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Assessing the acceptability of a text messaging service and smartphone app to support patient adherence to medications prescribed for high blood pressure: a pilot study.

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Abstract

Aims and objectives. This paper describes the pilot study of a highly tailored text message and smartphone app intervention to increase adherence to anti-hypertensive medication in primary care. The aim of this study was to evaluate the acceptability of the intervention and obtain patients views about the intervention content, the delivery mode, and the mechanisms by which the intervention supported medication adherence.

Methods. Patients diagnosed with hypertension were invited to the study via general practice text message invitation and recruited face to face by the researcher team. Participants tested the text message intervention for 28 or the text message followed by the app for 56 days. Participants completed baseline and follow up questionnaires and took part in a weekly or end of intervention telephone interviews. Digital log files captured patients' usage of the intervention. Participant transcripts were analysed using thematic analysis. Descriptive statistics were used to summarize data from questionnaires and log files. A mixed methods analysis generated data to respond to the research questions.

Results. 79 patients expressed their interest to participate in this study and 23 of these patients were recruited to take part. With one drop-out, 22 participants tested the text message delivery mode (with 20 being interviewed) and four requested to switch to the app (with 3 being interviewed). All participants used and engaged with the text message and app notifications, and most participants found the intervention content and delivery mode acceptable. They also self-reported that the intervention supported them to take their medications as prescribed.

Conclusion. This study provides evidence that the digital intervention is acceptable by hypertensive patients recruited in primary care, thus it should be tested for its effectiveness using rigorous research methods.

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Introduction

In England, over 12.5 million people are diagnosed with hypertension (high blood pressure; HBP [1]. High blood pressure is a major risk factor for developing serious long-term comorbid illnesses, decreasing quality of life, and increasing premature death [2]. Taking anti-hypertensive medication as prescribed can significantly reduce these risks [3]; however, studies have found that a substantial proportion of patients do not take their medication as prescribed. For example, a recent meta-analysis showed 41% of people do not adhere adequately to antihypertensive medications i.e. take less than 80% of a patient's prescribed tablets [4].

Non-adherence contributes to increased hospital admissions, additional consultations, referrals, investigations and medicine wastage. Improved adherence could save of just over £100 million per year,

thus National Institute for Health and Care Excellence (NICE, 2009) recommend novel interventions for medication adherence should be developed and tested [5].

Digital interventions such as text messaging and downloadable applications on smartphones (apps) are promising ways to provide advice, reminders, encouragement, and to support patients to take their tablets as prescribed. Sending and receiving text messages still remains a popular mode of communication in the United Kingdom (UK) (over 82 billion text messages sent in 2017) and using a smartphone has risen from 27% of adults in 2001 to 78% of adults in 2018 [6]. Our recent meta-analyses suggested that automated telephone-based interventions, including text messages [7] and/or apps [8] double the odds for adherence to medication. Our recent feasibility trial supported that digital interventions are feasible and effective to improve adherence as an adjunct to primary care consultations [9].

This study aims to build on our previous promising findings and pre-test a low-cost text messaging service followed by a mobile app to provide reminders and highly tailored advice messages to support medication adherence in patients with hypertension. To our knowledge, no other text message followed by a smartphone app intervention has been pre-tested to address non-adherence to medication within the UK primary care setting.

Qualitative and quantitative data collection were integrated into a mixed methods analysis to answer our primary research question: Is an individually tailored text messaging service followed by a smartphone app, acceptable to support medications adherence by high blood pressure patients? Our secondary research questions were to explore the acceptability of several components of the intervention content and delivery mode functionalities, and the mechanism by which these might have influenced medication taking behaviour.

Methods

Recruitment methods and procedure. Primary care practices were initially approached by the Clinical Research Network for Eastern England. We aimed to recruit, and succeeded in recruiting, three General Practices for this study. The three practices were located in Eastern England and were from diverse deprivation areas. Patients were deemed eligible to participate in this study if they a) had a diagnosis of hypertension (i.e. high blood pressure; HBP, b) were prescribed at least one antihypertensive medication for a duration of at least three months before recruitment, c) had poorly controlled hypertension (e.g. >140/90 mmHg; for a period of six months before recruitment), d) were aged 18 years or older, e) had a good understanding of English, f) own and use a mobile phone regularly, g) and had the capacity to provide informed consent. We aimed to recruit 25 participants to respond to our research questions.

Across the three recruited practices, a total of 1,340 patients eligible to take part in this study were identified, and a text message invitation to take part in this study was sent to all 1,340 eligible patients. Text message invitations were preferred over traditional postal invitations as text messages allow for quick, mass distribution to eligible patients, and are also much more cost-effective and environmentally friendly than postal invites. In total, 79 patients responded to the text message invitation with an interest

to participate, 54 of whom in the first 2 days. From those, 23 patients were deemed eligible to participate and enrolled in the intervention during a baseline meeting with a member of the research team. During recruitment meetings, a member of the research team explained to the patient the study activities, answered questions, and obtained written informed consent. Two researchers conducted the recruitment meetings from January until March 2019.

Intervention. Participants were provided with the option to receive either one-month text message intervention or two consecutive months of testing text message followed by the smartphone app. All patients were asked whether they would like to switch from a text message to the one-month app intervention, after they have completed the text message intervention.

Participants' received daily reminder messages (reminding participant to take the medication they indicated they would like to be reminded about, at the time they indicated to be reminded at), daily advice messages (messages of advice and tips regarding medication adherence), and query messages (a message enquiring if the participant took all their prescribed medication as prescribed and to answer with 'yes' or 'no').

