Supporting mental health during COVID-19 using a digital behaviour change intervention: an open-label, single-arm, pre-post intervention research study

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Submitted to: JMIR Formative Research
on: June 16, 2021

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Abstract

Background: COVID-19 is taking its toll on people's mental health, particularly as people are advised to adhere to social distancing, self-isolation measures and government imposed national lockdowns. Digital health technologies have an important role to play in keeping people connected and supporting mental health and wellbeing. Particularly in the wake of the COVID-19 pandemic as even before this unprecedented time, mental health and social services were already stretched.

Objective: Our objective was to evaluate the 12-week outcomes of the digitally delivered Gro Health platform, a digital behaviour change intervention for self-management of mental wellbeing, sleep, activity, and nutrition.

Methods: The study used a quasi-experimental research design consisting of an open-label, single-arm, pre-post intervention engagement using a convenience sample. From adults who had joined the intervention and had a complete baseline dataset (GAD-7 Anxiety Test Questionnaire, Perceived Stress Scale, PHQ-9 Patient Health Questionnaire), we followed all users for 12 weeks (N=273), including 33 (12.1%) who reported a positive COVID-19 diagnosis during the study period. Users engagement with the Gro Health platform was tracked by active minutes.

Results: Of the 347 study participants, 273 (78.67%) completed both baseline and follow up surveys. Change in scores for anxiety, perceived stress and depression was predicted by app engagement with the strongest effect being seen in change perceived stress scores $F(1,271)=251.397$, $p<0.001$, with an $R2$ of .479.

Conclusions: A digital behaviour change platform that provides remote mental wellbeing support can be effective in managing depression, anxiety, and perceived stress during times of crisis such as the current COVID-19 pandemic.

(JMIR Preprints 16/06/2021:31273)
DOI: https://doi.org/10.2196/preprints.31273

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Abstract

Background: COVID-19 is taking its toll on people's mental health, particularly as people are advised to adhere to social distancing, self-isolation measures and government-imposed national lockdowns. Digital health technologies have an important role to play in keeping people connected and supporting mental health and wellbeing. Even before COVID-19, mental health and social services were already stretched.

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Methods: The study used a quasi-experimental research design consisting of an open-label, single-arm, pre-post intervention engagement using a convenience sample. Adults who had joined the Gro Health platform (intervention) and had a complete baseline dataset (GAD-7 Anxiety Test Questionnaire, Perceived Stress Scale, PHQ-9 Patient Health Questionnaire), were followed up at 12 weeks (N=273), including 33 (12.1%) who reported a positive COVID-19 diagnosis during the study period. User engagement with the Gro Health platform was tracked by measuring total minutes of app engagement. Paired t-tests were used to compare pre- and post-intervention scores and linear regression analysis was performed to assess the relationship between minutes of active engagement with Gro Health and changes in scores across the different mental health measures.

Results: Of the 347 study participants, 273 (78.67%) completed both baseline and follow up surveys. Change in scores for anxiety, perceived stress and depression was predicted by app engagement with the strongest effect being seen in change perceived stress scores $F(1,271)=251.397$, $p<0.001$, with an R^2 of .479.

Conclusion: A digital behaviour change platform that provides remote mental wellbeing support can be effective in managing depression, anxiety, and perceived stress during times of crisis such as the current COVID-19 pandemic. The outcomes of this paper may also support the implementation of remote digital health apps supporting behaviour change and support for low levels of mental health in the community.

Introduction

COVID-19 has created an unprecedented global health challenge and has the capacity to stretch health care systems throughout the world. [1] To minimise the risk of infection and spread, and to protect the most vulnerable groups of people and population at large, governments across the world have advised people at higher risk to leave the home for very limited purposes. [2]

There is risk that the outbreak will create a "second pandemic" of mental health crises in health systems and communities. [3] Before COVID-19, mental health and social services were already stretched. Depression is the second leading cause of disability worldwide, and by 2030, it is expected to be the leading contributor to the global burden of disease. [4] Effort to contain the spread of COVID-19, including prolonged social distancing and self-isolation, may trigger or exacerbate social, mental, and physical health problems, such as anxiety, relationship breakdowns, domestic violence, substance abuse or withdrawal, and obesity. [5-7] This could be especially serious for those with preexisting medical and psychological conditions.[8]

Times are unprecedented and COVID-19 has created global uncertainty. During times of uncertainty, people are more likely to be stressed, depressed, and anxious. [9-12] In 2014, when the Middle East respiratory syndrome-novel coronavirus [MERS CoV] was reported, anxiety levels were associated with increased perception of susceptibility to infection and social avoidance behaviours related to travel and being in public places. [13] Data originating from Wuhan in Hubei province, collected through the National Health Commission of China reported that there was a correlation between the rapidly increasing numbers of confirmed cases and deaths and psychological problems, including anxiety, depression, and stress experienced by medical staff and the public. [14]

The unpredictability and uncertainty of the COVID-19 pandemic and the resulting economic breakdown could increase the risk of mental health problems and exacerbate health inequalities. [15] Preliminary findings suggest adverse mental health effects in previously healthy people and in people with pre-existing mental health disorders. [16] Health-care disparities will disproportionately affect socially disadvantaged patients including those from ethnic minorities who have worse access to healthcare and receive poorer quality care than their Caucasian counterparts. [17]

Roughly 5% of the general population experiences General Anxiety Disorder (GAD) at least once in their lifetime and the estimated lag time to treatment for GAD can be between 9 and 23 years.[18-19] A key challenge to delivering interventions is low level of engagement. [20-21]

Similarly, depression is the single largest contributor to global disability with an estimated 300 million affected. [22] Major depression has been found to impair quality of life [23] and psychosocial functioning. [24] However, resources are limited - the WHO Mental Health Atlas 2017 reported that a global median of 9 mental health workers per 100,000 people. [25]

Face-to-face therapy and guided self-help techniques such as Cognitive Behavioural Therapy (CBT) and mindfulness have been shown to be effective in treating depression and anxiety. [27-29] However, face-to-face therapy traditionally provides point-in-time support and will struggle to scale fast enough to address growing mental health challenges.[26] With restrictions in interactions and activities during COVID-19, innovative delivery methods are required to augment care.

Our study aims to add to the research and evidence-base on the effectiveness and engagement levels of a digital behaviour change app (Gro Health) in the context of the COVID-19 pandemic. Previous research shows that when mental health apps are properly designed, they can be cost-effective and scalable solutions for the treatment of anxiety, stress, and depression. [30]. Meta-analyses of randomized controlled trials shows that mental health apps are able to alleviate symptoms of anxiety and depression as well as assisting patients to self-manage their conditions. [31-34]. However there is still limited research on the effectiveness of mental health apps in promoting behaviour change and improving health outcomes. [35]. Health apps aiming at "lifestyle interventions" hold great promise but evidence of their use and efficacy amid the COVID-19 pandemic is similarly sparse. [36]

To address this gap, we designed a quasi-experimental study to evaluate the 12-week outcomes of the Gro Health platform, a behaviour change intervention for self-management of mental wellbeing, sleep, activity, and nutrition. The intervention provides education with modules such as stress management, building mental wellbeing and resilience, the benefits of meditation, and guided activities to maintain positive mental wellbeing including guided mindfulness-based meditations, classical music, 360-degree immersive guided relaxation videos and facilitated yoga classes.

