

Smartphone apps: A state-of-the-art approach for oral health education.

Aplicaciones para celulares: un enfoque de vanguardia para la educación en salud bucal.

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Abstract: While there is an ever increasing use of smartphones in recent times, cellular phone based mobile applications (apps) are hardly used by the public to improve oral health. Hence, this cross-sectional study was conducted to evaluate the features of the current oral health education smart phone apps pertaining to dental patients. **Materials and Methods:** Oral health terms were queried in the online app stores. Among the apps found, all patient-related apps were listed and categorized. The apps were assessed for type, cost, rating, average number of downloads, involvement of dental professional in their development, target group, local or global applicability, the benefits and drawbacks of the apps and user reviews. **Results:** A total of 146 oral health apps for patient use were found, with the most common being about techniques for oral hygiene (33.5%) and tooth brushing timers (25.3%). The majority of apps (69.2%) were available for downloading for no cost. 'Happy teeth, healthy kids app', 'Disney Magic timer' and 'Happy Kids timer' were the most downloaded apps. **Conclusion:** A considerable number of mobile apps are currently available for patients to help them in maintaining oral health, though most of them are brushing timers or demonstrate oral hygiene techniques.

Keywords: Medical informatics applications; smartphones; oral health; telemedicine; mobile applications; medical informatics.

Resumen: Objetivos: Si bien existe un uso cada vez mayor de teléfonos celulares inteligentes en los últimos tiempos, el público apenas utiliza las aplicaciones móviles (aplicaciones) para teléfonos celulares para mejorar la salud bucal. Por lo tanto, este estudio transversal se realizó para evaluar las características de las aplicaciones actuales para teléfonos celulares inteligentes de educación sobre salud bucal desarrollada para el uso de pacientes. **Materiales y métodos:** se consultaron los términos de salud oral en las tiendas de aplicaciones en línea. Entre las aplicaciones encontradas, todas las aplicaciones relacionadas con el paciente se enumeraron y categorizaron. Las aplicaciones se evaluaron por tipo, costo, calificación, número promedio de descargas, participación de un profesional dental en su desarrollo, grupo objetivo, aplicabilidad local o global, los beneficios y desventajas de las aplicaciones y las revisiones de los usuarios. **Resultados:** se encontraron un total de 146 aplicaciones de salud bucal para uso de los pacientes, siendo las más comunes sobre técnicas para la higiene bucal (33.5%) y los temporizadores para cepillarse los dientes (25.3%). La mayoría de las aplicaciones (69.2%) estaban disponibles para descargar sin costo. 'Happy teeth, healthy kids app', 'Disney Magic timer' y 'Happy Kids timer' fueron las aplicaciones más descargadas. **Conclusión:** actualmente hay un número considerable de aplicaciones móviles disponibles para ayudar a mantener la salud bucal de los pacientes, aunque la mayoría de ellas son temporizadores de cepillado dental, o demuestran técnicas de higiene bucal.

Palabras Clave: Aplicaciones de la informática médica; teléfono inteligente; salud bucal; telemedicina; aplicaciones móviles; informática médica.

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INTRODUCTION.

In recent times, the amplification of information technology in various fields such as communication, commerce, education among others has made these fields become exposed in entirely new forms. Equally, it is transforming the health care in various spheres ranging from self-diagnosis, to consultations, to enhancing patient self-management and self-reliance. The use of information technology has been stretched in numerous ways like mobile internet devices (MIDs), smartphones and proprietary software applications (apps).

Apps are software applications designed to run on smartphones, tablet computers and other mobile devices. The app stores, which are the native distribution platforms, provide a variety of apps. Some of the most popular operating system-native stores are Apple's App Store, Google Play for Android and Windows Phone Store.

Smartphone apps are particularly useful in dentistry, where, a considerable amount of diagnosis is based on visual examination and there is a substantial scope for the prevention of dental diseases through self-management.¹ There are certain apps for teaching and motivating tooth brushing methods and usage of other aids for oral hygiene in children and adults.

