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Oral Health Promotion Apps: an assessment of message and behaviour change potential

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Abstract

Background: Oral health worldwide needs improving: untreated dental caries is the most common health condition affecting people globally. Mobile applications (apps) have potential to provide preventative oral health interventions. This study aimed to investigate the quality of available oral health promotion apps, assessing information provided and the barriers to oral health addressed using psychological frameworks.

Methods: A content assessment of oral health promotion apps targeted at adults in the UK iTunes store was conducted. The quality of 22 apps was assessed against three objective indices derived from the Delivering Better Oral Health toolkit, Theoretical Domains Framework and Behaviour Change Technique Taxonomy. Index scores were calculated and descriptive analyses were completed.

Results: On average, four Delivering Better Oral Health messages, seven Theoretical Domains Framework components and eight Behaviour Change Technique Taxonomy components were addressed per app. The most common components were: 'take at least two minutes to brush' for the Delivering Better Oral Health index, 'goals' and 'intentions' for the Theoretical Domains Framework index and 'goal setting (behaviour)' for the Behaviour Change Technique Taxonomy index.

Conclusion: The quality of information available in oral health apps requires improvement with the majority addressing only a few barriers to oral health. Currently there is no recognised scale for evaluating oral health apps: this study provides a suggested method for future app evaluation. There is opportunity for a new app to be created based on health behaviour change theory which includes all the Delivering Better Oral Health messages.

Keywords: Mobile applications; Dental health; Health education; Oral hygiene; Health care; Goals

Introduction

Oral health worldwide needs improving: the Global Burden of Disease Study 2017 found that untreated dental caries in permanent teeth was the most common health condition affecting people globally [1]. The high caries rate implies difficulty maintaining oral health. Poor oral health is recognised to negatively impact general health and wellbeing [2].

Preventative treatments such as oral hygiene advice are essential to reduce disease [2]. In the United Kingdom, these are usually carried out face-to-face by dental professionals following the evidence-based guidance in the Delivering Better Oral Health (DBOH) toolkit [2]. The toolkit focuses on eight key topics, such as fluoride, toothbrushing and tobacco cessation. It is routinely used amongst dentists nationally and is accepted as the gold standard of oral health promotion information. This ensures consistent messages are given by dental professionals, which increase the chance of an individual given these messages improving their oral health [2]. The DBOH toolkit was chosen as a proxy for information quality as, although clinical guidelines may not be directly translatable to an app, they are developed from the best-available evidence and continuously revised [2].

There is growing interest in the use of mobile applications (apps) to deliver preventative interventions, such as oral hygiene advice [3, 4], with seventy-nine percent of UK adults using a smartphone [5]. Owners generally have constant access to them and users even become emotionally attached [6]. The role of digital technologies in dental care, including use of apps, has been listed in the top ten research priorities by the James Lind Alliance [7]. It would be reasonable to predict

that the importance of patient-led home interventions will increase in the current COVID-19 pandemic with restrictions on the practice of face-to-face dentistry [8]. As apps are easily accessed by the majority, this makes them ideal for delivering oral health interventions in situations where face-to-face appointments are limited. Consequently, it is imperative that the content and effectiveness of currently available apps is assessed.

There is limited research into the content of oral health apps, meaning there is little evidence base available for clinicians to confidently recommend their use. Information provided has been found to be of poor quality [9, 10], however, these studies did not use any empirical guidelines to evaluate this information. Previous analyses highlight the lack of app regulation, leaving patients at risk of harm due to inaccurate information [4, 9].

As there is presently no regulation of apps for medical use, it is vital that research is conducted into their safety and efficacy. The National Health Service (NHS) provides a list of endorsed apps with assured clinical safety [11]. A free app, *BrushDJ,* has been developed using the Delivering Better Oral Health (DBOH) toolkit to encourage consistent oral hygiene practice and is included in the 'dental' category [12].