Data collection methods and procedure. Data were collected using questionnaires, telephone interviews, and digital log files.

Questionnaires. Questionnaire asked questions regarding patients' adherence to medication, their beliefs about medication adherence, and their medication-taking routines. The baseline questionnaire also asked questions which were more specific to the patients' prescribed medications (e.g. name of medications and dosage), which time they would like to receive the intervention messages, as well as demographic questions. Patients' answers to the baseline questionnaire were used to tailor the content of the text message and app notifications. Patients completed questionnaires at baseline and at the end of the intervention. End of intervention follow up questionnaires obtained views about the acceptability of the intervention. Baseline questionnaires were completed during the recruitment meetings and follow up questionnaires using an online webpage, which was emailed to participants.

Interviews. Semi-structured interviews were chosen due to its nature of extracting in-depth accounts of participant experiences, thoughts and beliefs as well as the detailed answers provoked through the researcher's use of open-ended questions, prompts and freedom to ask the participants to either to clarify or to expand on areas of interest [10].

During the interviews, a member of the research team used a semi-structured interview guide to prompt patients' views about the intervention content and delivery modes and obtain recommendations for improvement (please see Appendix 1 and Appendix 2 for semi-structured interview guide). The participant had been provided with the option of a weekly 15-minute telephone interviews or one hour-long telephone interview at the end of the intervention. Seventeen patients opted for the weekly calls, and the other five for the interview at the end of the trial period. Interviews were audio-recorded, and the audio files were

transcribed by a third-party company. Patients who could not attend the interviews (n=1) provided their feedback using emails. Interviews were conducted from February until April 2019.

Collecting the data at more frequent time-points (weekly calls) is a unique and novel exploration form of data collection method in comparison to one-to-one interviews with participants at the end of the trial period. In qualitative research, the richness of data is commonly more important than the frequency of collecting it. However, at the time of writing this paper, no literature compares qualitative research using one data collection time-point per participant (e.g. one-to-one interview at trial end) against more frequent data collection points for each participant (e.g. weekly one-to-one interviews for the duration of the trial). Thus, whilst rich datasets are strived for by qualitative researchers, we have no knowledge of how the frequency of data collection may uniquely encourage or dissipate the depth of information divulged by participants.

Moreover, major characteristics of traditional qualitative research include discovery, exploration, and hypothesis generation [11]. Therefore, it may stand to suggest more frequent data collection time-points will generate the opportunity, and thus the ability, for the researcher to explore each participant's viewpoint in more depth, and to discover underlying concepts which would not have been accessed during a singular data collection time-point.

Additionally, qualitative research allows for the researcher to identify and analyse dynamic processes related to the study phenomenon, such as sequential patterns and change over the course of a trial. Therefore, it may be possible that more frequent data collection points would greatly support the identification of dynamic processes as weekly data collection points could capture evolving participant thoughts and experiences in parallel to their formation [11,12].

Lastly, frequent data collection time-points may also aid the identification of dynamic processes as the researcher collects data from participants throughout the duration of the study, meaning the participant may be less likely to forget some of their thoughts, opinions, or recommendations. Taking a month-long study as an example, participants may forget their initial reactions they experienced at the beginning of the trial when asked to describe them in an interview at the end of their participation. However, in a study with weekly data collection time-points, it is possible to capture participant thoughts and opinions within its present context as opposed to potentially weeks later, thus deriving more detailed, richer data from each participant. Therefore, this novel and unique data collection method was utilised in this research in an exploratory attempt to uncover richer data from participants regarding their pre-testing of the text messaging service and/or app.

Digital log files. The usage of the intervention was captured by digital log files. Digital log files captured whether and what intervention content participants received and interacted with (e.g. reported whether or not the medication was taken, check feedback on adherence to medication, used app settings to tailor message delivery). The log files are a document detailing each participants' recorded actions and responses whilst using the digital intervention and were used as support for the qualitative data generated from participant interviews and as independent evidence which provides a narrative of

intervention usage and engagement from different participants. Data from log files were extracted by a member of the research team and integrated into the analysis.

Analysis

Two members of the research team used thematic analysis and analysed all patient interview transcripts independently, coding for emerging themes aimed to provide answers to our research questions. The two researchers compared notes and codes for each interview transcript and made a mind map to visually link quotes and codes to one another. The two researchers (C.A.C and A.K) discussed in depth themes that had emerged from the data, and different interpretations of each theme. Nvivo software was used to facilitate data analysis.

Data from log files were coded by a member of the research team. Data obtained from questionnaires and digital log files were summarized using descriptive statistics. A mixed method approach was used to synthesize data to provide answers to our research questions.

Results

Seventy-nine patients answered to the text message invitation and expressed their interest to participate in the study (5.9% response rate to invitation), of whom 23 patients were contacted and signed the consent form to participate. All 23 initially recruited patients were given, and completed, the baseline questionnaire (100% completion rate). One patient dropped out of the study before beginning to test the intervention due to personal reasons. In total, 22 participants pre-tested the intervention: all tested the intervention for 28 days using text message and four of them selected to switch to the app and test the intervention for 56 days (see figure 1).

Twenty patients (out of the final 22 participants) completed follow up interviews (90.9% response rate) and 19 completed the follow up questionnaires (86% completion rate). The study recruited significantly more men, aged between 60 and 69, and those who are retired (see table 1).