There are apps to be used for references and as dental disease guides for patients. Few apps even guide patients about the dentists available nearby as well as for appointment scheduling, advice on procedures/medications or adverse effects. Then, there are gaming apps for children related to dentistry.²⁻⁴

Though many studies are present on medical apps for patients, studies on dental apps are very meager. Literature search revealed lack of reviews on the categories of oral health educational apps for patients.

Hence, the aim of this study was to evaluate the features of the current oral health educational smartphone apps for patients. The objectives were:

1) to identify oral health related apps from the app stores of two smartphone platforms developed by Apple and Android and

2) to categorize and describe them based on payment option, cost, rating, average number of downloads, involvement of dental professional in their development, local or global applicability, year of launching/updating,

average rating and number of ratings, the benefits and drawbacks of apps and user reviews.

MATERIALS AND METHODS.

This was a cross-sectional study that identified and categorized educational smart phone apps on oral health and was presented following the STROBE guidelines.

A survey of oral health related apps from within the app stores of two smartphone platforms developed by Apple and Android was done between September 1st 2017 and September 10th 2017.

These mobile platforms were chosen on the basis of popularity as evidenced by device sales in 2016.⁵ A Sony Xperia C4 with Android OS (version 5.0 Lollipop) was used to search Google Play (Google Inc., Mountain View, CA, USA). An iPhone 6s (iOS 09) was used to search the itunes store (Apple Inc., Cupertino, CA, USA); the search was performed within the App Store section of the iTunes Store. The search terms used were 'Dental Education', 'Oral health', 'Oral Education', 'Caries', 'Dental Caries', 'Dental Decay', 'Dental Treatment', 'Dental Trauma', 'Periodontitis', 'Oral Cancer', 'Brushing', 'flossing', 'Oral Hygiene', 'Tele-dentistry', 'Orthodontics', 'Gingivitis', 'Oral Mucosal lesions' and 'Prosthetics'.

Apps with both 'lite' and 'full' version were counted as separate apps since accessible information would be different for both versions. Duplicate apps obtained from the keywords search were deleted. Only English language apps were included. Applications which were student and clinician related, for marketing dental practice, tobacco cessation related, general medical and gaming apps were excluded. Only those apps which were targeted towards patient oral health education were included in the present study. The description given by the developer was checked and accordingly, each app was categorized into 12 groups as:

1. General Dental References,
2. Dental Dictionary
3. Dental Anatomy
4. Dental Magazines
5. Prosthodontics
6. Conservative Dentistry and Endodontics
7. Orthodontics
8. Emergency Dental Trauma Management

9. Oral Cancer Education
10. Oral hygiene techniques
11. Tooth Brushing Timers and
12. Miscellaneous.

The applications were assessed for payment option, cost, rating, average number of downloads, involvement of dental professional in their development, local or global applicability, year of launching/updating, average rating and number of ratings, the benefits and drawbacks of apps and user reviews.

Apps were downloaded if description was not clear or not sufficient, or if more details were required to assess the app. When an application was present on both platforms the ratings were summed up as was done in a previous study.⁶ Two independent raters evaluated the applications. The criteria and coding system were discussed and then rating was done separately. When there was a difference in rating for any criteria among them, a third rater's opinion was taken. Inter rater reliability was assessed; the reliability value was 0.82.

RESULTS.

A total of 261 apps were identified, with 125 apps on android store and 136 apps on i-phone stores, using the search terms mentioned above. Among them, 43 were excluded from the android apps and 72 were excluded from iphone apps as they did not fulfill the inclusion criteria. Thus 82 android apps and 64 iphone apps were included in the study. Of these, 19 apps existed on both operating systems.

Table 1 gives the categorization of apps. About one third (33.5%) of the total apps were related to oral hygiene techniques, which included tooth brushing and flossing methods. Two of the tooth brushing apps, 'Oral-B app' and 'Philips Sonicare' are Bluetooth guided tooth brushing apps. These apps, together with the Bluetooth enabled electric toothbrushes help drive oral care compliance.

They help improve oral care routine with real time feedback and brushing guidance, getting alerts when the patient presses too hard, define custom programs and focused care areas to address the specific oral care needs, and track progress over time via the statistics. Another app, 'Brush Up' had the user's face also shown on the

screen so that they can replicate the video as accurately as possible.

