

Mobile Health Applications for Postpartum Depression Management: A Theory-Informed Analysis of Change-Use-Engagement (CUE) Criteria in the Digital Environment

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Abstract

Postpartum Depression (PPD) is the most common childbirth complication, with approximately 15% of postpartum women experiencing depression symptoms. Mobile applications have potential to expand delivery of mental health interventions. However, our understanding of how these tools engage women with PPD and facilitate positive behavioral changes is limited. In our paper, we analyze 15 commercial PPD applications to understand their role as facilitators of change, engagement, and sustained use. Applications reviewed contained an average of four theory-based behavioral change techniques, and highest patient engagement level reached was to empower patients through patient-generated data. Heuristic violations were identified in areas including user control and freedom, aesthetic and minimalist design, and help and documentation. An inverse correlation was found between the number of theory-based behavior change features and patient engagement. Findings suggest underserved populations may suffer further limitations accessing relevant health resources in the current application market.

Keywords:

Mobile Health, Mental Health, Postpartum Depression

Introduction

Postpartum Depression (PPD) is a disabling form of depression that can occur within 12 months of childbirth [1]. It is the most common complication of childbirth, affecting approximately 15% of postpartum women [1]. A diagnosis of PPD is based on criteria similar to that of a major depressive episode and carries a stigma that impacts treatment [2]. Many women of reproductive age do not receive adequate treatment for depression, despite symptoms being common among this population [3]. Factors such as issues with childcare, lack of time, and stigma, have been shown to be barriers to treatment of depression in women [4]. Though overall rates of PPD have declined in recent years, symptom rates remain high for certain subpopulations of women [5].

Availability and access to address women's health issues is an ongoing concern. About 1 out of 8 women defer needed health care due to barriers including cost, language or logistical factors [6]. A large proportion (18%) of women without health insurance in the U.S. are more likely to forego care [7]. A low-income person is at higher risk of access restrictions and worse health outcomes [8] and is significantly likely to be a woman

[9]. Additionally, one-third of women prefer to seek psychological treatment from a female therapist [10], but only 34 percent of U.S. psychiatrists are women [11].

Mobile smartphone applications have significant potential to expand the delivery of mental health interventions [12], and a recent study has shown that PPD treatment delivered via smartphone application may provide accessibility and help overcome barriers to care [13]. Rigorous scientific evidence supporting mental health smartphone apps is limited; although the overall evidence of potential for efficacy and improved treatment accessibility is promising [14]. However, our understanding of the current domain of PPD related mHealth tools is limited, in terms of their ability to engage women and facilitate positive behavioral changes (e.g., shaping knowledge) that are integral to PPD prevention and management. To this end, the main objective of our study is to review and analyze existing PPD smartphone applications to evaluate their standing along three critical dimensions- (a) grounding in behavioral theory (an app's ability to drive change), (b) integration of digital engagement features (an app's ability to sustain user engagement), and (c) usability through design elements (an app's ability to enrich ease of use). Such analysis will allow us to understand the sociotechnical barriers and facilitators to engaging women in PPD management through mobile health technologies.

Theoretical Rationale

Theoretical fidelity: The Behavior Change Technique (BCT) Taxonomy. Michie et al. outlined a hierarchical grouping of individual theory-linked techniques that are useful independently in affecting inter and intra-personal human behavior processes [15]. The taxonomy can be used to harness mHealth features to support lasting and long-term positive health behaviors. The 93 theory-linked techniques in BCT Taxonomy allow the exploration of theory-driven behavior change constructs within mHealth features. The taxonomy provides a standardized vocabulary to quantify how socio-behavioral and psychological constructs and unique behavior change theories are operationalized in a specific intervention. Within the context of our study, the taxonomy can be used to assess implementation of techniques that have been shown to improve mental health management (such as self-monitoring [16]) in PPD-specific mobile health interventions.

