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# Applying the Behavior Change Technique Taxonomy to Mobile Health Applications: A Protocol

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**Abstract.** The lack of standardized descriptors of behavior change facilitators in mobile health apps makes it difficult for clinicians and consumers to quickly evaluate the potential of a mobile health app. The Behavior Change Technique Taxonomy (BCTT) was developed to evaluate health interventions for the presence of behavior change techniques. This paper describes the methods used and methodological results in applying the BCTT to commercially available mobile health apps in the respiratory and sleep domains.

**Keywords.** mHealth, mobile health applications, consumer health informatics, behavior change

## 1. Introduction

Over 325,000 mobile apps are now available through the major app stores, yet the majority have less than 5,000 downloads [1]. Unlike traditional health interventions that have originated from clinicians or clinical researchers, mobile health apps are often developed commercially with little clinician or consumer input. While the intent is to improve health outcomes, the evidence in using mobile health apps for this purpose is limited [2]. Evaluating the effectiveness of mobile health apps has been hindered by limited examples of sustained adoption, particularly by individuals who could receive the greatest benefit. Mobile health adopters tend to have higher education-levels, stronger self-reported health and be more physically active [3,4]. In a systematic review on engagement with mobile health apps, lack of motivation was identified as a potential barrier, with key behavior change facilitators being notifications, personalized interventions, feedback, social comparison, and clinician influence [5]. However, there are limited examples of best practice approaches and tools that can evaluate the presence of behavior change facilitators in app design [2]. This makes it difficult for clinicians and consumers to quickly evaluate the potential of a mobile health app.

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There is overlap between these described facilitators and behavior change techniques (BCTs). BCTs are understood to be the "active ingredients" within health interventions; the smallest identifiable strategies that are likely to produce a specific behavior change [6]. Over the past decade, the Behavior Change Technique Taxonomy (BCTT) has been developed and applied in evaluating the presence of BCTs within healthcare interventions [2,7,8]. BCTT development was a top-down, bottom-up approach, that involved a literature review looking cross behavior change theories and a Delphi survey with expert behavior change researchers. The BCTT includes 93 individual behavior change techniques (BCTs) within 16 categories, with common categories being goals and planning, feedback and monitoring, social support and reward and threat. Since its development, the BCTT has been used to evaluate the presence of BCTs across numerous health interventions and in different delivery mechanisms. In the literature, it has been noted that it can be difficult, yet not impossible, to identify the individual BCTs within an intervention due to incomplete descriptions of the interventions, outcomes or populations [6]. In a recent scoping review, the authors were able to identify 135 studies that identified BCTs and assessed effectiveness [6].

This research team has used the BCTT to initially map interventions from our original clinical trials to a telehealth kiosk, a new delivery mechanism [9,10]. While mapping the conversion to a new technology, it was noted that the technology itself introduced unique considerations. Some BCTs in the original intervention studies could not be replicated in the telehealth kiosk, while the technological functions offered opportunities for new BCTs to be introduced. Additionally, the telehealth kiosk could have potentially replicated some of the social support functions that have been traditionally categorized as human interactions.

To further understand the distinct considerations for applying the BCTT within consumer health, in this research pilot study, we retrospectively applied the BCTT to mobile health apps within two domains (respiratory and sleep). The research question was: *'Can the Behavior Change Technique Taxonomy be used to reliably describe the functions/features of mobile health apps that are designed to influence a person's health outcomes?*'. This research differs from prior BCTT research as the team evaluated the delivered content of mobile health apps rather than evaluating researchers' written descriptions of the intended interventions. This paper describes the methods used and methodological results in applying the BCTT to commercially available mobile health apps versus in-person health interventions described in the literature.