Data analysis generated results in three main themes to provide answers to our research questions:

1. acceptability and usage of several components of the digital intervention to patients diagnosed with hypertension
2. mechanisms by which these components have supported medication adherence
3. recommendations to improve the acceptability of the digital intervention

1. Acceptability and usage of the digital intervention in patients diagnosed with hypertension

All participants interviewed (n = 20) reported that the text messaging service was easy to use (see Table 2 quote 1, and Figure 3). Similarly, patients testing the app also reported the app functionalities were easy to navigate (see Table 2 quote 2, and Figure 3).

Reminder messages. Commenting on the reminder messages, one participant thought the simple message sufficed, and also allowed for the participant to internally 'double-check' that they had taken their medication that day (see Table 2 quote 3). Most participants reported the reminder messages as acceptable and a positive aspect of the digital intervention (see figure 2 and figure 3). However, few participants reported disliking the frequency of the daily reminder messages, with one participant finding them overbearing. When asked for his suggestion on what we may do to make them less bothersome, he noted reducing the frequency of receiving these messages (see Table 2 quote 4 and 5). Both app patients have used the snooze functionality of the app to re-schedule the time of the reminder messages (see Table 3).

Advice messages. Participant opinions on the advice, non-reminder messages were much more split (see figure 2). For example, one participant attributed the varied advice messages to increasing his attention with reading the messages, and in turn increasing his attention to needing to take his medication (see Table 2 quote 6). This may be due to receiving a variety of advice messages throughout testing the digital intervention, with each message perceived to emphasise a different information regarding medication adherence. Data from digital log files suggested that participants who used the app, acknowledged or dismissed the receipt of all advice messages.

Query messages. Furthermore, the 'query' message was sent to participants asking them to reply 'yes' or 'no' as to whether they had taken all their prescribed medication. The concept of the query message arose from the behaviour change strategy of 'reporting whether or not the behaviour was performed' [13]. All participants reported to query messages and most reported that they liked these messages (see Table 3 and Figure 2). Query messages to both text message and app notifications had 100% response rate and this engagement score was maintained throughout the intervention, indicating high participant engagement with the digital intervention and acceptability of these messages.

Participant discussed the benefits of the 'feedback on behaviour' functionality on the app, which generates a percentage score of patients' self-reported medication adherence over the past day and week. Participant found this data informative and reported using it to self-monitor the peaks and dips of their medication adherence to find patterns in their medication-taking routine (see Table 2 quote code 7). Both app users requested the feedback on their self-reported behaviour by checking the app functionality, in most cases after they have self-reported medication adherent behaviour (see Table 3).

Tailor message delivery. This function allows the participant to change the time and/or date of the reminder messages, which is useful if the participant is particularly busy at the time the reminder appears. Participants tailored the delivery of the reminder messages on average 5 times. Patients have also scheduled the time and date of their refill prescription reminders on average 7 times, during 4-weeks (see Table 3). In all occasions, they tailored the delivery of the reminder messages successfully, implying the importance of including this function in the app, as well as how easy it is to use it.

Acceptability of collecting sensing data. Lastly, all participants were asked about their views on the app using GPS, WiFi and accelerometer to collect sensing data during the intervention. All participants

reported having no concerns over the security of their personal and private information being gathered through the app sensing data (see Table 2 quote 8 and 9).

2. Mechanisms by which the intervention has supported medication adherence

For some participants, receiving the query message was an opportunity to reflect on their medication-taking behaviour and raise their awareness to whether they had taken all the medication they were prescribed (see Table 2, quotes 10, 11 and 12, and Figure 3). This strategy seemed to have motivated medication taking through several ways; (a) by increasing participants' commitment to reply to the query message, (b) by raising awareness of tablet-taking routine, (c) by increasing feelings of involvement with their own medication-taking routine and (d) by empowering them to take their medications as prescribed (see Table 2 quotes 13, 14 and 15). These findings suggested that reporting behaviour is a powerful behavioural change technique, which can lead to increased performance of the target behaviour.

The importance of accessing feedback regarding medication adherence behaviour in motivating participants to change their behaviour was also suggested by participants testing the app. Both of the app testers checked this app tab immediately after successfully downloading the app (see Table 3), with one of the participants attempting to view their adherence report six times in the first day of downloading. This could be explained by an initial exploration period after first downloading the app, however the participant continued to check the tab with feedback on behaviour at least once a day for the following four days. Similarly, the other participant testing the app also attempted to view their adherence scores at least once every day for the first three days after downloading the app, implying the tab is a function that participants find interesting and an engaging feature of the app and that feedback on the target behaviour might be important to increase patients' motivation to change behaviour.

It was also found that knowing the digital intervention will send different daily advice messages may have caused an increase in the participants' attention and curiosity when interacting with the intervention, and therefore an increase in reflecting and acting upon the advice messages.

A number of participants agreed that the digital intervention may also help to increase patients' feeling of empowerment and ownership of their long-term health condition, with one participant expressing how he particularly liked one of the advice messages which encouraged patients to take responsibility for their own medication-taking routines as a self-care process. The participant reports finding this message particularly useful as it establishes a sense of ownership over the condition and motivates participants to be more self-aware of the independent responsibility they have over their health (see Table 2 quotes 16, 17, 18 and 19).