This was followed by tooth brushing timer apps (25.3%) specifically for children to guide brushing time and apps on general dental references (21.9%). The latter included apps like 'Dental Desk', 'Anatomy Guide' and 'Dental Explorer' among 31 of them. These apps had platforms for answering the queries pertaining to dental problems and providing temporary relief from various dental problems by using common household techniques. Few apps acknowledged people regarding various alarming dental problems and inform them regarding various treatment modalities.

'Xperts RCT' was one app with an Augmented Reality (AR) approach that provides doctors a tool for patient education on root canal treatment procedures in a unique way. When the camera is focused on a target image, the application recognizes target image and overlays a 3D model of a tooth. 'Dentist - A dental app' is also an app with Virtual Reality (VR) and AR. This VR application includes a fun quiz VR game for naming parts. 'Dental explorer' is a visualization software with self-explanatory didactic videos, 3D-clips, and 3D-images available for explaining treatment alternatives, biological basics or health care information. 'Carriere ortho' has new generation software based on virtual reality in 3D and hence, the movement of teeth at all the stages of treatment, in three planes of space and in real time can be visualized.

'Orasphere', 'Toothflix', 'Dental pain lite', 'American Dental Software-3D Dental patient education', 'Dental Education (Oral - B)' are the apps that can be used by dentists for their patient education.

Emergency Dental Trauma Management apps formed 2.7% of all apps. 'Dental Trauma First Aid' and 'Knocked Out' help parents, teachers and sports coaches to give the best first aid to those suffering from dental trauma.

'Dental Monitoring' is an android app, intended to use under the supervision of a clinician and hence, can be used if access is provided by the clinician. Orthodontic patients need to follow teeth movements with 3D matching technology and requires the use of a cheek retractor. Using these set of pictures, the app allows practitioners to accurately monitor teeth and occlusal movements.

The apps like 'Brace Accelerator' and 'Rubberband

Table 1. Distribution of patient educational apps based on its focus.

Category of app	Android	Apple	Total (%)
General Dental Reference	14	17	31 (21.9%)
Dental Dictionary	01	01	02 (1.3%)
Dental Anatomy	03	01	04 (2.7%)
Dental Magazine	01	00	01 (0.7%)
Prosthodontics	00	01	01 (0.7%)
Conservative Dentistry and Endodontics	01	01	02 (1.3%)
Orthodontics	02	03	05 (3.4%)
Emergency Dental Trauma Management	04	00	04 (2.7%)
Oral Cancer Education	03	00	03 (2%)
Oral hygiene techniques	28	21	49 (33.5%)
Tooth Brushing Timer	19	18	37 (25.3%)
Miscellaneous	06	01	07 (4.8%)
Total	82	64	146

Table 2. Distribution of Patient Educational Apps Pertaining to Various Features

		Android	Apple
Payment	Paid	08	24
	Free	64	37
	Free with in app purchases	12	03
Cost Range	Up to 15 USD	20	26
	15 – 75 USD	0	1
	Above 75 USD	0	0
Downloads	Up to 1000	39	
	1000-5000	08	
	5000 - 10000	10	^
	10000- 50000	12	
	Above 50000	07	
Involvement of Dentist/ Dental team/	Yes	57	19
Organization in development	No	27	45
Applicability of app	Local	06	02
	Global	78	62
Year of launching/updating	2009	00	01
	2010	01	03
	2011	02	06
	2012	03	05
	2013	04	05
	2014	19	09
	2015	34	18
	2016	22	17
Average Rating for the app	Up to 2	03	01
	2 - 4	39	09
	Above 4	34	11
Number of Ratings	Upto 100	57	16
	100 - 500	13	03
	500 - 1000	02	00
	Above 1000	04	02

^: Download range has not been provided for iphone apps.

Table 3. Characteristics of Dental apps with maximum number of ratings and rated above 3.5.