Behaviour change techniques

For an oral health app to improve health outcomes, as well as including accurate information, it is reasonable to assume it should incorporate behaviour change

theory. The Theoretical Domains Framework (TDF) provides a broad list of the key determinants of health behaviour. If an intervention does not cover these, it is less likely to be effective in changing behaviour [13]. The TDF has been successfully applied to the development and evaluation of oral health behaviours and interventions [14, 15, 16, 17, 18]. An alternative method of classifying health interventions is the Behaviour Change Technique Taxonomy (BCTT), which provides a detailed list to enable categorisation of the specific techniques that are being used to address the determinants of health behaviour [19]. The BCTT has also previously been applied to assessing oral health interventions [17, 20].

App evaluation scales

There is currently no all-encompassing rating system available for evaluating health apps for behaviour change [21]. The scale which is most widely used for evaluating the quality of apps is the MARS (Mobile App Rating Scale) [22], however this does not include behaviour change techniques further than 'goals'. In order for dental health professionals to confidently recommend effective apps, it is imperative that there is a comprehensive tool available which evaluates both accuracy of messages provided and behaviour change potential.

In view of the importance of addressing barriers to effectively change behaviour, there are surprisingly few studies evaluating the inclusion of behaviour change techniques in oral health app development. Therefore, this content review aims to address the gaps in the literature and investigate the quality of existing oral health apps through use of a newly-developed proforma which:

1. Assesses information provided in apps in line with DBOH guidance;

2. Assesses the barriers to oral health addressed by coding the apps against TDF and BCTT domains.

Methods

App selection

A systematic search of the UK iTunes store was conducted on 8 April 2020. Appropriate apps were identified using the following search terms: 'dental health', 'dental hygiene', 'oral health', 'oral hygiene', 'toothbrush' and 'tooth brushing' (Figure 1).

Eligibility was judged based on the description provided in the app store. Apps were included if they were:

- Relevant to oral health promotion

- Mobile device compatible

- Aimed at adult patients

- In English

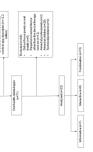Apps were excluded if they:

- Did not focus purely on oral health

- Required a named device other than the device the app runs on, for example, a specific toothbrush

- Aimed at professionals

- Aimed at children

- Had technical problems, for example, unable to load

Figure 1: App selection flow diagram

Coding

A data extraction proforma was created to collect information on the quality of the advice provided, using DBOH guidelines as a proxy, and to assess barriers to oral health addressed using the TDF. Information was also collected regarding app format, developer, price, size and app store rating. Where available, information regarding named psychological theory or information source use in app development, and details of app content contradictory to DBOH recommendations, was collected and recorded.

A pilot study was conducted to lend methodological strength to the proforma [23]. Five randomly selected apps were used for a minimum of five minutes. Using only the TDF as a theory-inclusion proxy was found to lack detail, therefore the BCTT was added. The DBOH index was expanded from eight broad categories to 23 more detailed categories. Then each eligible app was coded using the updated data extraction proforma (as detailed in Supplementary Appendix).

The five randomly selected apps were then reanalysed with a 100 percent concordance rate indicating satisfactory validity and intra-rater reliability [23]. Ten percent of the whole sample was second-coded by a behavioural scientist, with satisfactory validity and inter-rater reliability.

Results

Twenty-two apps were eligible for analysis. The majority of apps (16) were free and the mode type of app was 'combination': providing information whilst also allowing the user to interact with the app, for example entering personal information. The average size was 51.8MB. Almost all the apps (20) included a toothbrushing timer.

Delivering Better Oral Health

Two apps named DBOH as their information source, unsurprisingly addressing the most DBOH messages with *My Dental-Care* including 14 and *BrushDJ* including 11. On average, four DBOH messages were addressed per app.

Table 1: Mode elements from Delivering Better Oral Health addressed

Delivering Better Oral Health element	Number of apps addressing (n=22)
Take at least two minutes to brush	17 (77%)
Remove plaque from tooth surface and gingival crevice	12 (55%)
Brush twice per day	11 (50%)
Daily interdental cleaning	9 (41%)
Replace toothbrush every 1-3 months	7 (32%)

Nineteen apps addressed some oral hygiene DBOH message. The most commonly addressed message was 'take at least two minutes to brush' (17 apps (77%), Table

2): 88% of these apps did this using a toothbrush timer. All apps addressed this message using TDF domain 'knowledge' and BCTT components 'goal setting (behaviour)'. Other domains used to address this message included further elements such as TDF components 'memory, attention and decision processes', 'reinforcements' and 'behavioural regulation'.