Finally, all participant discussed the importance of the digital intervention including interactive elements and reported feeling motivated to continue taking tablets regularly and as prescribed after receiving interactive messages of positive feedback (see Table 2 quote 20).

Most participants expressed preferences toward the advice messages which included positive reinforcement to take their tablets (see Table 2 quote 21). The subject of advice messages came up multiple times during the interview process for this study, specifically in the context of increasing patients' knowledge around hypertension as a long-term health condition (see Table quote 22).

3. Recommendations to improve the acceptability of the digital intervention

All patients reported that they would recommend the intervention to other people who have been prescribed medications for long term health conditions and those newly prescribed (see Figure 3), and they made recommendations to improve intervention content and delivery.

Many participants suggested receiving separate reminder messages for every medication they take each day. However, many other participants reported patients who are prescribed multiple daily medications a potential limitation to this idea, for example sending individual reminder messages to an individual who takes ten or more tablets every day will most probably be less acceptable (see Table 2 quote 23). However, another participant recommended a solution to this problem, suggesting combining the medication reminders into morning, lunchtime and evening text messages (see Table 2 quote 24).

Furthermore, one of the participants testing the app reported not knowing the existence of additional app functions, which could be used to tailor the delivery of the medication reminder until a later time of the participants' choosing (see Table 2 quote 25). The participant recommended a help guide that explains all features of the app and how to use them when first downloading the app (see Table 2 quote 26). A help guide to aid patients' navigation through the app would increase accessibility and inclusivity to patients with high blood pressure.

Participants also recommended different ways to summarize the feedback on behaviour, such as graphs or colour-coded systems, traffic light colour code systems (green = goal met; orange = room for improvement; red = goal unmet, improvement needed) which are universally understood and easy to interpret. Thus, might be accessible to a range of individuals with varying learning styles (see Table 2 quotes 27 and 28).

Moreover, the frequency of the query message was also discussed between participants, with some participants suggesting responding to the query message every day would be effortful and thought other patients wouldn't want to have to respond to their reminder message every day. However, another participant suggested receiving a daily query message, stating that it would help those with poor memory and those who experience anxiety around their medication-taking routine (see Table 2 quote 29).

Many participants suggested once a week, instead of every day, was an appropriate amount of times to receive the advice message to improve acceptability and engagement (see Table 2, quote 30). However, one participant expanded upon this idea and suggested the impact of the advice messages decreased when receiving them daily (see Table 2 quote 31), and thus receiving one or two advice messages a week

would have a more significant influence when encouraging a patient to take their prescribed medications regularly.

Clear and honest communication is needed to explain the purpose and privacy of using sensing data in the app delivery mode of this digital intervention (see Table 2 quote 32). Furthermore, some participants also suggested using the logo of the NHS or University of Cambridge to visually link the app to a trusted institution (see Table 2 quote 33).

Overall, participants suggested that the digital intervention could be an acceptable adjunct to primary care and increase satisfaction with the health care provided by GP practices (see Table 2 quotes 34 and 35, and Figure 3).

Patient and Public Involvement and Engagement. Two PPI/E members have taken part in pre-testing the intervention for one month and provided ongoing feedback using telephone, email, meetings and end of study interviews. Members of PPI have commented on the preliminary results of this study during a PPI group meeting. Two PPI members have read and made comments on previous drafts of this paper. Their input has been integrated in data analysis and discussion.

Discussion

This mixed methods study suggests that this novel digital intervention is acceptable by patients with high blood pressure, and that it supported medication adherence by improving motivation to self-monitor their medication taking behaviour and by empowering them to manage their long-term health condition.

This study aimed to pre-test the acceptability for a low-cost text messaging service followed by a smartphone app to provide reminders and highly tailored advice messages to support patients' medication adherence as an adjunct to primary care consultations. To our knowledge, no similar intervention has been pre-tested to address non-adherence to medication within the UK. Thus, this study is the first to obtain thoughts of and recommendations about the acceptability of a highly tailored digital intervention which targets adherence to medication as adjunct to primary care consultations.

A strength of this study was its unique data collection method of calling participants weekly to discuss their experiences of testing the digital intervention. Weekly interviews allowed the researcher to build a higher level of rapport with patients, which has been found to capture richer data from participants [12]. This was the case for this study also, as we were able to obtain data at four regular time-points from 15 participants, in comparison to the 4 participants who were able to be contacted for a one-hour interview at the end of the trial period and struggled with recalling their experiences of testing the digital intervention at the beginning of the trial. Weekly interviews also allowed us to reach data saturation more explicitly and quickly then using the traditional hour-long interview at the end of the trial. This was especially apparent when the structure of weekly interviews allowed participants to think about a question asked and answer the following week, therefore amassing greater in-depth answers to questions regarding participants' experiences of testing the digital intervention in the present.

Furthermore, the results of this research recommend structured advice messages to discuss different knowledge-based topics each week, and for these messages to be framed within a positive context. However, participants also had varied opinions on the frequency of receiving the advice messages, thus it is important for future interventions to allow for the frequency of messages to be tailored to individual preference. Similarly, it is important for future interventions to allow for individual tailoring of the query message frequency. Some participants thought replying to the query message as effortful, whilst others recommended receiving daily query messages due to its ability to increase individuals' self-efficacious nature for medication-taking routines.

Additionally, the finding of this study informed the acceptability of the upcoming trial of this digital intervention, during which the app delivery mode will be using GPS, WiFi and accelerometer data to tailor the delivery of the intervention messages to each participant. Moreover, participants of this study also detailed the importance of including opt in/opt out options for the use of sensing data in the app, and the importance of using transparent, lay communication to describe the use of such data.