## 2. Methods[3]

### *2.1. Preparation*

Prior to coding all three coding researchers completed a 25-hour online BCTT training course that encompassed tutorials, six graded practice sessions and two assessment tests [11]. In addition to the BCTT online training resources, the research team developed a BCT-App Codebook which contained data collection steps and standardized persona data. Two domains, respiratory and sleep, were initially chosen for review, as these had not been included in the original BCTT development, and no examples were found that

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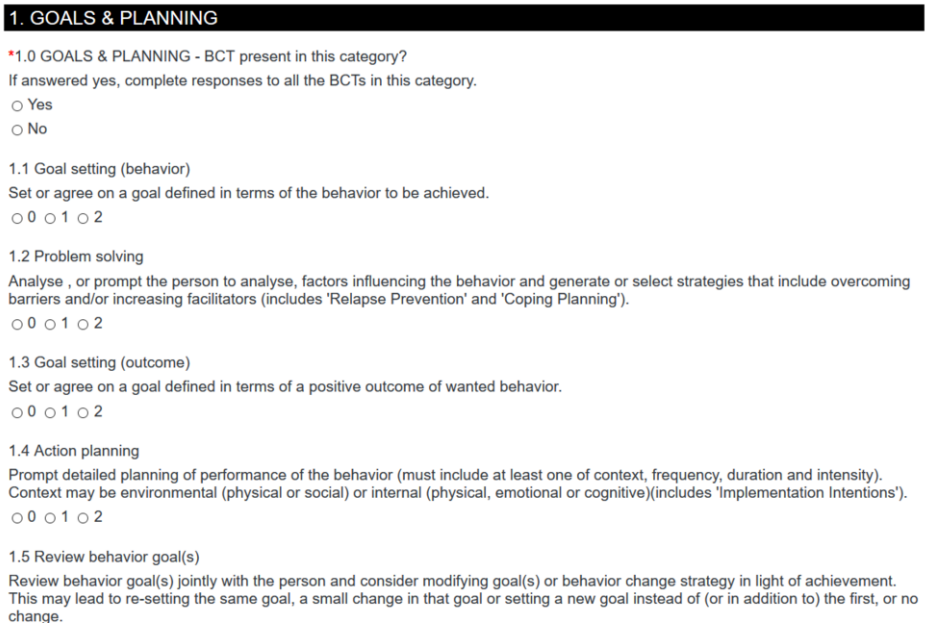
applied the BCTT in evaluating sleep or respiratory health apps. The steps prior to coding each domain involved:

- Defining the search strategy and inclusion/exclusion criteria for locating relevant apps in the domain;
- Conducting an environmental scan (sufficient number of apps to review, creating standardized persona data);
- Developing an online survey tool to facilitate data entry for each of the 93 codes (Figure 1) and data analysis;
- Creating the timeline for app review: at least two reviewers were assigned to each app, and the team was scheduled to meet after evaluation of each set of five apps.


1. GOALS & PLANNING

*1.0 GOALS & PLANNING - BCT present in this category?

If answered yes, complete responses to all the BCTs in this category.

○ Yes

○ No

1.1 Goal setting (behavior)

Set or agree on a goal defined in terms of the behavior to be achieved.

○ 0 ○ 1 ○ 2

1.2 Problem solving

Analyse , or prompt the person to analyse, factors influencing the behavior and generate or select strategies that include overcoming barriers and/or increasing facilitators (includes 'Relapse Prevention' and 'Coping Planning').

○ 0 ○ 1 ○ 2

1.3 Goal setting (outcome)

Set or agree on a goal defined in terms of a positive outcome of wanted behavior.

○ 0 ○ 1 ○ 2

1.4 Action planning

Prompt detailed planning of performance of the behavior (must include at least one of context, frequency, duration and intensity). Context may be environmental (physical or social) or internal (physical, emotional or cognitive)(includes 'Implementation Intentions').

○ 0 ○ 1 ○ 2

1.5 Review behavior goal(s)

Review behavior goal(s) jointly with the person and consider modifying goal(s) or behavior change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first, or no change.

**Figure 1.** Example of the First Category in the BCTT-App Coding Survey

## *2.2. Data Collection*

Each reviewed app was downloaded onto a smart phone by the coder. Standardized persona data were used where possible. Data was collected through screenshots that recorded interactions with the apps. Screenshot data were stored on a secure server at the University of Victoria. Depending on the environmental scan, the interaction period with each app varied between three and seven days. Apps that were identified as having weekly functions were scheduled for longer interactions.

If an app was available on Android and iPhone, both versions were evaluated by at least two coders. One coding survey that detailed each BCT was filled out for each app by the coder. A second coding survey was submitted if subsequent interactions with an app yielded additional BCTs. A three-point system was used for coding (0 = not present;

1 = may be present, unsure; and 2 = present, confident). For the "Social Support" construct, additional modifiers were included in the survey so coders could indicate the source of the social support (0 = technology; 1 = person unknown; and 2 = family or friend). Open text for each BCT was included so coders could write field notes and indicate which screenshots corresponded to their codes for a BCT.

