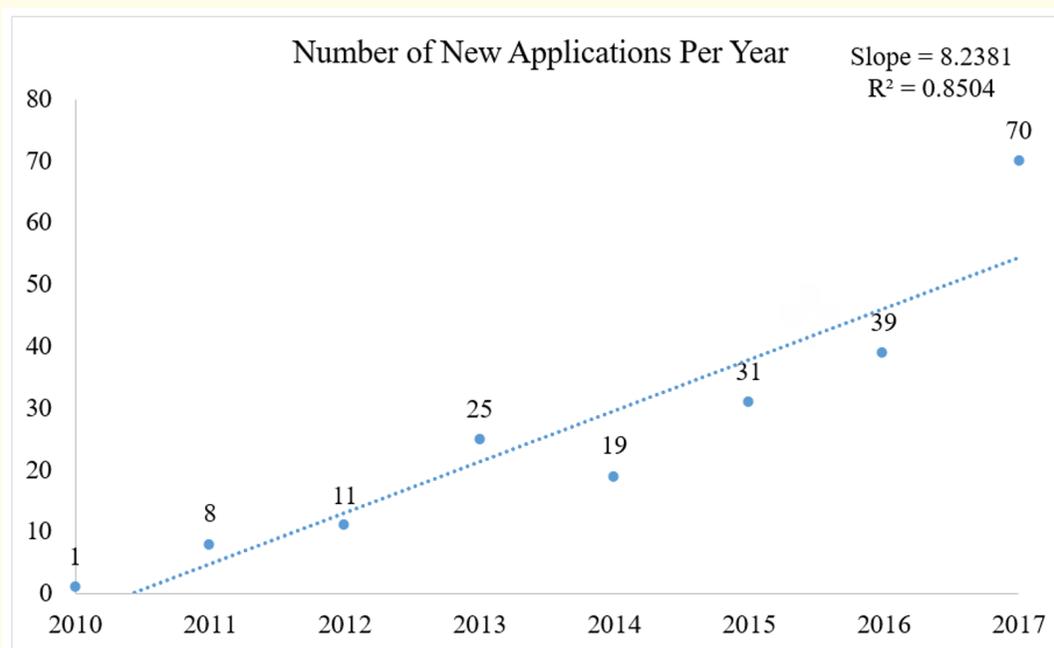
The distribution of app function and platform is described in table 1. The overall distribution was significantly different when comparing Apple apps and Android apps (p-value = 0.0035). For example, apps for doctor only for clinical purposes were more likely from Android platform than Apple (40% vs. 17%). Apps for the general public were more likely from Apple platform than Android (28% vs. 19%).

	App Function	Android	Apple	Total
Doctor Only (Clinical)	These apps provide clinical information for dental procedures, medical reference, chairside tools, etc.	35 (40%)	27 (17%)	62 (25%)
Doctor Only (Management)	These apps provide practice management information	15 (17%)	32 (20%)	47 (19%)
Doctor-Doctor Both	These apps allow exchange of information or interaction between two or more clinicians, i.e. forums, Dental town, dental conference tools.	5 (6%)	16 (10%)	21 (9%)
Doctor-Patient Both	These apps allow two way exchange of information or interaction between the clinician and the patient, i.e. virtual consultation, video chat with dentist, chairside patient education tools.	10 (11%)	16 (10%)	26 (11%)
Patient Only	These apps provide information for a particular group of patients	6 (7%)	22 (14%)	28 (11%)
General Public	These apps provide information to the general public without an association with a dental office	17 (19%)	45 (28%)	62 (25%)

Table 1: Distribution of app function and platform.