Furthermore, the 100% response rate to the messages enquiring participant to report about adherence to medication demonstrates a promising projection of engagement that will be especially important in the trial of this study as effective engagement with digital interventions might provide information about how intervention usage associates with changes in behavioural and clinical outcomes [14]. Thus, not only do the results of this study suggest that both the text message and app delivery modes of the digital intervention are acceptable, but also that the content of the intervention and the behavioural change techniques developed within the digital intervention are acceptable by patients with high blood pressure. Therefore, the positive results from this study, provides us with confidence to proceed into testing this digital intervention for at a feasibility randomised controlled trial.

Conclusions

This study provides evidence for this novel digital intervention to be acceptable by patients diagnosed with hypertension. Not only is the content of the intervention acceptable, but also the two digital delivery modes in which the intervention is delivered were found to be acceptable by patients. This study also found the digital intervention to be highly engaging and supportive to patients. When considering the high cost medication non-adherence imposes upon the NHS, this study is of particular importance as it provides evidence supporting that this low-cost intervention may be an acceptable answer to help achieve healthcare priorities.

Declarations

Ethics approval and consent to participate. The current study represents a pre-testing study in which there was no randomisation or delivery of treatment. Ethical approval was sought through the Integrated Research Application System (IRAS reference 252979) from the Research Ethics Committees (reference 18/LO/1959) and the Health Research Authority and Health and Care Research Wales.

All participants were informed about the aims and objectives of the study and the procedures for trialling the digital intervention and for data collection. All patients signed a consent form before their participation in this study commenced. This information included standard formulation regarding the voluntary nature of study participation as well as participants rights to withdraw from the study at any time without giving reason or attracting any negative consequences.

Consent for publication. Participants' informed consent to participate in the study included consent for publication of group-level results as well as unidentified interview excerpts.

Competing interests. The authors have no competing interests.

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Authors' contributions. S.S. and A.K. conceived and designed the study. C.A.C drafted study materials and assisted in recruitment and data collection and analysis. A.K. supervised and gave expert guidance to C.A.C during all stages of this research. S.S. provided IT expertise in developing the text messaging service. S.M. and J.C. provided IT expertise in developing the smartphone app. J.B. provided IT support in data transfer. Author C.A.C drafted this manuscript under the supervision of A.K. C.A.C., A.K and S.S. contributed in writing this paper. All authors have provided advise or attended meetings during the formation of the research questions of this study. Authors have read and approved this manuscript before submission.

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Tables

Table 1. Practice (n = 3) and participants' (n = 22) characteristics

Practice area Index of Multiple Deprivation rank*, patients with HBP/doctor ratio**, patients with HBP/staff ratio (excluding doctors)***	Participants			
	Patient ID	Age bracket	Gender	Participated at follow up****
7,422, 11350/5, 11350/10	1	70-79	Male	Yes
	2	60-69	Female	No
	3	30-39	Female	Yes
	4	60-69	Male	Yes
	5	50-59	Female	Yes
	6	50-59	Female	Yes
	7	70-79	Male	Yes
	8	70-79	Male	Yes
	9	60-69	Male	Yes
	10	70-79	Male	Yes
	11	70-79	Male	Yes
12,046, 13445/6, 13445/8	12	40-49	Female	No
	13	60-69	Male	Yes
	14	60-69	Female	Yes
	15	60-69	Female	Yes
	16	60-69	Male	Yes
	17	70-79	Male	Yes
	18	60-69	Male	Yes
12,046, 3553/7, 3553/13	19	60-69	Male	Yes
	20	70-79	Female	Yes
	21	70-79	Male	No
	22	60-69	Male	Yes

* The Index of Multiple Deprivation ranks every small area in England from 1 (most deprived area) to 32,844 (least deprived area).

** includes doctors and GP associates

*** includes nurses, health practitioners and health care assistants

**** if participant was interviewed during/after testing the DI.

Table 2. Thematic analysis results.

THEME 1. Acceptability of the digital intervention for patients diagnosed with high blood pressure		
Quote		Participant ID, age, and tested delivery mode
1	"No, no, everything was straightforward really. There was nothing at all that stood out as being awkward about it, or difficult."	Participant 7, M, age 70-79, TEXT
2	“Logical, smooth interface, easy to navigate.”	Participant 9, M, age 60-69, TEXT AND APP
3	"No, it’s just a straightforward message, have I taken all my meds? Which I suppose if I hadn’t, it would have made me think, well have I?"	Participant 1, M, age 70-79, TEXT
4	"P: It’s almost patronising I: Erm is there any sort of erm specific message that you can remember that you just thought oh this is so annoying this is so patronising? P: To be honest I just delete them as soon as they come in. I don’t even read them."	Participant 16, M, age 60-69, TEXT
5	"I: Okay, so do you have any suggestions of how we might try and change that so it’s not so as annoying or patronising? P: Well maybe less frequency"	Participant 16, M, age 60-69, TEXT
6	"Because it’s a different that was every day, you know it’s not going to be the same message so you’re going to pay attention and read it, and reading it should reinforce in your mind ah, I need to take my pill."	Participant 9, M, age 60-69, TEXT AND APP
7	“This tab (with feedback on behaviour), for me personally, did I stick to the right times, how far off was I off, how was I on, do you know what I mean? That sort of information, for me, would have been yes, great. Say after about a week or a month you could look and think what’s going on here?”	Participant 18, M, age 60 to 69, TEXT AND APP
8	"I: Would you have any reservations about us using GPS data? P: None at all. I think that’s probably better than messages coming through when you’re out and when you’re driving or shopping, say you say. It’s rather intrusive. If anything comes through when I’m driving, it has to wait until I’ve finished driving. I don’t even acknowledge it."	Participant 1, M, age 70-79, TEXT
9	"Simply because the greater the likelihood of getting the message, I don’t know, would equivocally improve delivery of the message."	Participant 14, F, age 60-69, TEXT
THEME 2. Mechanisms by which the digital intervention has supported medication adherence		
Quote		Participant ID, age, and tested delivery mode
10	"I: So, it makes you think back onto the past week and reflect? P: Yes, yes. And you think, let me look at my tablets, to see if there’s as many left as there ought to be?"	Participant 1, M, age 70-79, TEXT
11	“Whereas, if it goes off in your pocket and you think I will get it after, but about 5 o’clock or	Participant