The next most commonly addressed message of the DBOH was 'remove plaque from tooth surface and gingival crevice'. Of apps addressing this, all used TDF domains 'knowledge', mainly as a simple written sentence or short animation. Eighty-three percent of these apps also included the use of 'memory, attention and decision processes'.

Theoretical Domains Framework

The mean number of domains addressed from the TDF was seven. The mode domains addressed were 'intentions' and 'goals' (22 apps (100%), Table 2). The app addressing the most TDF components was *DentAdvisor* (11 components). This app addressed 15 BCTT components and nine DBOH messages. This is a 'combination' app, providing advice on maintaining oral health, animated timers and a glossary of dental words.

Table 2: Mode Theoretical Domains Framework and Behaviour Change Technique

Taxonomy domains covered

Theoretical Domains Framework domain	Number of apps addressing (n=22)	Behaviour Change Technique Taxonomy domain	Number of apps addressing (n=22)
Goals	22 (100%)	Goal setting (behaviour)	22 (100%)
Intentions	22 (100%)	Adding objects to the environment	20 (91%)
Environmental context and resources	20 (91%)	Feedback on behaviour	16 (73%)
Memory, attention and decision processes	20 (91%)	Prompts/cues	15 (68%)
Knowledge	20 (91%)	Instruction on how to perform behaviour	13 (59%)

Behaviour Change Technique Taxonomy

The mode domain addressed from the BCTT was 'goal setting (behaviour)' (22 apps

(100%), Table 2). The mean number of BCTT domains used was eight. The app

addressing the most BCTT components was *Brush'n'Save* (21 components). It also

addressed nine TDF components and four DBOH messages. *Brush'n'Save* contains

instructive animations, a toothbrush timer and an ability to set a reward after 30

consecutive days of toothbrushing. The app records days brushed and enables

comparison with other users: users can input details of their friends to compete for the longest consecutive brushing streak. Further rewards include unlocking new app backgrounds. The app advises on toothpaste amount and when to replace toothbrushes. The app recommends brushing for at least eight minutes but the timer can be set to two minutes.

Contradictory information

Instead of addressing DBOH messages correctly, some apps gave contradictory information. For example, *Let's Brush Free* recommends using a 'soft-bristled' toothbrush rather than the 'medium-textured' brush advocated by DBOH. Binary scoring of the DBOH messages was not appropriate for three apps, indicating that these may have touched on messages without including the full information or included incorrect information alongside correct statements.

Discussion

This study aimed to investigate the quality of available oral health apps, assessing information provided and the barriers to oral health addressed using psychological frameworks. Results show that, on average, oral health advice in apps follow DBOH messages. However overall the information provided is limited. Furthermore, including multiple DBOH messages did not guarantee the app would address the various barriers to oral health behaviours.

The most common DBOH message addressed was 'take at least two minutes to brush', which is interesting as it has the weakest supporting evidence of all DBOH messages [2]. This may be because it is more straight-forward to focus on toothbrushing, which involves carrying out a behaviour for four minutes per day, than for example to 'increase intake of non-starchy vegetables and fruit'. This element of DBOH was not included in any app and may have been ignored by developers because it would involve a lifestyle change rather than a routine change, which is perhaps outside an app's scope. Another DBOH message not addressed was 'ensure toothpaste is low in abrasive level'. This is surprising as it would be easy for a toothbrushing timer app to include this, either as a 'pop-up' or in a 'Frequently Asked Questions' section.

Strengths and Limitations

There were several potential limitations of this study. The coding scheme and questionnaire was developed specifically to address the research questions, meaning it is possible that other variables which could impact results were

inadvertently excluded. A further limitation was due to time restrictions it was only possible to search one app store. Alternative stores, such as GooglePlay, may include useful apps not available in iTunes. Also, the stringent eligibility criteria may have excluded potentially useful apps, such as general health apps with oral health components. In addition, it must be considered that eligible apps may have been introduced or deleted from iTunes since the data was collected; however, this study does give a useful overview of what is currently available.