The primary study objective was to determine the effectiveness of delivering mental wellbeing activities using the Gro Health app on self-reported symptoms of anxiety (GAD-7), depression (PHQ-9) and perceived stress (PSS). [37-39] We posited that greater engagement in the guided activities to maintain positive mental wellbeing (e.g. yoga, guided mindfulness) would lead to improvements in anxiety, depression and perceived stress compared to baseline.

Methods

Intervention

Gro Health is a digital health intervention for which provides behavioral change support through structured education and guided activities in the areas of mental wellbeing, nutrition, sleep and activity. The app utilizes a similar behaviour change architecture as the Low Carb Program which has been demonstrated to achieve long-term engagement and sustainable behaviour change. [21]

Gro Health provides education and therapeutic behavioral change support in four therapeutic areas - mental wellbeing, sleep, activity, and nutrition. Of particular interest for this study, engagement with the Wellbeing area of the app was examined. The Wellbeing area of the app provides structured education modules on topics including stress management, building mental wellbeing and resilience, and the benefits of meditation delivered by video and text. These are supported with behavior change tools and resources such as guided mindfulness-based meditations, classical music, 360 degree immersive guided relaxation videos and facilitated yoga classes. Guided activities are of varying lengths (approximately 7 to 24 minutes long) and are presented in video and podcast format. Please see Multimedia Appendix 1 for screenshots.

On March 1, 2020, Gro Health was updated to include education around minimizing the risk of infection and spread of COVID-19, in response to the feedback from users. The education syllabus can be seen in Table 1. The digital platform also provides digital tools for self-monitoring data activity (steps, distance), weight, blood pressure, heart rate, mood, food intake, body weight and blood glucose levels. Participants can converse with coaches should they have questions and speak to peers in a moderated peer-to-peer community. Weekly automated feedback is provided to users based on their use of the program through email notifications, and participants are notified weekly to engage within the app. Prior studies demonstrate that peer support may help prevent stress and burnout, anxiety, and symptoms of depression. [40-43] The platform encourages social support by recommending discussions and based on those posted by people with similar demographics including age, gender, and their self-selected goal.

#	Title	Learning objectives
1	**Safety Notes**	To ensure appropriate clinical safety context was provided and understood

2	**Introduction to COVID-19**	To understand what COVID-19 is, its origins and current understandings
3	**Symptoms of COVID-19**	To define the symptoms of COVID-19 with the latest available evidence.
4	**How to stay safe / preventing catching and spreading virus**	To understand protocol around social distancing
5	**Washing your hands**	To ensure washing hands is efficient and being completed often with the most effective technique
6	**What to do if you feel unwell**	To understand the latest protocol for illness during COVID-19
7	**If I catch Coronavirus will I get better?**	To share the latest available information about COVID-19, in particular the recovery rates
8	**What to do if you need to go to hospital or see a doctor**	To understand the latest protocol for hospital/doctor appointments during COVID-19
9	**Living in self-isolation**	Creating a routine to support social distancing while self-isolating (e.g food delivery services)
10	**Managing stress**	Understanding steps that can be taken to minimise stress levels during COVID-19
11	**Mindfulness**	Utilising mindfulness-based practices to support wellbeing
12	**Mental wellbeing**	Understanding steps that can be taken to support mental and emotional wellbeing during COVID-19
13	**What is meditation?**	Understanding what meditation is and how it could be incorporated into a daily routine

Table 1: Syllabus of the in-app COVID-19 program within Gro Health

The content and strategies used in the program are reviewed by primary care physicians and build off prior research and theory. [21] The program encourages participants to select a goal on registration (e.g. lose weight, improve fitness, healthier life for family, reduce stress, improve dietary choices, to be happier, improve a health condition). Participants are periodically prompted to consider how close they are to attaining their goal.

Study design

The study used a quasi-experimental research design consisting of an open-label, single-arm, pre-post intervention. The study obtained ethics approval via the Royal Holloway, University of London ethics review board. Participants were not paid for their participation and accessed the Gro Health app for free. Participants downloaded the app and agreed to the Gro Health app Terms of Service and Privacy Policy, which included consent to use anonymized data for research purposes. Minimal de-identified data required for the study was used.

Participants

We took a convenience sample of 347 members aged 22 to 70 (mean = 49.6, SD= 9.24) who signed up to the Gro Health app between February 26, 2020 and March 27, 2020. Just over half of participants were female (59.3%, 162/273). All participants were based in the United Kingdom, 40.3% (110/273) participants were in full time employment, 68.1% (186/273) were white and 219 participants (80.2%) reported being obese. An a priori power analysis using G*Power 3.1 indicated that a sample size of 270 people would be sufficient to detect a medium effect size (r = .3) with 80% power using a linear bivariate regression with an alpha of .05. Thus our proposed sample size of N = 347 was more than adequate for detecting an effect of the linear predictor (wellbeing engagement) separately on the outcomes of PHQ, GAD and PS change.

See table 2 for baseline characteristics Figure 1 for the participant flowchart of the study. At baseline, mean age was 49.6 years (SD 9.2).

Characteristic	**Pooled (n=390)**
Age (years), mean (SD)	49.6 (9.2)
Gender, n (%)	
Male	111 (40.7)
Female	162 (59.3)
Employment, n (%)	
Full-time employment	110 (40.3)
Part-time employment	65 (23.8)
Retired	82 (30.0)
Student	1 (0.4)
Unemployed	15 (5.5)