	something it goes off in your pocket and you think oh, I had better get this. Have you taken your medicine? No, I haven't, so then I've got to then go upstairs, view it and then press yes. So, then it's forced on me, if you like, to make sure I do take it."	18, M, age 60 to 69, TEXT AND APP
12	"I was waiting for the alarm to go off. Then it was about 20 minutes late, but I was already there with the tablets to take anyway. So, it's made me take them, even though I didn't get the alarm at eight o'clock, if you see what I mean. So, that was fine. So, I had taken them anyway because that's made me more aware that I should take them at that time rather than any time, at random times."	Participant 15, F, age 60-69, TEXT
13	"P: Well, yes just exactly what I mean, being committed to take your tablets as prescribed because it's for your own benefit.	Participant 1, M, age 70-79, TEXT
14	"I do think it does help if people feel as though they're involved (with taking their medications)"	Participant 20, F, age 70-79, TEXT
15	"To me, that's saying have you taken it yes or not, I suppose you could lie about it but if you're going to do that what's the point of having the text message, I don't see the point. But yes, it's an interactive thing isn't it? So, you're taking ownership, if you like and dealing with it that way."	Participant 18, M, age 60 to 69, TEXT AND APP
16	"P: What's the next one? 'Tablets are part of your self-care.' I think that was the last message. It's a reminder that the ultimate responsibility lies with yourself, so take ownership. I: Do you think that's important for people when taking their medication regularly to take ownership of their condition, their illness and to, I guess, it is taking ownership and that self-control over taking medication, is that an important part of adhering to your medication? P: It's, I'm taking that in the wider aspect of the world, that everything seems to be everybody else's fault but your own. People don't take enough personal responsibility. So, if you like, that was quite a good reminder – well actually your meds are down to you and nobody else. You are prescribed them, but you've got to take them."	Participant 9, M, age 60-69, TEXT AND APP
17	"If you just get a reminder all the time and it goes off in your pocket, you think it's just a text, I'll answer it later. If you think that oh, that could be about my medication and I'm going to have to respond yes or no, then you take it out and you're going to look at it and you're taking ownership of your responsibility obviously it's your anyway for taking your meds."	Participant 18, M, age 60 to 69, TEXT AND APP
18	"I: Okay, is there anything else that you wanted to speak about regarding the messages at all, like the query message style message? P: No, no. Like I say, I think, to have that, sort of, as a summary of how has the week gone? Have you taken your tablet? Yes. Well done. And, like I say, in a strange sort of way, it's very motivational. I: Well that's good. So, did it motivate you, and how did it motivate you? P: Well I think you sort of smile when you get the 'Well done' and (inaudible 00:10:19) the following week. And I actually did manage to take my tablet every day, on time. So, it just sort of ... it's like an added encouragement."	Participant 13, M, age 60-69, TEXT
19	"If you just get a reminder all the time and it goes off in your pocket, you think it's just a text, I'll answer it later. If you think that oh, that could be about my medication and I'm going to have to respond yes or no, then you take it out and you're going to look at it and you're taking ownership of your responsibility obviously it's your anyway for taking your meds."	Participant 18, M, age 60 to 69, TEXT AND APP
20	"But yes, it's an interactive thing isn't it? So, you're taking ownership, if you like and dealing with it that way."	Participant 18, M, age 60 to 69, TEXT AND APP

THEME 3. Recommendations to improve the acceptability of the digital intervention