S.N	Name of the App	Platform	Paid/Free	Cost in range	No. of ratings	Rating	Specialty	Year of Launch/Update	Appli-cability	Version	Involvement of Dentist
1	Happy teeth, healthy kids	Both	Free with in-app purchases	56 -282	26205	3.9	Tooth brushing techniques	2015	Global	1.0.3	Involved
2	Disney Magic timer by Oral -B	Both	Free	-----	17968	3.8	Tooth brushing timer	2015	Global	3.7.0	Involved
3	Happy kids timer	Both	Free with in-app purchases	77	2018	4.2	Tooth brushing timer	2015	Global	4.0.3	Involved
4	Toothbrush timer	Apple	Free	-----	979	3.5	Tooth brushing timer	2011	Global	1.2	Involved
5	Brush dj	Both	Free	-----	4	943	Tooth brushing timer	2016	Global	4.0.4	Involved
6	Aqua fresh brush timer	Android	Free	-----	3.6	469	Tooth brushing timer	2015	Global	1	No involved
7	Chomper chums	Android	Free	-----	219	4.1	Tooth brushing techniques	2014	Global	1.2	Involved
8	iBraces help	Apple	Free	-----	214	3.5	Ortho-dontics	2015	Global	1.8	Involved
9	Carriere ortho	Both	Free	-----	182	4.2	Ortho-dontics	2012	Global	1.1.4	Involved
10	Brush up	Both	Paid	62-621	237	3.6	Tooth brushing techniques	2015	Global	1.0.1	Involved

Reminder’ can be considered suitable for patients utilizing alerts for elastic and aligner. Our younger patients have grown up in a digital age and the use of such technology in their orthodontic treatment may help increase motivation and compliance.

‘Toothpic’ is an app, which, using a mix of innovative algorithms for ranking oral cosmetics and social platforms for anonymous feedback, gives users an easy access to maintain their oral health.

Table 2 shows the distribution of patient educational apps pertaining to various features. The majority of apps (69.2%) were available to download for free. Some of them were freely available, but had in-app purchases (10.3%) to allow complete access. Almost all the apps (95.7%) were

costing less than 15 USD. Only 23% of apps had more than 10,000 downloads. More than two thirds of all apps had involvement of Dentist/Dental team/Organization in their development. Nearly 95% of all apps were globally applicable. The rest had local applicability, in that, patients could easily contact the dental office, request an appointment, or request emergency treatment (and include a photo of the problem area if appropriate). Some have information about dentist and dental office (Periodontist app). There has been an increase in the launching of apps in recent years.

Table 3 lists down the iphone and android apps with more than 200 ratings and rated above 3. ‘Happy teeth, healthy kids app’ is an educational app with tooth

brushing timer. It has seven educational and creative activities to encourage children to care for their teeth with animations and sound effects. 'Disney Magic timer' by 'Oral-B toothbrush timer' focuses on motivating the child with a tooth brushing calendar. The child can earn stickers and complete the album with brushing every time. 'Toothbrush timer' allocates stipulated time to each quadrant, so as to cover all areas of the mouth. 'Brush DJ' app and 'Chomper chums app' are mainly timer apps, but also have short animated videos demonstrating basic oral hygiene tasks. 'Chomper chums app' directs the child to switch to each area of the mouth after a specified time.

'Braces help' and 'Carriere ortho' have high-quality patient education tools with interactive 3D appliances.

DISCUSSION.

With increasing growth in technology like never before, the use of mobile apps is likely to play more and more sophisticated roles in dentistry. Khatoun *et al.*,² reported that a large quantity of apps could be used for oral health education for patients.

Hence, the present study evaluates features of the current oral health educational apps designed for patients. In this survey, two smartphone operating systems with the largest market share were searched as they share a major percent of the total market share.⁵

Nearly half of all the apps focused on tooth brushing and oral hygiene maintenance, half of which were only tooth brushing timers. Among 40 apps which focused on tooth brushing techniques, only nine apps demonstrated precise method of brushing.

