Effect of a Mobile Monitoring System vs Usual Care on Depression Symptoms and Psychological Health
A Randomized Clinical Trial

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Introduction

Early detection and monitoring of mental health symptoms are crucial, yet many patients and clinicians are unable to receive timely and reliable indicators of clinical progress. Mobile monitoring systems allow for passive tracking of vocal and behavioral indicators of symptoms and can provide infrastructure to securely store, analyze, and provide feedback to patients and clinicians. However, the evidence for the effectiveness of mobile monitoring systems in clinical settings is limited. We conducted a randomized clinical trial to assess whether patients using a mobile monitoring system with clinician access experienced improvements in depression symptoms and well-being.

Methods

Recruitment

Between February 2016 and June 2017, patients from 2 Brigham and Women's Hospital Patient-Centered Medical Homes with colocated primary care and behavioral services were recruited through clinician referrals, online advertising, and within-clinic advertising. Exclusion criteria included the presence of a psychotic disorder, suicidal or homicidal risk, history of a cognitive disorder, or not owning an Android smartphone (Figure 1). Researchers obtained Partners Healthcare institutional review board approval and written informed consent from all participants. This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guideline. The trial protocol appears in Supplement 1.
Mobile Monitoring System
Patients were randomized to receive usual care (control) or usual care plus the mobile monitoring system (intervention). Patients in the intervention group downloaded the mobile monitoring application to their smartphones. For the 6-month study duration, the application passively collected metadata on smartphone use, including short message service logs, call logs, and geolocation data. Metadata were analyzed against 3 previously modeled Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition) diagnostic criteria for depression and posttraumatic stress disorder, including fatigue, social isolation, and diminished interest.1 Patients could also leave short audio recordings through the application, which enabled voice feature analyses and provided an additional measure of depressed mood. Visual feedback on these 4 metrics were provided to patients via the mobile application (eFigure 1 in Supplement 2) and to clinicians via a desktop dashboard (eFigure 2 in Supplement 2). Clinicians were trained to review the dashboard as part of daily workflows, weekly team huddles, and routine clinical visits with patients in the intervention group.

Outcome Measures
At baseline and 6-month follow-up, patients completed the 2 following primary outcome measures: the Patient Health Questionnaire3 sum score for depression severity, ranging from no depressive symptoms (0-4) to severe major depression (>20), and the Schwartz Outcome Scale4 sum score, ranging from 0 to 60, with higher scores indicating better overall psychological health. A subset of patients in the intervention group completed questions at follow-up on their level of comfort with sharing data with clinicians and whether the application changed their patient-clinician communication. Patients were asked whether they believed this mobile monitoring system respected their privacy (range, 0-10, with 10 indicating very much so).

We used 2 mixed-design 1-within, 1-between analyses of variance with repeated measures on the assessment time factor for our 2 primary outcomes, ie, the Patient Health Questionnaire and the Schwartz Outcome Scale. Statistical significance was set at \( P < .05 \), and all tests were 2-tailed. Data were analyzed beginning in July 2018. Final data analysis was conducted in November 2019. All analyses were conducted using SPSS statistical software version 25 (IBM Corp). Additional detail appears in the eMethods in Supplement 2.

Figure 2. Depressive Symptoms and Psychological Health During the Study Period

Scores on the Patient Health Questionnaire range from no depressive symptoms (0-4) to severe major depression (>20). Scores on the Schwartz Outcome Scale range from 0 to 60, with higher scores indicating better overall psychological health. Error bars indicate 95% CIs.
Results

Sixty-eight patients were randomized (33 to usual care and 35 to usual care plus the mobile monitoring system). Among them, 55 patients (40 [73%] women; 18 [33%] non-Hispanic white; 14 [25%] non-Hispanic black/African American; 11 [20%] Hispanic/Latinx; mean [SD] age, 36.8 [12.9] years) received usual care (27 [49%]) or usual care plus the mobile monitoring system (28 [51%]) as allocated. Overall, 53 patients (96%) completed follow-up surveys, and from the intervention group, 15 patients (54%) completed the user experience survey.

Analysis of variance revealed a significant treatment-by-time interaction effect, supporting decreased depressive symptoms ($F_{1,51} = 4.36; P = .042; \text{partial } \eta^2 = 0.08$) and improved psychological health ($F_{1,51} = 4.24; P = .045; \text{partial } \eta^2 = 0.08$) among patients receiving the mobile monitoring system compared with usual care (Figure 2). A total of 12 patients (80%) from the intervention group who completed the user experience survey reported that they would likely or definitely share mobile monitoring data with clinicians. Eight (53%) reported that the mobile monitoring application had at least somewhat improved their communication with clinicians, and 4 (27%) reported directly discussing scores with their clinicians. Patients felt the application respected their privacy (mean [SD] score, 8.80 [1.82]).

Discussion

In this randomized clinical trial, patients using a mobile monitoring system with clinician access showed significant improvement on depressive symptoms and psychological health compared with patients receiving usual care. This study has limitations, including its small sample size in 1 metropolitan area in the northeastern United States. These results provide initial empirical support for the effectiveness of mobile monitoring systems in outpatient clinical settings. Future research will test the intervention in additional clinical populations and examine potential mechanisms by which information on symptoms is associated with clinical decisions and behavioral health outcomes.
Conflict of Interest Disclosures: Dr Blanch-Hartigan reported being a paid research consultant for CompanionMX during the conduct of the study and receiving a grant from the Arnold P. Gold Foundation outside the submitted work. Dr Marci reported being an officer of CompanionMX, which has a license to the technology used in this study. No other disclosures were reported.

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Data Sharing Statement: See Supplement 3.

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REFERENCES

SUPPLEMENT 1.
Trial Protocol

SUPPLEMENT 2.
eMethods. Supplemental Methodological Descriptions
eFigure 1. Patient View of Mobile Monitoring System Smartphone Application
eFigure 2. Clinician View of Desktop Dashboard
eReferences.

SUPPLEMENT 3.
Data Sharing Statement