Table 1: Baseline characteristics of participants

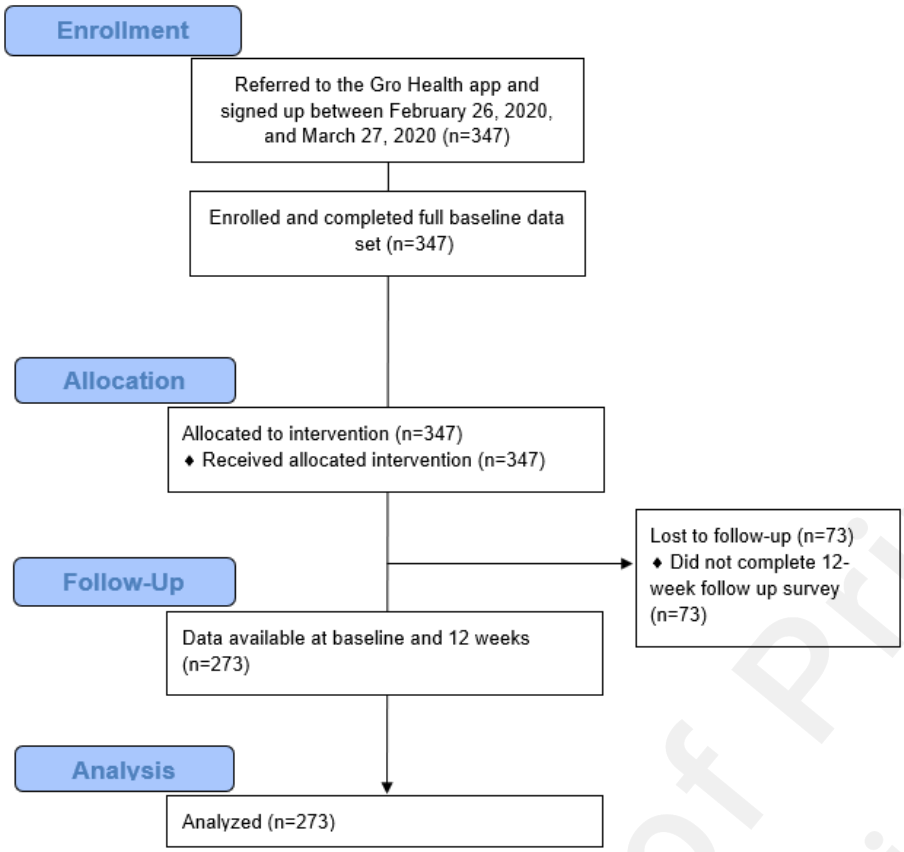

Figure 1: Participant flow chart for this study.

Measures

On sign up to the app (baseline) participants were asked to report on their age, gender, health goal and diagnosis of any pre-existing health conditions; and asked to complete the Generalised Anxiety Disorder Assessment (GAD-7), Patient Health Questionnaire (PHQ-9), and Perceived Stress Scale (PSS). At 12 weeks, participants were again asked to complete the same scales; GAD-7, PHQ-9, and PSS in the same format. Engagement with the Gro Health app was monitored and recorded as the total number of minutes of active engagement with the app recorded across the 12-week study period. Of the 347 participants to have full baseline data, 273 (78.67%) people completed the follow-up surveys at 12 weeks (N = 273).

Statistical analyses

Analyses were performed using the SPSS version 22.0 (SPSS Inc, Chicago, IL, USA). Firstly, paired-sample t-tests were utilized to compare mean changes in the three outcome measures as measured by GAD-7, PHQ-9 and Perceived Stress Scale between baseline and follow up. Secondly, a linear regression analysis was used to calculate how in-app engagement in the wellbeing area of the app (minutes) predicts participants' change in mental health status; change in anxiety, depression, and perceived stress scores. Change scores for anxiety were calculated by subtracting follow-up anxiety scores from baseline anxiety scores, with a positive calculated score indicating a reduction in anxiety. Depression and stress change scores were calculated in the same way. To control for potential effects of demographics and other health-related variables, age, gender, and COVID-19 self-diagnosis were included in the regression as control variables. Occupation status and ethnicity, as multi-categorical variables, were used as factors in one-way ANOVAs with the three outcome measures. Bonferroni post-hoc tests followed up any significant effects. Relevant statistical assumptions were assessed prior to the analysis. The normal distribution of the outcome measures was met, indicating the data was suitable for

parametric analyses. Additionally, the assumptions of independence and normal distribution of residuals, linearity and homoscedacity were tenable, meaning the data was appropriate for a linear regression analysis.

Results

Of the 273 study participants who completed both the baseline and follow up surveys, 12.1% (33/273) reported that they had received a positive diagnosis of COVID-19. App engagement was measured through total minutes-of-use, an analytic indicator used in prior studies to evaluate the effective engagement of digital health apps. [44-45] The mean number of engaged minutes with the Wellbeing area of the Gro Health app was 36.74 minutes (SD 25.9) recorded during the 12-week study period.

Changes in depression

Across the 12 week study period there was a statistically significant change in PHQ-9 scores of 2.33 (SD 2.97), reducing by 32.95% from an average score of 7.07 (SD 4.62) at baseline to 4.74 (SD 3.82) at follow up, $t(272) = 15.6$, $p < 0.001$, 95% CI [2.04, 2.63].

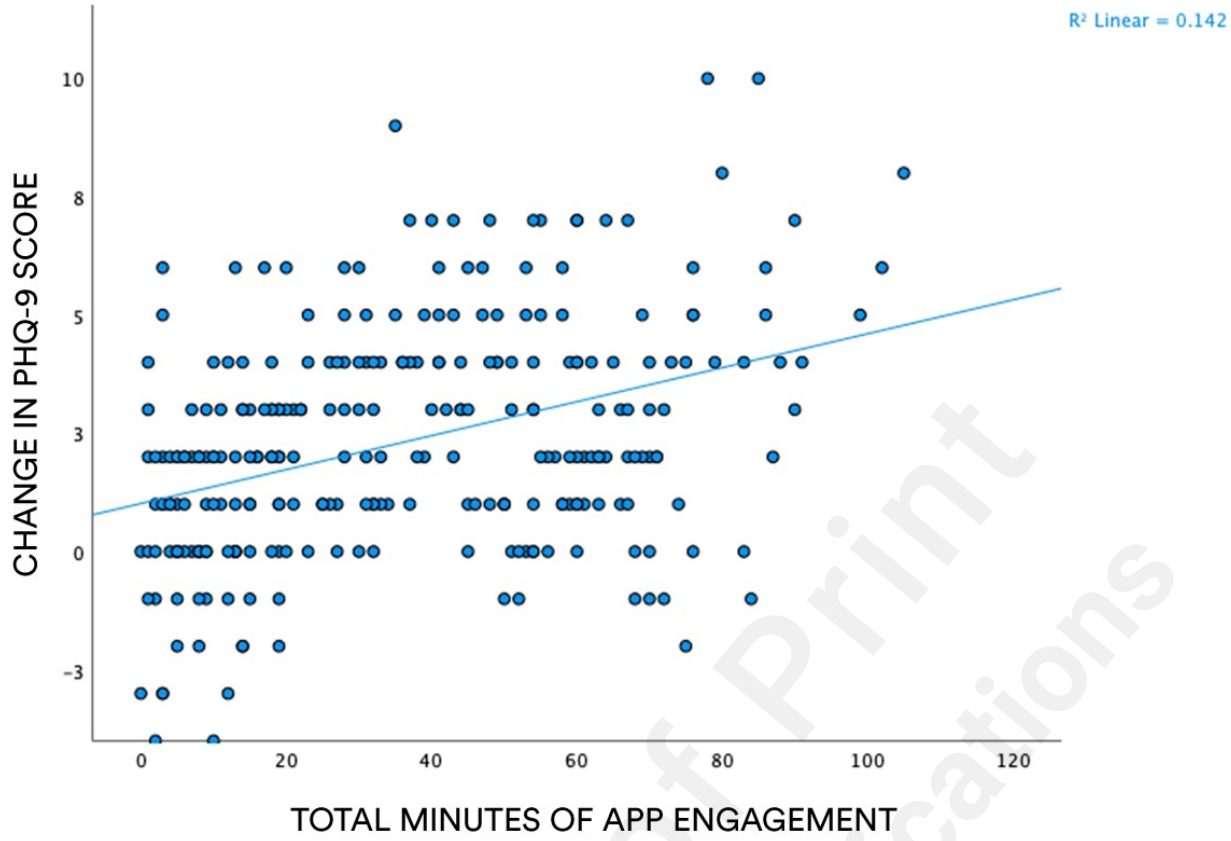

Figure 2: Correlation between Gro app wellbeing engagement and pre- post-test difference in PHQ-9 scores.