It would be reasonable to generalise these results to apps available on other platforms, such as GooglePlay, as the study has high external validity through the inclusion of all eligible apps in the UK iTunes store. An additional strength is high construct validity: two methods of categorising BCTs were used, with the data extraction proforma and coding guided by psychological theory. This improves methodological accuracy and robustness. Internal validity of results was confirmed by second-coding of ten percent of the apps by a behavioural scientist with full concordance.

Implications

Especially in situations where face-to-face dental care is limited, oral health apps can provide an indispensable source of information. If app use is to be increased, there is a growing urgency to ensure health promotion apps are at the very least providing safe and correct information, and ideally using effective and multiple behaviour change techniques. Some apps may cause harm by providing incorrect advice; this must be considered by the public when using apps which are not endorsed by public

health bodies. This analysis provides a clear method of comprehensively assessing oral health apps to provide a basis for recommending apps to patients, and as a 'checklist' for future app development, providing a framework for app quality assurance.

The importance of incorporating technology into healthcare is highlighted in the NHS Long Term Plan [24]. Over the next decade, patients should have greater control of their care via use of technology, in turn enabling clinicians to allocate time and resources more effectively. One of the proposed methods is through a triaging system; patients begin with digital methods of managing their health, with escalation to face-to-face as needed. An oral health promotion app could fit seamlessly into this.

Two apps addressing multiple behaviour change barriers have been identified: *Brush'n'Save* and *BrushDJ.* A study carried out by the developer of *BrushDJ* found it effective in eliciting behaviour change with regards to frequency and duration of toothbrushing [25]. Another toothbrush timer, including multiple DBOH domains whilst addressing a large number of TDF and BCTT components, was *Brush'n'Save*. This app also used rewards and competition with peers, which is recommended to improve oral hygiene [26]. These apps have the potential to be prescribed by dentists to help form daily toothbrushing routines, acting as more than simply a knowledge transfer medium.

Widespread use and prolonged engagement with apps could greatly benefit the nation's oral health and maintenance between appointments, with patients having a reminder in their pocket to carry out beneficial oral health practices. It would be beneficial to create an app which includes more DBOH messages whilst addressing behaviour change barriers in order to elicit effective behaviour change. Co-design, encouraging prospective users to actively participate in intervention development, could be an effective way of addressing relevant barriers. This can lead to successful digital health intervention development for many health issues [28].

Apps have potential to reach those who do not or cannot attend appointments. It is important to bear in mind that a 'one size fits all approach' is unlikely to be sufficient. For example, it is imprudent to think that an app aimed at an demographic such as young professionals needs to address the same barriers to oral health as one aimed at elderly patients. The ability to tailor an app to the specific needs and health literacy of the patient would be useful. Those who have difficulty attending appointments, such as the house-bound, are also less likely to benefit from digital health technology, for reasons such as digital poverty or low digital literacy [28]. The NHS Long Term Plan does aim to make digital healthcare accessible to all, including those with low digital literacy [24]. However, it is likely that some may never access digital healthcare and instead will benefit from resources released by others who are able to successfully use digital healthcare [29].

This preliminary analysis shows clear indications for future research. Two apps have potential to be effective behaviour change interventions with regards to toothbrushing. Randomised control trials should be carried out to compare efficacy

of app use compared to traditional dental health promotion methods, such as face-to-face appointments with a member of the dental team. Further searches across all app stores should be conducted to ensure no useful apps are missed. The inclusion criteria could be widened to include all age groups and languages. The data extraction proforma can be used in further research for app evaluation and to guide app development.

Conclusions

In conclusion, this study has shown that the quality of information in available oral health apps requires improvement; with the majority restricted in the number of barriers to oral health they address. Currently there is no recognised scale for evaluating oral health apps: this study provides a suggested method for future app evaluation. Further research should examine the efficacy of promising apps and look towards the development of an app grounded in behaviour change theory, which covers all eight DBOH message categories.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

authors and not necessarily those of the NHS, the NIHR or the Department of

Health and Social Care.

ACCEPTED MANUSCRIPT

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