A majority of the apps were targeted towards either dentists (n = 109) or the general public (n = 62) (a combined total of n = 171, 69%). For apps targeting dentists, they were further categorized as either clinical or management. Many of these Doctor only (Clinical) apps provide chairside on-demand references regarding medications and dosages, head and neck and dental anatomy, oral pathology, dental terminology, dental instruments, dental materials, anesthetics, suture techniques, cavity preparation, and esthetic shade matching etc. Doctor only (Management) apps provide features such as managing daily schedules, appointments, photo uploading, and communication with dental labs. Doctor-Patient Both apps provide venues for interaction between the dentist and the patient. Some of these apps allow the patient to contact the dentist directly through the app and receive feedback, while others store the patient’s information for both the dentist and the patient to have access later. For example, Dental Monitoring® (Dental Monitoring, Paris, France) allows a dentist to use the phone camera to take photos of the patient’s teeth, and the pictures are stored in the app. Both the dentist and the patient have full access to the photos through the app. The dentist can then use these photos to analyze, take measurements, or make calculations then communicate back to the patient. The categories of Patient Only and General Public differ in a way that Patient Only apps require a user to have an association with either dental office or insurance. General Public apps provide general information about dentistry, dental procedures, oral hygiene instructions and tools (such as brushing timer), and educational games usually in layman’s terms.

Launch date was available for 225 of the 250 applications and ranged from 2010 to 2018. A linear regression was used to determine if the number of new applications was increasing by year between 2010 and 2017. There was a significant linear trend between launch year and the number of new applications (p-value = 0.0011), with an estimated additional 8.24 applications per year (95% CI: 4.79 - 11.69, Figure 2) compared to previous year.



Smartphone apps' characteristics were summarized by platform (Table 2). The app costs (free or not free) were not significantly different between Android and Apple apps (p-value = 0.1258). For both Android and Apple apps, a vast majority of apps (82% Android, 89% Apple apps) were available free. Each app store determines the application category as Business, Education, Health and Fitness, Medical, or Others (Entertainment, Games, etc.). There was a significant association between platform and application category (p-value = 0.0032). Specifically, Educational apps were more likely to be found on Android (24% vs. 9%) while Health and Fitness applications were more likely on Apple (22% vs. 10%). Apple app store has more Medical apps.

	Android	Apple	Total	P-value
Cost				0.1258
Free	75 (82%)	142 (89%)	217 (87%)	
Not Free	16 (18%)	17 (11%)	33 (13%)	
Category in the App Store				0.0032
Business	8 (9%)	11 (7%)	19 (7%)	
Education	22 (24%)	14 (9%)	36 (14%)	
Health & Fitness	9 (10%)	35 (22%)	44 (18%)	
Medical	33 (36%)	71 (45%)	104 (42%)	
Other	19 (21%)	28 (18%)	47 (19%)	

Table 2: Summary of smartphone app characteristics by platform.

The majority of applications were free (87%) while others ranged in price from \$0.99-\$399.99, with a median cost of \$9.99. Cost was significantly associated with application category (p-value = 0.0036). Medical applications had highest chance of cost (22%) followed by Education and Others (11% for each). Applications geared towards clinical audience were also more likely to have a fee than those for laypersons (18% vs. 6%, p-value = 0.0074) (Table 3).

	Free	Not Free	P-value
Category in the App Store			0.0036
Business	19 (100%)	0 (0%)	
Education	32 (89%)	4 (11%)	
Health and Fitness	43 (98%)	1 (2%)	
Medical	81 (78%)	23 (22%)	
Other	42 (89%)	5 (11%)	
User Groups			0.0074
Clinical (Dentists, Hygienists, Students)	113 (82%)	25 (18%)	
Layperson (Patients, General Public)	101 (94%)	7 (6%)	

Table 3: Summary of smartphone app costs by category and user groups.

Discussion

There is an overwhelming number and large variety of smartphone applications that resulted from a search of the term, “dental”. This indicates huge demands on mobile resources and the active presence of oral healthcare and dentistry in the smartphone app market. Apple apps are still dominating in numbers compared to Android apps. Apple as a first and strong player in smartphone market and app

store in the U.S. likely led to this distribution. Our study found that apps with Android platform were more prevalent among dental clinicians while apps Apple platform were for general public. This is not consistent with Seabrook, *et al.*'s study which found Apple was more prevalent among physicians in 2012 [14]. Rapidly increasing Android users and available apps might have contributed to this inconsistency.