As shown in Figure 2, a positive relationship exists between wellbeing engagement and change in PHQ-9 scores. This suggest that individuals who engaged for more time with the app also experienced the greatest reduction in markers of depression. A simple linear regression was calculated to predict participants change in PHQ-9 scores based on wellbeing engagement, whilst controlling for demographic and health-related variables. Demographic variables (age, gender) and health-related variables (COVID-19 diagnosis) were entered into the model first as controls, with Gro Health app engagement entered into a separate block as the predictor variable. The final model significantly accounted for 19.5% of the variance in PHQ-9 change scores, $R = .442$, $R^2 = .195$, $F(1, 271) = 10.74$, $p < 0.001$. Wellbeing engagement significantly positively predicted PHQ-9 change scores $\beta = .378$, $t = 6.8$, $p < .001$, 95% CI [.026, .046], and accounted for 14% of variance in PHQ-9 change scores when controlling for the demographic and prior COVID-19 diagnosis. For every additional minute of engagement with the app, PHQ-9 change scores increased by B = .036, meaning participants' depression decreased when using the app.

A second linear regression was conducted to see if wellbeing engagement would predict PHQ-9 change scores in participants with higher levels of depression (N = 50), (i.e., those who scored >= 12) [38]. The regression indicated that like the previous analysis, wellbeing engagement significantly positively predicted PHQ-9 change scores $\beta = .488$, $t = 3.654$, $p < .001$, 95% CI [.021, .073], and accounted for 21% of variance in PHQ-9 change scores, when controlling for the demographic and prior COVID-19 diagnosis. For every additional minute of wellbeing engagement with the app, PHQ-9 change scores changed by B = .047, meaning participants with higher engagement levels within the app saw a greater improvement in their PHQ-9 score.

Changes in anxiety

Across the 12 week study period there was a statistically significant change in GAD-7 scores of 2.18 (SD 2.26), reducing by 31.82% from an average score of 6.85 (SD 3.25) at baseline to 4.67 (SD 3.08) at follow up t(272) = 15.9, p < 0.001, 95% CI [1.91, 2.45].

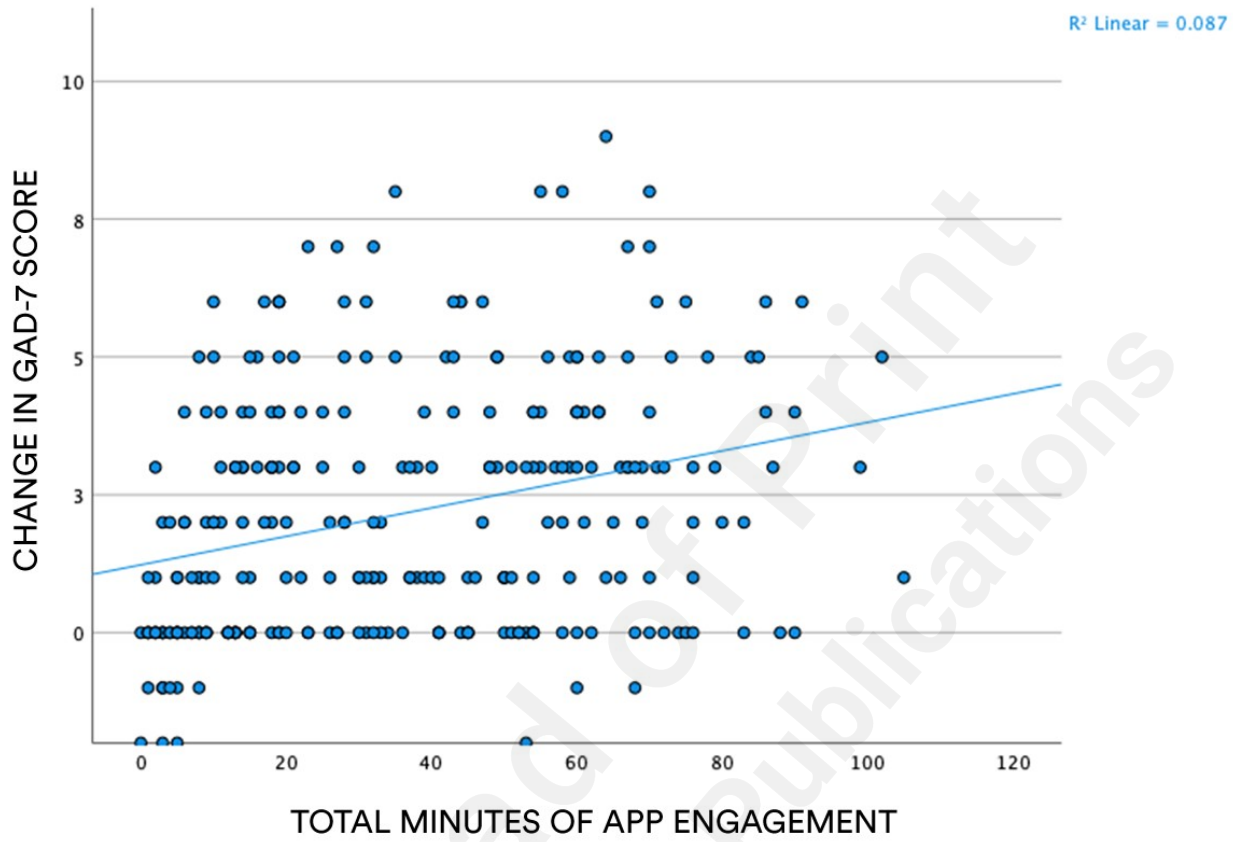

Figure 3. Correlation between Gro app wellbeing engagement and pre- post-test difference in GAD-7 scores

As can be seen in Figure 3, a positive relationship exists between total minutes of app engagement and change in GAD-7 scores, suggesting that as expected, those individuals who engaged more with the app were also those who experienced a greater reduction in anxiety.