User engagement: The Patient Engagement Framework (PEF) is a tool developed by the Healthcare Information and Management Systems Society (HIMSS) that classifies potential

mHealth features into five compounding layers: “Inform me,” “Engage me,” “Empower me,” “Partner with Me,” and “Support my e-community” [17]. The PEF was developed to utilize technology towards the improvement of patient engagement strategies, and ties into the standards originally set forth by Meaningful Use [17]. The framework can help assess whether market solutions are meeting necessary engagement levels for PPD patients, who have specific engagement needs including community support and interdisciplinary care [18].

Usability: “10 Usability Heuristics for User Interface Design.” Usability engineering can be simplified to ten rules, which account for the majority of usability problems that are faced by users [19, 20]. The simplified guidelines set out by Nielsen can be used to measure usability and user satisfaction [19] subjectively. Previous research suggests usability design elements have an important role in promoting patient retention and satisfaction with digital health interventions for mental health (including PPD) [21].

Ultimately, these three components form the core components of our analysis to identify the current status of Change-Use-Engagement (CUE) criteria implementation in existing mHealth solutions for PPD prevention and management.

Methods

Study Design

This study is a descriptive and systematic review and analysis of selected PPD applications currently available from the Apple App Store and the Google Play Store. Features were mapped to the 93 hierarchically-arranged BCTs based on the BCT label and description. BCT delivery was counted in the affirmative for application features that encouraged user self-delivery of the BCT or delivered the BCT directly to the user. Applications were also evaluated for patient engagement and usability with the PEF and heuristic measures respectively. Final analysis of each application was based on total number and hierarchical position of demonstrable BCTs, patient engagement features, and heuristic violations.

App Selection and Inclusion

We searched the Apple App Store [22] and the Google Play App Store via a manual search using the keywords “Postpartum depression”, “Postpartum”, “postnatal depression” and “postnatal” in February and March 2019, and May 2021. Applications with an associated cost were excluded from the search. The initial search returned 349 unique applications. The inclusion criteria defined for this study is a specified focus on PPD in the application title, description, or representative images (i.e. “depression” in general is not included). Twenty-four of the 349 initially identified applications met these criteria. Except for one application that was not available for download due to its deauthorization by Google Play Store, these applications were downloaded for full feature assessment. Eight of these 23 applications were meant for general mental health support and would require PPD support to be initiated by the user. These applications were, therefore, disqualified for final review and analysis.

Final review and analysis of 15 applications was based on the classification of application features from the lens of CUE criteria using the BCT (representing the CUE criteria of Change), PEF (representing Engagement), and heuristic evaluation (representing Use). Nine of the applications were reviewed by a single researcher, and six were reviewed by two independent reviewers for inter-rater reliability. Additionally,

each application was evaluated for interoperability features described under “Permissions” settings of the Google Play store and the Privacy Policy documentation from the Apple App store. With digital delivery of mental health services becoming commonplace due to COVID-19 restrictions, interoperability features such as network connection capabilities and app privacy are important factors in PPD patient engagement with digital health technologies [23].

Results

Table 1 summarizes the content and features of each of the 15 applications reviewed. All apps are targeted at women who have recently given birth. Three of the fifteen applications appear to be research driven and include a theoretical basis for development, while the remaining 12 are consumer-focused.

Table 1: Summary of Applications Included for Review

App Name	Content and Feature Summary
Little Mother's Helper™	Provides suggestions for activities to prevent or lessen PPD.
MGHPDS	Screening tool for PPD
MomentHealth	Helps Postpartum women recognize symptoms of postpartum depression. Provides suggestions for local healthcare professionals and the opportunity to connect socially via their Facebook community. Paid features are also available, such as mood tracking.
Post Pregnancy Recovery/ Postpartum Recovery	Provides information on PPD symptoms, treatment options, risk factors, and causes. Suggestions for self-help and support and medical and pharmacological support are provided.
Postpartum Depression	Helps postpartum women understand and recognize the symptoms of postpartum depression. It provides suggestions for natural remedies and information about causes and treatment.
PPD ACT	Screening tool for PPD
Postpartum Depression Self-Evaluation	Screening tool for PPD
MamaMend: Postpartum Health	Contains information on different areas of postpartum health, including PPD. Provides links to information resources.
Canopie: Mental health, pregnancy and Postpartum	Offers postpartum mental health support in the format of audio files narrating women's personal experiences with conditions including PPD.
Edinburgh Postnatal Depression Scale (EPDS)	Screening tool for PPD