Quote	Participant ID, age,

		and tested delivery mode
21	P: Well, the negative sides makes you think oh god, you know, you start to get a little bit thinking that oh, ... if you see what I mean, but not, you know, but if it's then positive, you think yes, that's why I need to take them.	Participant 15, F, age 60-69, TEXT
22	"I think the advice part is like kind of key, but also I think, even though it's text message and it limits you to characters, but I think giving succinct points, people are more likely to read them, so maybe on the advice have one topic a week and every day, come up with a different aspect of that topic"	Participant 5, F, age 50-59, TEXT
23	"I: If you were designing the service, was there anything that you would do differently? P: Well, the only thing that I could suggest would be, although it might be a bit long-winded, if you've got morning medication and evening medication that you would perhaps need, like I've said before, be more likely to forget the evening one than the morning one because it's not in my routine so much. But I didn't get a message for the evening one, so could possibly need a message for both situations. I: Okay. And would you want those messages to come through separately at the times you take your medication, or would you want one sort of big text message in the morning reminding you of all the medications that you need to take that day? P: Yes, it would have to be at different times, I suppose, because if I had a message about the morning one and the evening one in the morning, I'm still likely to forget if I was going to in the evening one. So, you'd need two messages a day and I suppose if you're going to be taking lots of things at different times that might become a little troublesome, I suppose."	Participant 22, M, age 60-69, TEXT
24	"And they have am and pm on them, or lunch time one as well. So, you could do it three times a day because most people it is only three times a day for medication. Morning, lunch time, and evening, isn't it? "	Participant 6, F, age 50-59, TEXT
25	"I: So, if the reminder came through at a time where you couldn't take your medication, did you just press no or did you use the snooze button to snooze? P: To be honest, on the app? I: Yes, on the app? P: I didn't know there was one. I never saw that."	Participant 18, M, age 60 to 69, TEXT AND APP
26	"I think help-wise, like a how to maybe, because it's obviously complicated, a little how to maybe, that could probably help."	Participant 18, M, age 60 to 69, TEXT AND APP
27	"I didn't really understand, like looking at this (feedback on behaviour) tab and bits and pieces like that ..."	Participant 18, M, age 60 to 69, TEXT AND APP
28	"I: Do you wish that we maybe used a bar chart, maybe something more visual or was it okay for you? P: No. well, everybody is different, aren't they? Some people prefer, some people learn by visualise, look at it, other people like the colours, like the graphs, other people prefer data as it's written down."	Participant 18, M, age 60 to 69, TEXT AND APP
29	"P: Probably because, I mean I much easier to just do it on a daily basis becomes sometimes you can be forgetful, unless you write it down, I don't know. Maybe it might make people anxious about their memory and stuff like that, I don't know. As much as it has a clinical purpose, why do you need to ask them at the end of the week when it's just better to ask them every day since their short-term memory is probably much more reliable? I: Yes, that's true. So, you would suggest asking, having that query message sent every day instead of once at the end of the week?	Participant 14, F, age 60-69, TEXT

	P: Yes."	
30	"P: I'd probably put a bit less advice in, it might get a bit boring after a while, it's okay the first week they were all different, I'm sure that if that goes on for months and months and months you'd have to repeat some of them quite regularly. I: So, less frequent advice messages? P: All I really would need is a reminder. I: So, the reminder every day and how often would you have the advice message come through? P: Probably once a week would be good."	Participant 11, M, age 70-79, TEXT
31	"The advice. Not the one reminding you to take your medication, the other one after that. Maybe once or twice a week would be alright, to put something like that out. But getting that every day, seemed to be a little bit too much really.... No. I just think, at my stage, to keep getting advice messages like that, it would lose the point of it, it would lose its impact then ... I just think if it was less frequent, then maybe it would have more of an impact."	Participant 7, M, age 70-79, TEXT
32	"What I don't have any problem with is somebody who comes up front and says this app is going to do and it's going to watch where you go because, because, because. So, yes, I have concerns, but as you've explained that, I have no concerns at all because you've been upfront about it."	Participant 9, M, age 60-69, TEXT AND APP
33	"I: Okay, so is it that NHS name or that label of the NHS that makes you think (it's secure)? P: I think it would be the label. I: So, the labelling of the NHS makes you feel a lot safer with the data? P: Yes. I: Okay, similar too, would you feel the same if it was the University of Cambridge logo instead of the NHS? P: I don't see why not. I don't see it being a problem, because I mean you're with them now and we're discussing it aren't we, so I don't think that would be a problem. It might be for some people. "	Participant 15, F, age 60-69, TEXT
34	"I personally think, because I'm 70 next year, but in my head, I'm only 50, if you know what I mean. But a lot of people who are my age are forgetful. So, if you're leading a busy life, I would say at least six weeks, and I'm in week three, but because I get up early in the morning and everything, I'm busy doing things, I tend to forget if I'm sitting in front of the television or something. So, yes, I think six weeks would be a good routine because as I said, I've done it in three where I've been, oh god, I must take my tablets, it's eight o'clock. So, I personally think perhaps six weeks would make them more aware that they should be doing this, and that would built a routine."	Participant 15, F, age 60-69, TEXT
35	"P: So, you don't feel as if actually they do take care with what's happening. It sounds very negative, I don't mean it quite like that, but I think it's just a question that they probably would feel worthwhile and that someone understands that they are taking tablets you see. Because I never see the same doctor. I: So, do you think that this service could maybe help to counteract some of those feelings of being...? P: Oh yes, definitely."	Participant 15, F, age 60-69, TEXT

Table 3. Intervention usage per delivery mode

Text messages	Frequency
Report whether or not the behaviour was performed	72
App	
Report whether or not the behaviour was performed	52
Feedback on behaviour daily weekly	 15 9
Tailor messages delivery snooze reminder messages update refill reminder day and time	 5 7

Usage of the intervention for the duration of 28 days. N= 22 patients for the text messages. N=2 for the smartphone app, after the text message intervention. Data extracted by digital log files.