A simple linear regression was calculated to predict participants change in GAD-7 scores based on Gro Health app engagement, whilst controlling for demographic and health-related variables. As before, demographic and health related variables were entered into the model first, followed by the Gro Health app engagement data. The final model significantly accounted for 11.9% of the variance in GAD-7 change scores, R = .345, R^2 = .11.9, F(6 ,272) = 5.977, p < 0.001. Gro Health app engagement significantly positively predicted GAD-7 change scores β = .287, t = 4.938, p < .001, 95% CI [.015, .035], and accounted for 8% of variance in GAD-7 change scores, when controlling for the demographic and prior COVID-19 diagnosis. For every additional minute of engagement with the app, GAD-7 change scores increased by .025, meaning participants' anxiety decreased when using the app. COVID-19 self-diagnosis β = .137, t = -2.3, p < .01, 95% CI [.138, 1.772] predicted GAD-7 change scores. Individuals self-diagnosed with COVID-19 had greater reduction in anxiety scores (GAD-7) (B = .955) after app engagement compared to those not self-diagnosed.

Changes in perceived stress

Across the 12 week study period there was a statistically significant change in perceived stress scores of 4.13 (SD 3.03), reducing by 23.95% from an average score of 17.24 (SD 3.43) at baseline to 13.11 (SD 2.87) at follow up, t(272)=22.4, p<0.001, 95% CI [3.77, 4.5].

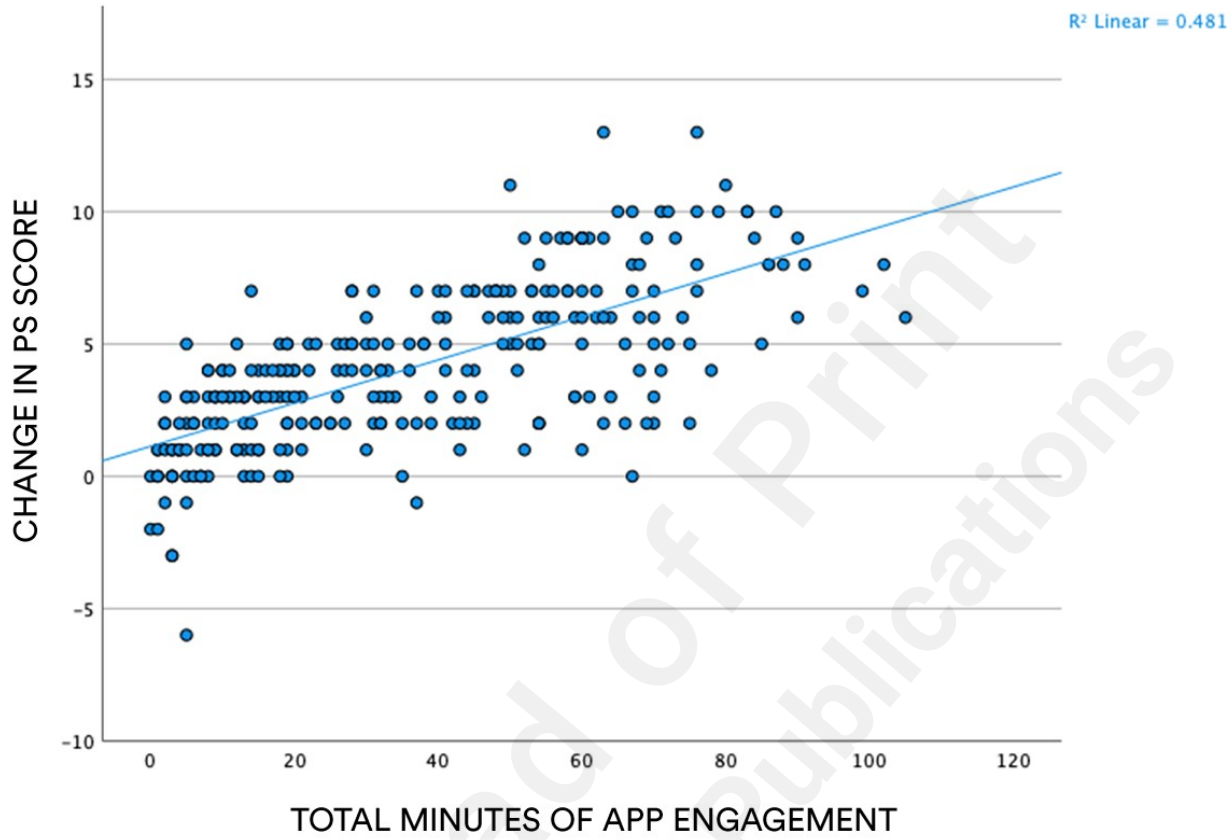

Figure 4. Correlation between Gro app wellbeing engagement and pre- post-test difference in PS scores

As described in Figure 4, a positive relationship exists between total minutes of app engagement and change in PS scores, suggesting that as predicted, those individuals who engaged more with the Gro Health app were also those who experienced a greater reduction in stress.

A simple linear regression was calculated to predict participants' change in perceived stress scores based on Gro Health app engagement while controlling for demographic and health-related variables. Like the previous analyses, demographic and prior COVID-19 diagnosis were entered into the model first, followed by the Gro Health app engagement predictor. The final model significantly accounted for 49% of the variance in PS change scores, R = .70, R^2 = .49, F(6 ,272) = 42.61, p < 0.001. Gro Health app engagement significantly positively predicted PS change scores β = .684, t = 15.461, p < .001, 95% CI [.07, .091], and accounted for 45.8% of variance in PS change scores when controlling for the demographic and prior COVID-19 diagnosis. For every additional minute of engagement with the app, PS change scores increased by .081, meaning participants' stress decreased when using the app.

A series of one-way ANOVAs were conducted to explore the potential effect of employment status on PHQ-9, GAD-7 and PS changes scores. The only significant effect found was for PS change scores F(2, 270) = 4.969, p < .01. A Bonferroni post-hoc comparison revealed that PS change scores were significantly greater for retired participants (5, SD 3.07), compared to part time and full time individuals (3.78, SD 3.05, p < .01). Therefore, those who were retired had greater improvements in perceived

stress compared to those in employment. A series of one-way ANOVAs were conducted to explore potential differences in PHQ-9, GAD-7 and PS changes scores as a function of ethnicity. The only significant effect found was for PHQ-9 changes scores F(3, 269) 12.5, $p < .001$. A Bonferroni post-hoc test found that people of white ethnicity (1.76, SD 2.25) had significantly smaller PHQ-9 change scores compared to participants of mixed ethnicity (4, SD 1.52, $p < .001$), and compared to individuals of Indian and Asian ethnicities (3.45, SD 2.88, $p < .001$). Participants of mixed ethnicity had the greatest improvement in depression overall. Overall, Gro Health app engagement had the greatest impact on reducing stress scores (PS change).

Discussion

Results are consistent with prior research on the use of digital health interventions for mental health showing improvements in symptoms of perceived stress, depression and anxiety. [46-48] Over three-quarters (78.67%, 273/347) of participants who signed up to the Gro Health app completed both baseline and follow up surveys. There were statistically significant interactions between app engagement and change in mental health scores with the greatest effect being in perceived stress scores.