*2.2.1. Inclusion/Exclusion Criteria*

**Exclusion criteria** - Apps were excluded from the data set if:

- Did not focus on the patient as the user;
- Was a diagnostic tool;
- Provided only educational or background information on the disease (no user interactivity);
- Only provided music or sounds for relaxation;
- Was not available in English or in Canada

Additional exclusion criteria specific to the sleep domain:

- Only function was an alarm clock;
- Less than a four star rating on the app store.

**Inclusion criteria** - Apps needed to have the following characteristics to be included in the data set:

- Reference the sleep or respiratory domain (i.e. chronic obstructive pulmonary disease (COPD) or asthma) in the introduction/overview of the app;
- Focused on behaviors (e.g. breathing, sleep, physical activity, etc.) or monitoring indicators of the illness (oxygen saturation, etc.);
- Free apps on Google Play or iTunes designed to be used on a mobile device.

*2.3. Data Analysis*

The study design was an iterative process where the protocol, codebook and online survey were adapted to address the areas of discrepancies identified during research team meetings. This resulted in progressive changes to analysis procedures. The initial protocol outlined that reliability in coding was to be assessed using Cohen's $\kappa$ with a criterion of 0.75 for agreement. However, during evaluation of the first domain, respiratory apps, percent agreement was used as there was considerable variation in confidence level of coding (1 and 2's). The variability in the survey results for the sleep apps, resulted in the team completing analysis through consensus conferences.

## 3. Results

The quality of respiratory apps affected the ability to effectively apply the BCTT, as few apps demonstrated presence of BCTs. When the coders switched to the second domain (sleep), there was greater diversity in the BCTs that were identified within the apps, with representation across multiple categories. However, agreement on coding the apps was not achieved. A consensus conference revealed a unique consideration in BCTs that focused on monitoring and how they may be interpreted for technological applications.

For example, “biofeedback” was defined as an external device that monitors physiological or biochemical state [11]. There was disagreement whether apps that monitored snoring rates and breathing patterns were sufficient to meet this definition. Similarly, “self-monitoring of behavior” was defined as establishing a method for the person to monitor their behavior [11]. It was unclear initially whether an app that encouraged a person to place the phone at the bed side each night to monitor a person’s movement should have been coded for this BCT.

The issues for consensus in the second set of sleep apps were specific to concepts in the domain rather than the BCTT definitions. For example, for apps that featured alarm clocks there was disagreement as to whether the time setting feature within an alarm clock was sufficient in meeting the criteria of 'setting a goal'. Additionally, the team discussions revealed that apps involved different categorizations for changing sleep patterns. For some apps sleep was viewed as the *outcome* in developing better sleep patterns, where the *behavior* to be changed focus on alcohol consumption, physical activity, and caffeine intake. Other apps conveyed the sleep pattern (e.g. oversleeping) as the *behavior* change, where an alarm would wake the person within an ideal phase of the sleep cycle. The second consensus conference for the sleep domain resulted in further instructions being added to the BCT-App Codebook and refinement of definitions and domain-specific examples within the BCT-App Coding Survey. Additionally, a disagreement area-specific test set was created to evaluate the modifications before assessing the next app set.

## 4. Conclusions

Based on these experiences, the following recommendations are made for evaluating BCTs in mobile health apps:

1. Conduct a pre-evaluation environmental scan of the domain to identify the persona information needed;
2. Plan for consensus conferences for coders with each new domain. Consensus conferences should be held after a small set of mobile health apps (<10) has been independently reviewed to identify domain specific issues;
3. Utilize data collection tools that reinforce BCT definitions and give domain examples where appropriate.

Assessing presence BCTs through mobile health use, introduces is a key methodological limitation. Only the displayed functions or interactions of mobile health apps can be coded, as the intentions of the app developers cannot be inferred from the apps themselves. This will decrease the potential for false positives in coding BCTs, but does mean that intended behavior facilitators may not be recognized if the intended interaction is not delivered fully or in the manner intended.

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