In the field of prosthetics, a mobile app (Dental Calendar) was tested that allowed patients to take pictures of their own oral cavity parts that require dental treatment allowing the provision of professional advice much more quickly. A study on the usage of this app showed a significant improvement in appointment reminder systems and rearrangement of appointments in case of sudden declining prosthesis.⁷ In another study done by Canbazoglu *et al.*,⁸ a mobile app was developed with an effective user interface design to support the dentist-patient interaction in the consultation of implant dentistry was tested.

Presentation of potential implants and implant supported prosthetic treatments with rich 3D illustrative content

to the patients was feasible with this app. In yet another study, conducted by Bohn *et al.*, four patient educational apps describing fixed partial dentures were presented to participants and opinions about each app's content, images, features and use were collected and tested.⁹ The authors concluded that, participants favored esthetic images of teeth that did not show structural anatomy, such as tooth roots and preferred interactive features. Many orthodontic apps have been tested in the patients for their feasibility and ease of use.¹⁰⁻¹²

A study conducted by Baheti *et al.*,¹⁰ conducted a study on the orthodontic apps available. 'Ibrace help', 'Invisible braces scan' and 'Learn about braces' were some of the apps available, as in our study. There were other orthodontic apps to remind patients to wear and change their elastics like 'Brace accelerator' and 'Rubberband reminder'. Another study was done to test the effectiveness of a messaging app (WeChat) in improving patients' compliance and reducing orthodontic treatment time and found it to be effective.¹¹

Mobile smartphone image resolution has improved considerably now and may no longer pose a limit to its use in teledentistry.¹³ In fact, recent research found that an app that uses doctors to evaluate lesions had more than 98% sensitivity.¹⁴ This technology, both efficient and practical, provides underserved communities with access to the clinical expertise of metropolitan doctors.

Al-Musawi *et al.*,¹⁵ conducted a study to test the knowledge of Emergency Dental Trauma Management from 'Dental Trauma App' as compared to didactic lectures. The authors concluded that 'Dental Trauma App' alone is an effective means of providing accessible knowledge to guide laypeople in managing tooth avulsion, and it can be superior to a lecture-based delivery of information.

Very few apps were developed or endorsed by organizations or universities. 'Toothflix' is a general oral educational app developed by American Dental Association and 'Muskan' was developed by the Indian Dental Association as a part of National Oral Health Program.

The 'Bad Breath Report' is one app that claims that halitosis can be completely eliminated by a secret formula. In its description it mentions how to get rid of the white coating on the tongue without scraping. It also claims to have an "astonishing ancient Indian remedy for bad breath, tooth decay, and gum disease all rolled into one!"

To date, no formal guidelines have been framed for mobile app developers.^{5,16} Few reviews have been published on the quality of medical apps.¹⁷⁻¹⁹ Currently, regulations under the U.S. The Food and Drug Administration (FDA) Safety and Innovation Act are limited to any app that meets the definition of “device” in section 201(h) of the Federal Food, Drug, and Cosmetic Act and is used as an accessory to regulate medical device or transform a mobile platform into a regulated medical device.²⁰

But, these regulations cannot be enforced effectively, as most apps do not constitute a medical device. However, efforts are underway to require companies with apps making medical claims to apply for FDA approval in a manner similar to that used for a medical device. Already, in 2011 the US Federal Trade Commission outlawed a mobile app that touted an unsubstantiated “acne cure.”²¹

Nevertheless, this study has few limitations. Only two smartphone platforms were included, owing to their largest market shares.

In future, apps could be directed towards educating patients on the ill effects of tobacco and development of oral cancer using the latest AR and VR technologies. Apps could also be used to provide information on self-examination for oral cancer and to provide information on the initial management of oral infections. Presently not much of regulations are there on the content of apps. We

anticipate a formal set of regulations to be made to enforce safety, quality, and validity of content within the medical mobile app market.

CONCLUSION.

Most of the apps available focused on brushing techniques and brushing timers. These apps are mainly helpful for teaching children tooth brushing techniques. Mobile apps could act as an effective aid to motivate oral hygiene maintenance.

More apps could be developed to demonstrate dental disease processes and risk factors in simpler terms. This could help patients know the risk factors for dental diseases thus enabling them to know how to work towards prevention.

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