The findings indicate that digital health solutions such as Gro Health which provide mental wellbeing resources could be of significant benefit when provided at-scale to help address the growing mental health crises faced by global health services in the wake of COVID-19. [49-50]

There were greater changes in perceived stress scores in participants who were retired compared to the rest of the population. The results from this research contradict prior evidence on the differences in employment status during the COVID-19 pandemic on mental health and wellbeing. Prior research evaluating employment and mental health during the initial stages of the pandemic, found that when compared with their counterparts, individuals who were employed at the start of the pandemic reported lower levels of mental health distress, higher levels of psychosocial well-being, better overall quality of life, and lower levels of overall loneliness, social loneliness, and emotional loneliness.[51] Further research should explore the variances in impact of this intervention in different employment groups.

There were differences in the impact of the app on depression scores between ethnic groups. Individuals of Indian or Asian ethnicity reported greater improvements in depression scores. This may be due to several factors including that mindfulness-based approaches may be more acceptable due to their grounding in eastern traditions.[52] Additionally, these results support prior research demonstrating that to engage people of various cultures and ethnicities within digital health solutions, they must be adapted to satisfy individual needs.[53]

Individuals self-diagnosed with COVID-19 had greater reduction in anxiety scores after engaging with the app compared to those not self-diagnosed. Further research should explore whether the behaviour change techniques provided by the app may help the longer-term mental health crisis that may occur in the aftermath of the pandemic both in those with a prior diagnosis of COVID-19 and those living with long-COVID.

Limitations

Our study has several limitations. We encouraged participants to engage in guided activities, however, we did not control for participants using other functionality of the app alongside the mental wellbeing tools. We also measured health outcomes (PHQ-9, GAD-7, Perceived Stress Scale) using a patient self-report, rather than measuring them through medical records. However, previous research has found that these self-reported health outcomes can be quite close to actual values. [54] Similarly, patterns of engaged minutes were not analyzed. Although outside the scope of this study, further analysis should

examine if patterns of app engagement impact the levels of change in mental health scores.

This was not a randomized controlled trial, so we cannot compare the 12-week results to a control or standard-of-care group. Therefore, the results of our trial should be interpreted cautiously because the study used convenience sampling, a single-arm design and pre-post self-reported outcomes. Criticism of convenience sample use is the lack of control over potential intervening variables (such as other stress mitigating or mental wellbeing boosting activities) that active participants may have been engaging in. Since the sample is not representative of the population, the results of the study cannot speak for the entire population. The study results have low external validity. However, a significant proportion of participants were from hard-to-reach populations (e.g., retired, unemployed, ethnic groups) or diagnosed with type 2 diabetes, hypertension or high cholesterol. Individuals with these health conditions are more at-risk of COVID-19 and its complications which makes this sample of particular interest.[55]

The sample contained 33 participants who self-reported a COVID-19 diagnosis. As the research context is set in the pandemic, ANCOVA tests were conducted to evaluate if app use had a greater effect on those who had COVID-19. The results are mixed. When app engagement time is controlled, there is a statistically significant difference on GAD-7 ($p = 0.004$) between the two groups, but not on PHQ-9 and PSS.

Despite several limitations, the study suggests a digital platform that provides remote mental wellbeing support can be extremely effective in managing depression, anxiety and perceived stress during times of crisis such as the current COVID-19 pandemic. Future studies with 6- and 12-month post-tests will provide a stronger assessment of the impact of the intervention on mental health outcomes.

Further research should explore the most appropriate mechanisms by which to scale such digital health interventions to help manage and mitigate the mental health demands that will inevitably follow a national pandemic such as COVID-19. [49-50] Additional research should also explore the use of the intervention in patients diagnosed with long-COVID. Emerging evidence suggests 20% of patients diagnosed with COVID experience symptoms of long-COVID, including anxiety, breathlessness, and fatigue. [56] Further research should explore whether the behaviour change techniques provided in the Gro Health app could also help alleviate the symptoms or burden of long-COVID.

Although our design does not support causal conclusions, further research should investigate the particular in-app guided activities that are impactful on users' perceived stress, depression and anxiety scores. In addition, it is important to conduct further research into identifying for which participants self-guided digital interventions may be sufficient in supporting mental wellbeing, and those who may need triaging to additional face-to-face or intensive support.

Conclusion

A digital platform providing remote mental wellbeing support (Gro Health) can be effective in managing depression, anxiety and perceived stress during times of crisis. such as the current COVID-19 pandemic. Further research should explore how best to implement such digital health solutions at scale to mitigate the burden on national health services during pandemics.

Acknowledgements
We thank Dr Peter Foley for his medical governance and support.

Conflicts of interest
CS is employed by DDM, which operates the Gro Health app. The rest of the authors declare no conflicts

of interest.