Postpartum Depression Test	Screening tool for PPD, also offers links to PPD resources.
Postpartum Screening for Moms	Screening tool for PPD
Mom Genes Fight PPD	Screening tool for PPD
Postpartum Health- Care and recommendations	Contains a variety of topics on postpartum health, divided into different modules. One of these modules is dedicated to PPD.
Postpartum Depression	Contains educational modules on PPD, including definition and signs.

Of the 93 BCTs present in the BCT Taxonomy, 25 (26.9%) were represented by features in the selected applications. These included "1.1 Goal setting (behavior)," "1.2 Problem solving," "1.3 Goal setting (outcome)," "1.4 Action planning," "2.1 Observe or record behavior with the person's knowledge as part of a behavior change strategy," "2.2 Feedback on behavior," "2.3 Self-monitoring of behavior," "3.1 Social support (unspecified)," "3.2 Social Support (practical)," "3.3 Social support (emotional)," "4.1 Instructions on how to perform a task," "5.1 Information about health consequences," "5.4 Use methods specifically designed to emphasize the consequences of performing the behavior with the aim of making them more memorable (goes beyond informing about consequences)," "5.5 Anticipated regret," "5.6 Information about emotional consequences," "8.2 Behavior substitution," "8.3 Habit formation," "8.6 Generalisation of a target behavior," "9.1 Credible Source," "11.1 Pharmacological support," "11.2 Reduce negative emotions," "11.3 Conserving mental resources," "12.3 Avoidance/reducing exposure to cues for the behavior," "12.6 Body changes", and "15.1 Verbal persuasion about capability". The minimum number of BCTs represented in an application was one and the maximum was 12, with a mean number of 4.

Of the five levels of the PEF, the highest level attained by any application was 3. All features were categorized within "e-Tools" ("wellness guidance"), "Information and Way-Finding," and "Patient-Generated Data." All features identified within six applications ("Little Mother's Helper," "Post Pregnancy Recovery," "MamaMend," "Postpartum Health", "Postpartum Depression (PinkDev)", and "Postpartum Depression" (El Makaoui)) attained PEF level 1 based on the informative but non-interactive nature of the application features. Six applications reached PEF level 2 by including a map with mental health providers in the proximity of the user or interactive electronic forms. Three applications ("PPD Act", "Mom Genes Fight PPD", and "MGHPDS") attained PEF level 3 based on symptom assessment features.

Heuristic evaluation revealed potential usability problems in 11 of the 15 applications. As an example, one application ("Little Mother's Helper") was found to have three potential heuristics violations in the areas of "User control and freedom," "Aesthetic and minimalist design," and "Help and documentation". This is likely due to non-traditional and inconsistent menus and menu headings, tapping and swiping required to access content without cues to do so, content buried inside layers of design components, and minimal help availability, which appears under "tour" menu heading. Six applications ("Moment Health," "Post Pregnancy Recovery,"

and "Postpartum Depression" (PinkDev), "MamaMend", "Postpartum Depression Test", and "Canopie") had potential heuristics violation in the area of "Help and documentation". The rest of the applications did not show heuristics violations, though "PPD Act" and "Mom Genes Fight PPD" could not be fully reviewed for heuristics due to the clinical trial participation requirement.