Figures

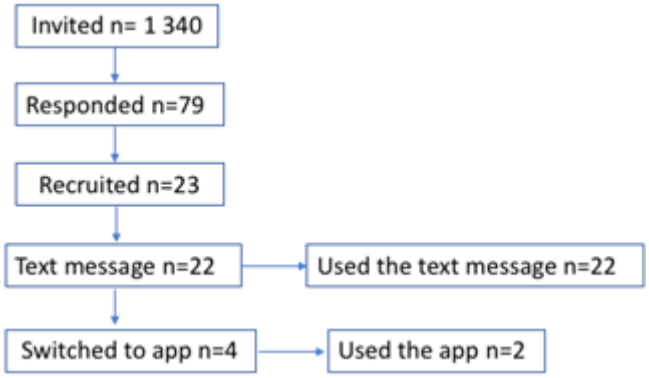

Figure 1

Study flow chart

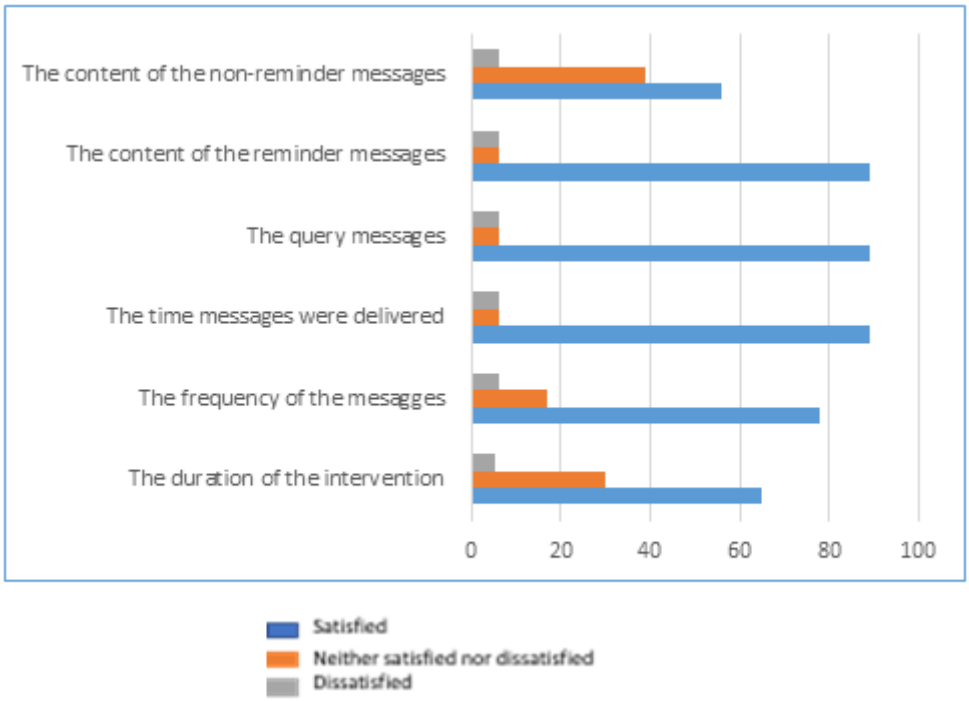

Figure 2

Satisfaction with the intervention N= 19 patients. Data collected by follow up questionnaires

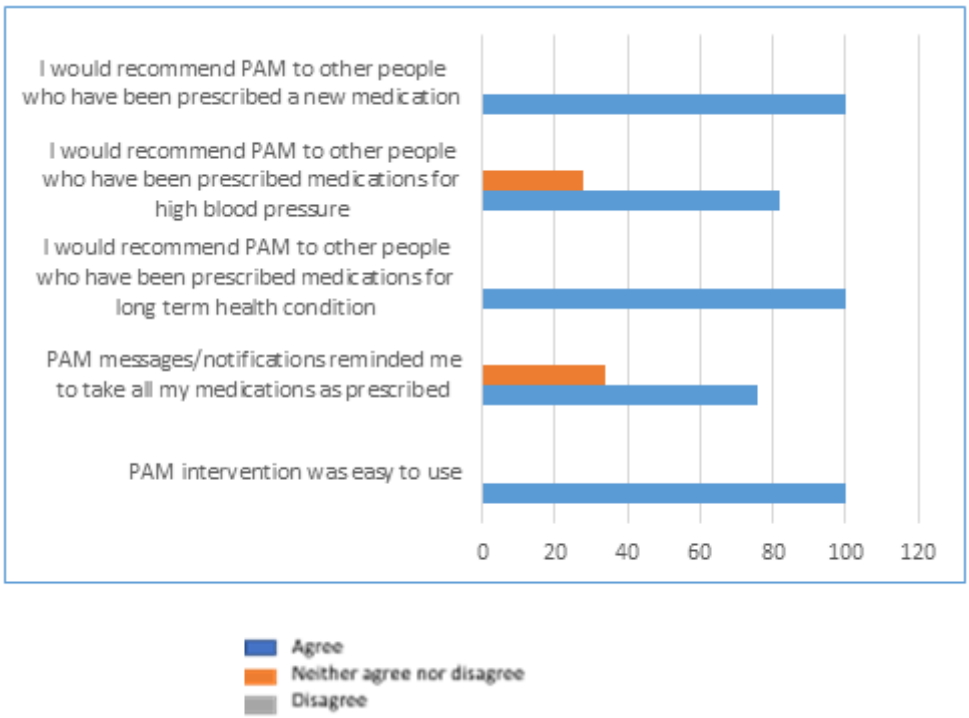

Figure 3

Acceptability of the intervention as an adjunct to usual care. N= 19 patients. Data collected by follow up questionnaires

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CONSORTextensionforPilotandFeasibilityTrialsChecklist.pdf
- Appendix.pdf