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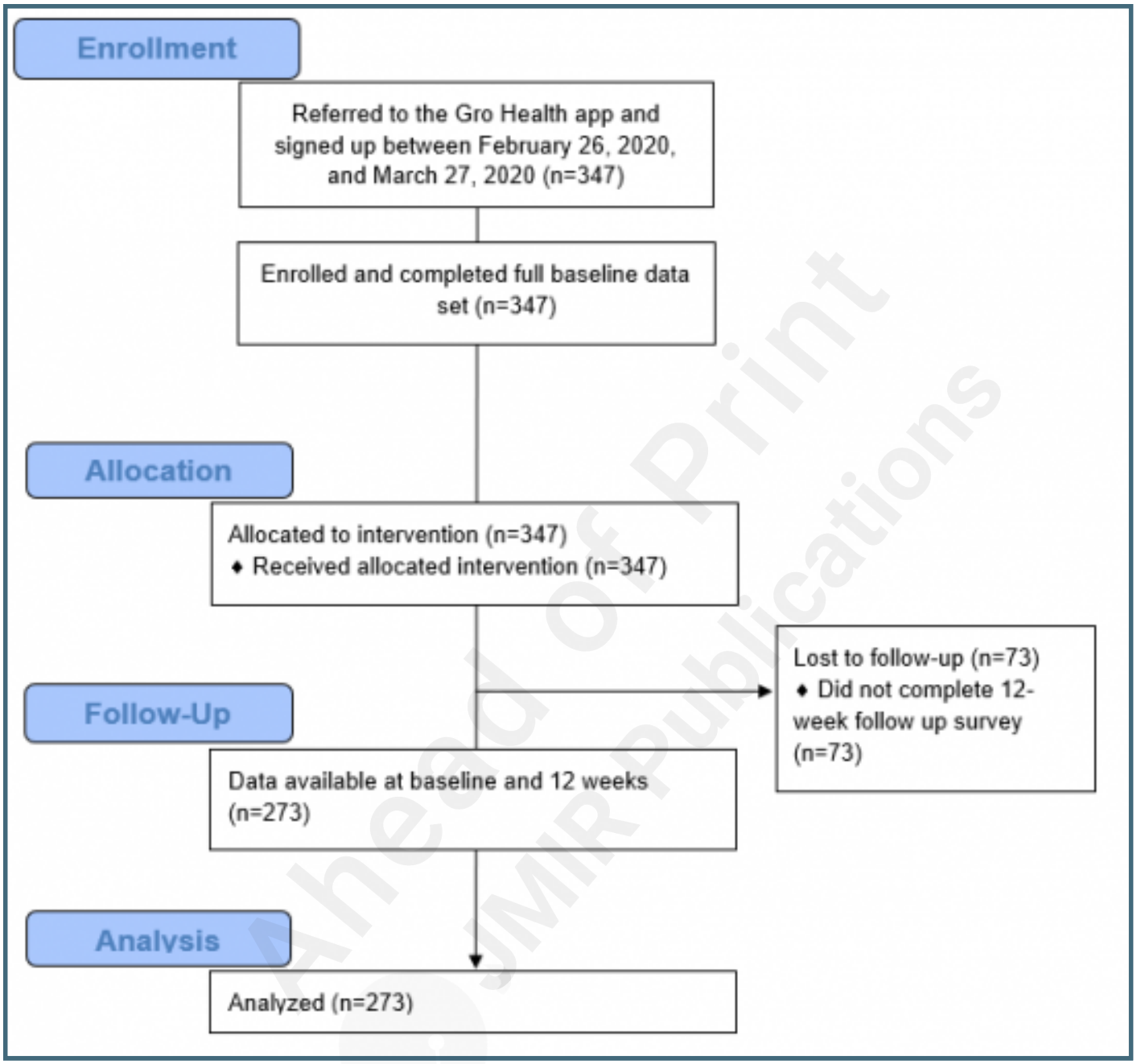
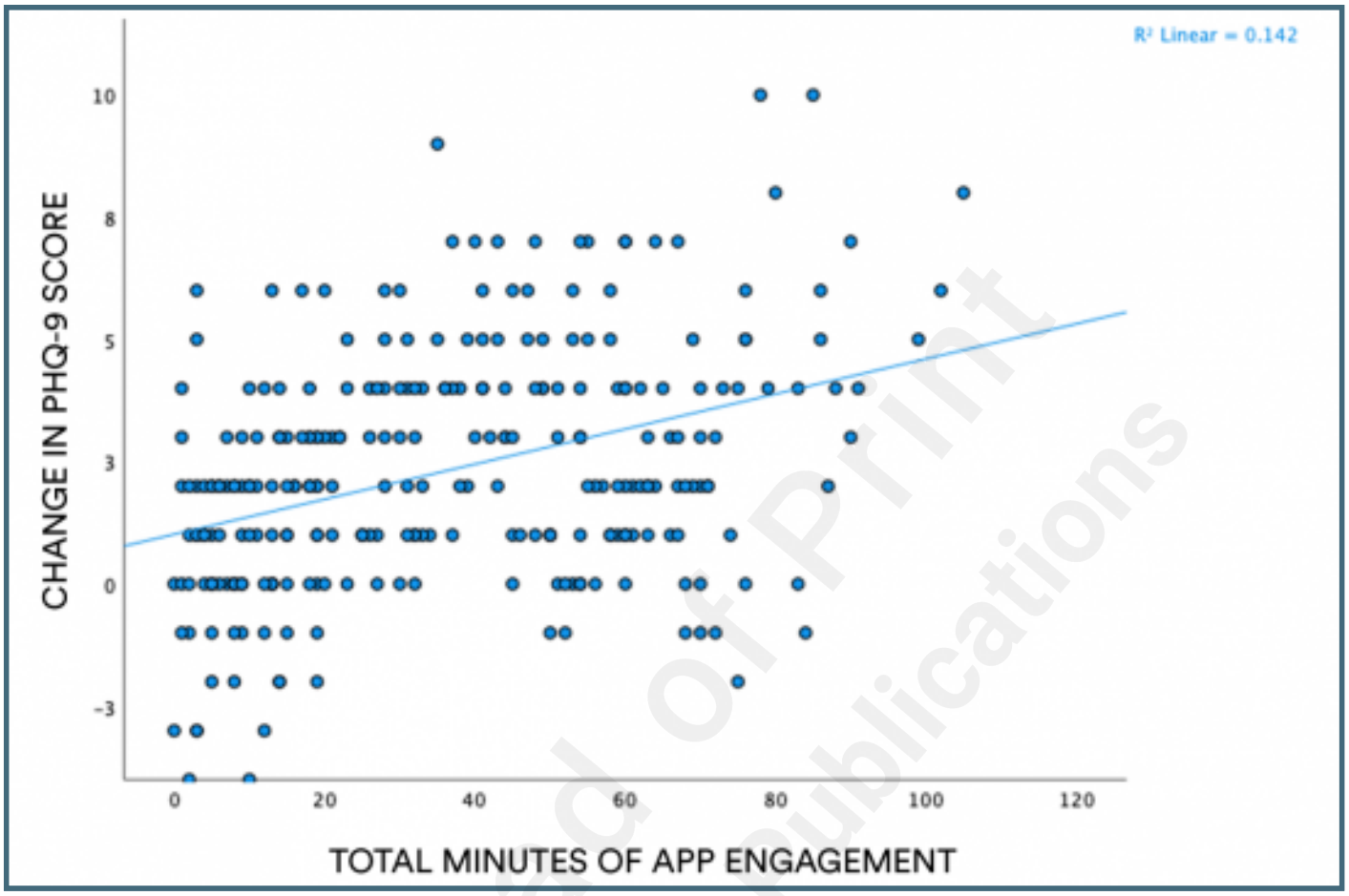
Supplementary Files