Potential benefits of using smartphone apps in dentistry

Smartphone apps can provide many benefits to clinicians as well as patients. For clinicians, the smartphone apps can stimulate evidence-based practice at the point of care. For example, disease diagnosis applications help clinicians to access references for differential diagnoses and treatment options at their fingertips within a few clicks. Interactive mobile apps allow two way communications with patients to help personalized patient education and monitoring home care. For the general public and patients, these smartphone apps likely create more access to oral healthcare information: general and personalized, highlight the importance of seeing a dentist for routine care, and empower them to maintain good home care such as proper oral hygiene techniques. The apps for doctor-patient communication suggests the potential use for tele-dentistry by allowing mobile consultation for people with limited access to care in a geographically isolated areas.

Potential risks of using smartphone apps in dentistry

For many apps, there seems to be a lack of verified guidelines or evidence-based references. Because the author(s) and their references are not always provided, we were unable to evaluate the validity of clinical information. This could mislead the general public and patients: a major concern. Many patients cannot distinguish factual, evidence-based information from inaccurate or unsupported evidence, and may self-diagnose. Similarly, dentists may use invalidated procedure information in a clinical setting. It is important for patients to continue going to a dental office in person for evaluation by a dentist. It is also essential for the clinician to practice based on evidence and learn new procedures through credible continuing education courses and peer-reviewed literature. Another concern is protection of privacy and health information. This study found that many apps promise to offer convenience access to private information for clinicians and patients without securing privacy protection and being regulated. It can easily result in breaching protected information and losing public trust.

Limitations of the Study

One of the main difficulties of a systematic review of smartphone app store results was that search results would vary with each new search. Presumably it is due to new apps available on daily basis but it is unclear what logics are used for app stores to display apps. Thus, as results were entered manually, there could have been a few apps that were inadvertently left out due to differences what order app show up in the search results. The purpose of each app was judged based on the written description, screenshots, and title, but apps were not downloaded by investigators. As apps were not judged based on number of current users or number of downloads, this study does not include an evaluation of the actual usage of each app.

There are dental and oral healthcare related social media available for smartphone users that may not have been included in this study if they are not results of a search of the term "dental" in the app stores. Smartphone users receive an enormous amount of information on social media sites such as Facebook, Instagram, Snapchat, and YouTube. Dental-themed Instagram accounts are largely popular with over 100,000+ followers. Future studies can examine these social media sites and oral healthcare.

Dentists' role

In order to continue to ensure optimal oral healthcare in the communities, dentists need to understand what may influence our patients and other clinicians in mobile world. Then dentists can take action on ensuring the apps' content is up to date and consistent with

evidence based dentistry and expert advice. At this time, no regulations exist regarding what information can be included in apps and its safety. Dentists can develop standards and guidelines for smart phone app contents and similar to ADA Seal of Acceptance products. Dentists can also work with technology companies such as Apple and Google to streamline app search so the public can easily access apps with useful information from credible sources.

Conclusion

There are increasing number of smartphone apps related to dentistry that allows faster and user-friendly information access. Apps for the general public provide oral health information such as common conditions and procedures and supplement direct dental care. Apps for the clinicians provide clinical and management tools such as chairside clinical information, scientific references, office management, communication with patients, and communication with other dentists. Dentists need to understand these mobile apps potentially influence our patients, general public, and dentists as well as dentist-patient interaction. It is imperative that they provide a leadership role in standardizing the apps, validating contents, and ensuring safe use.

Supplemental Data

The data used to support this study's findings are available upon request from the corresponding author.

Disclosure

None of the authors reported any disclosures.

Conflicts of Interest

Authors have to no conflicts of interest.

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