Most common interoperability features present in the applications included the ability to view network connections and full network access. The application with the highest interoperability features was MomentHealth, with all permissions enabled as described in the Google Play Store (i.e., ability to receive data from the internet, access to camera, storage). The application with the least interoperability features was Post Pregnancy Recovery, only being able to view network connections and having full network access. Research-based applications included interactive forms that collected and shared user data for research purposes, including identifiable information such as name, address, and email address.

Discussion

We found an inverse correlation between the number of application features representing BCTs and the overall PEF levels of the applications. Findings indicate that, while behavior theory elements are present in application features, patients are not required to actively engage with these change elements. This reflects the passive, informative nature of six of the 15 applications ("Little Mother's Helper," "Post Pregnancy Recovery," "MamaMend," "Postpartum Health", "Postpartum Depression" (PinkDev), and "Postpartum Depression" (El Makaoui)). Similarly, heuristic violations were likely limited due to the simplicity and informative nature of the applications. The proportion of PPD-relevant apps in relation to quantity of apps listed in the Apple App Store and Google Play Store is clearly inadequate. The number of available PPD apps is also highly dynamic, as illustrated by one of our reviewed apps ("Little Mother's Helper") being taken off market. Therefore, findings suggest that an already underserved population may suffer further limitations on access to relevant digital health resources in the current app market.

Applications with greatest incorporation of BCTs, PEF, and usability heuristics were more likely to obtain high user ratings. Of all applications reviewed, "Post Pregnancy Recovery" had the highest incorporation of BCTs (n=12) and an average user rating of 3.8 out of 5 stars. Four applications ("MGHPDS", "Postpartum Depression Self-Evaluation", "MamaMend", and "Canopie") had 5-star ratings. Of these, Canopie incorporates the highest number of BCTs (n=7), reaches the PEF category of "Engage Me", and has one minor violation in the area of "Help and documentation". Nine of the fifteen applications we reviewed incorporated one BCT, and none of these had existing user ratings. This indicates that incorporation of CUE criteria into development of PPD-specific applications results in greater user satisfaction with the end product.

Mechanism of delivery remains a possible barrier to delivering behavioral therapy for depression via smartphone applications [24]. Present results indicate that available PPD applications are not delivering engaging behavioral therapy for PPD. Patient engagement in Cognitive Behavioral Therapy is a known indicator of greater reductions in depression symptoms [25]. Taken within the context of the overall state of access to healthcare for women with PPD and the potential for mHealth delivery via smartphone, further research is urgently needed to intensify the understanding and development of engaging and

theory-based mHealth PPD treatment solutions. In previous work [26], we have conducted focus groups and interviews to assess the BCT and PEF features that women desire in PPD digital health solutions. Next steps in our research program will be to triangulate user needs with clinical expert interviews, and perform technical implementation of the desired features.

There are several limitations to the present study. Our evaluation process was limited in that some applications were reviewed by a single researcher, and our evaluation measures were based on a consensus-based theoretical treatment reporting measure, an eHealth user engagement measure, and a simplified heuristics measure. Additionally, the present study was limited in scope to applications that were available during a limited period in the two leading app stores, which may exclude applications from other platforms or in development. All mental health applications that did not specifically feature or promote treatment for PDD, regardless of potential adaptability to accommodate user-initiated PPD treatment options, were also excluded. Future studies should consider additional evaluation measures and user testing.

Conclusions

Postpartum depression is a significant public health issue that can potentially affect both maternal and neonatal health. We are in need of innovative solutions to help bridge PPD-related disparities in access to care. It is critical for us to understand the barriers and facilitators to PPD engagement through digital modalities from a technology development perspective to ensure meaningful and sustained use. While digital health solutions offer great promise in improving access to PPD care, our present study to understand CUE criteria in PPD-related mHealth apps indicates that current market solutions available to women exhibit many shortcomings, particularly in areas of patient engagement and incorporation of theory-based behavior change techniques. To help address this inadequacy, further research is needed to specify user needs in terms of the active ingredients necessary to successfully engage postpartum women in their mental health management.

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