Figures

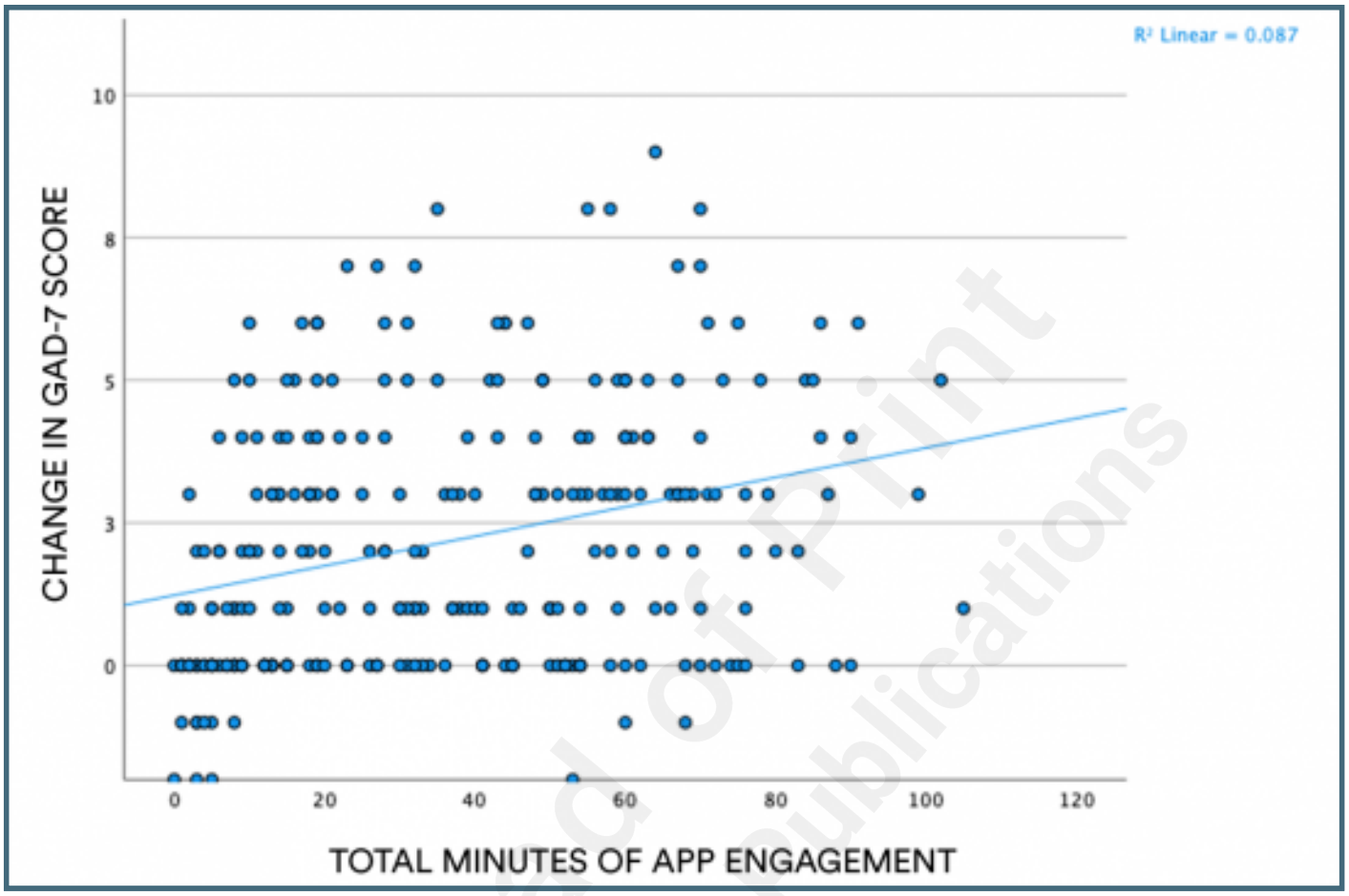
Participant flowchart.



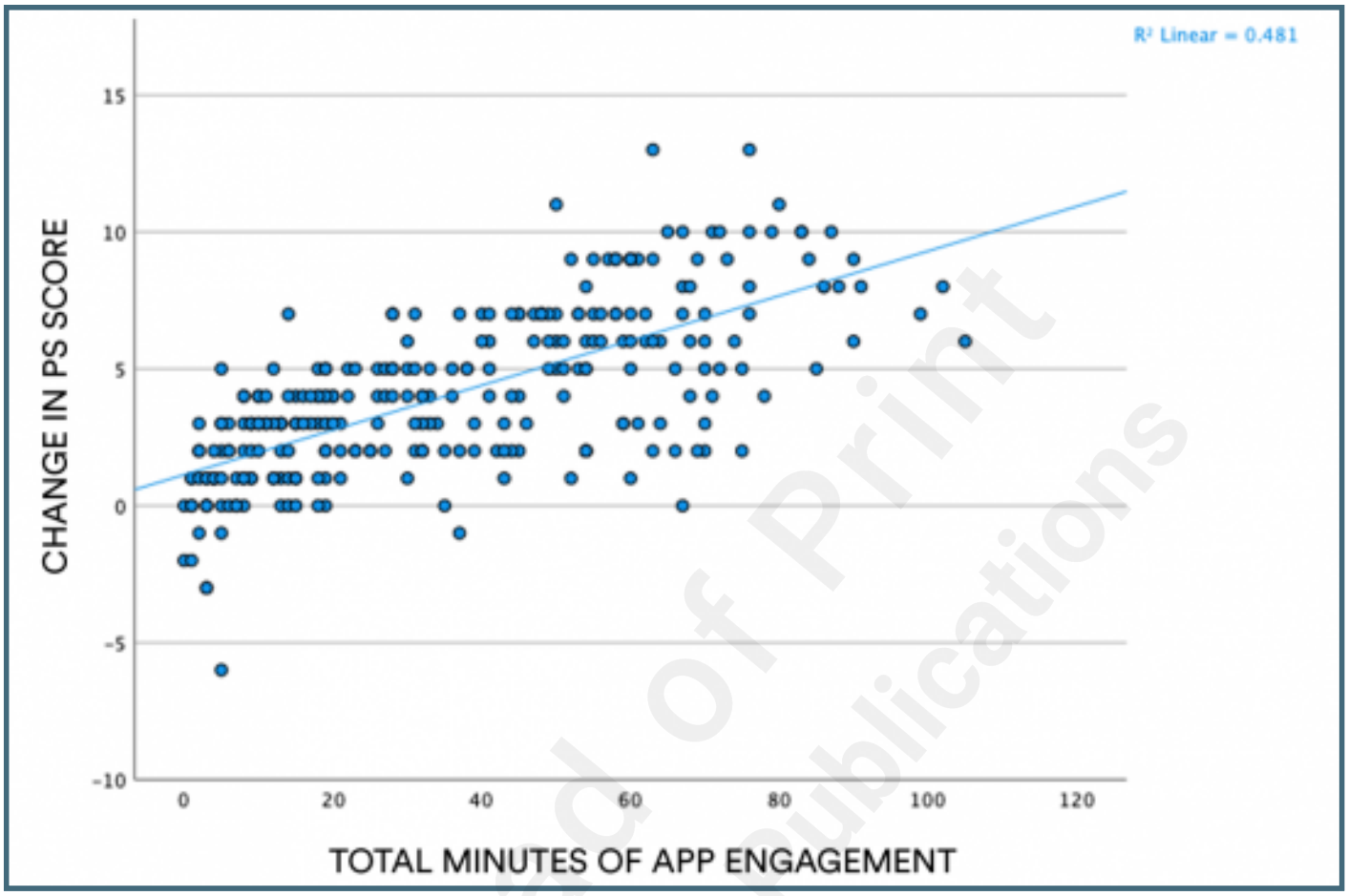
Scatter plot showing total minutes of engagement in wellbeing area of the Gro Health app and pre- post-test difference in PHQ-9 score.



Scatter plot showing total minutes of engagement in wellbeing area of the Gro Health app and pre- post-test difference in GAD-7 score.



Scatter plot showing total minutes of engagement in wellbeing area of the Gro Health app and pre- post-test difference in PS score.



Multimedia Appendixes

App screenshots - wellbeing area, education lesson and mindfulness-based behaviour change activity.
URL: http://asset.jmir.pub/assets/cc0bbd623deff3a87f616c6f97d630ca.png

TOC/Feature image for homepages

Person using Gro Health app.