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 a pilot non-randomised controlled study of a highly tailored 56-days text message and smartphone app prototype 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, 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 messages and were recruited face to face by the researcher team. Participants were asked to test the text message intervention for 28 consecutive days and switch to the smartphone app for 28 more days. Participants completed baseline and follow up questionnaires and took part in semi-structured 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 interest to participate in this study, of whom 23 (64% male, 82% above 60 years old) were recruited to take part. With one drop-out, 22 participants tested the text message delivery mode (with 20 being interviewed) and four of them (17%) switched to the app (with 3 being interviewed). All participants engaged and interacted with the text message and app notifications, and most participants found the intervention content and delivery mode acceptable. They also self-reported that the interactive elements of the intervention motivated 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. Future research could usefully investigate its feasibility and effectiveness using rigorous research methods.

Introduction

In England, over 12.5 million people are diagnosed with hypertension (high blood pressure) [1]. High blood pressure is a major risk factor for developing severe 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].

Non-adherence to prescribed medication may occur for a number of reasons, like patients forgetting or missing a dose or day of their medication. These reasons are described as non-intentional non-adherence (NINA) or intentional non-adherence (INA) [6]. Interventions are likely to be more effective, when they address either or both these determinants by providing highly tailored advice to the individual [7]. Tailored interventions include Behaviour Change Techniques (BCTs) mapped onto these key determinants of non-adherence. BCTs are assumed to be the 'active ingredients' of behavioural interventions [8]). For example, INA can be addressed by reinforcing positive beliefs about taking medications (e.g. "keep control of your blood pressure today by taking all your tablets as prescribed") and by prompting 'problem solving' of negative beliefs and concerns (e.g. "please do not forget to take your tablets, even when you do not have any symptoms. Pills have been prescribed to lower your blood pressure"). NINA can be addressed through explicit and implicit reminders [9]. Both NINA and INA can be addressed by simple query messages to report behaviour (e.g. "have you taken your medications as prescribed during the past 7 days?").

Digital interventions like 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. Our recent meta-analyses suggested that automated telephone-based interventions, including text messages [7] and apps [10] double the odds for adherence to medication prescribed for long-term health conditions. Our recent feasibility trial found that digital interventions, including text messages, can provide highly tailored advice to address either or both NINA and INA for medication adherence, and is feasible and potentially effective adjunct to primary care consultations [11]. However, there is no intervention that has combined text messages with a smartphone app, to both maximize the reach of the intervention and to utilise the advantages of the automated tracking technology emended into apps when facilitating a highly tailored behaviour change intervention.

Based on our previous promising findings [11] we have developed a 56-days prototype intervention, which we call PAM (Programme on Adherence to Medication), delivered by a text messaging service followed by a smartphone app. This pilot study aimed to pre-test its acceptability 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 in the UK primary care setting.

Qualitative and quantitative data collection were integrated into a mixed methods analysis to answer the primary research question of this pilot study: 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 the intervention content and delivery mode functionalities, and the mechanism by which these might have influenced medication taking behaviour.

Methods

Recruitment methods and procedure. Three General Practices were recruited for this study, which were located in Eastern England and at 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) owned and regularly used a mobile phone, g) and had the capacity to provide informed consent. We aimed to recruit 25 participants to respond to our research questions (see protocol at ISRCTN12805654).

Across the three recruited practices, a total of 1,340 patients eligible to take part in this study were identified from practice records, and a text message invitation to take part in this study was sent once to all 1,340 eligible patients. 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, the first 23 patients who met all the eligibility criteria to participate were enrolled in the intervention during a baseline meeting with a member of the research team. During baseline 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 the 56-days prototype intervention; which involved testing the text message for 28 days and then switching to the smartphone app for the consecutive 28-days. All patients were asked whether they would like to switch from a text message to the app intervention, after they have completed the text message intervention.

Participants' received daily reminder messages with explicit advice (e.g. "please do not forget to take your medication today: amlodipine, 2 tablets, 5mg"), daily advice messages (e.g. "the health benefits of taking your meds regularly is having low blood pressure. Please keep looking after yourself by taking your medications"), and query messages (e.g. "have you taken all your prescribed meds in the last 7 days/ today? Reply Yes or NO).

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

Questionnaires. Questionnaire included questions regarding patients' intention to adherence and beliefs about adherence to medication. Intentional (INA) and non-intentional non-adherence (NINA) was measured using the 5-items MARS questionnaire [12], and beliefs about adherence was measures using 10-items measuring necessity beliefs (e.g. 'If I were to take all my medications as prescribed without missing a day it would do more harm than good'), control beliefs (e.g. 'taking my medications as prescribed keeps my blood pressure under control'), affective attitudes (e.g. 'taking my medications as prescribed every day without missing a day is pleasant/unpleasant/neither'), social norms (e.g. 'If they were prescribed tablets, most people whose opinion I value, would take all their prescribed tablets without missing a day'), copping self-efficacy (e.g. 'I take all my medications as prescribed without missing a day, even if I am busy at home'), and generic emotional state (e.g. 'How much of the time during the past month have you felt calm and peaceful'). The tailoring questionnaires was developed based on our

previous studies [11, 13]. Patients' answers to these questions were used to tailor the content of the advice messages.

The baseline questionnaire also included questions which were more specific to patients' prescribed medications (e.g. name of medications and dosage), which time they would like to receive the intervention messages,. Patients' answers to these questions were used to tailor the content of the reminder messages and notifications.

Patients completed questionnaires at baseline and at the end of the intervention. Baseline questionnaire obtained patients demographic characteristics. 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 to obtain in-depth accounts of participant experiences, thoughts, and beliefs. Detailed answers were provoked by the researcher, who used open-ended questions and prompts to explore participants' experiences with using the intervention [14].

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). Each 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.

Weekly data collection time-points were selected 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. Regular data collections also aimed to identify and solve any technical issues that may arise when piloting an innovative digital intervention.

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 documents 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 of intervention usage and engagement. 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. The coding for emerging themes was deductive and aimed to provide answers to our research questions. Inductive themes were considered as recommendations for improvement. 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 discussed in depth themes that had emerged from the data. 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 [15].

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 completed the baseline questionnaire (100% completion rate), which included the tailoring questions and measured medication adherence. 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, four of them (17%) selected to switch to the app, and two installed the app and tested the intervention for 56 consecutive 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). Participants were 64% men and 82% above 60 years old (see table 1).

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

1. acceptability and usage of the components (i.e. content and delivery functionalities) of the prototype digital intervention to patients prescribed medications to treat high blood pressure
2. mechanisms by which these components might 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 '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 suggestions on what we may do to make them less bothersome, he noted providing the option for participants to reducing the frequency of receiving these messages (see Table 2 quote 4). 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 variable (see Figure 2). For example, one participant attributed the advice messages to increasing his attention with reading the messages, and in turn increasing his motivation to take his medication as suggested (see Table 2 quote 5). This may be due to receiving a variety of advice messages throughout testing the digital intervention, with each message perceived to emphasise and address a different reason 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. Participants were asked to respond to the query message one per week (when testing the text messages) or when each medication was taken (when switching to the smartphone app). The concept of the query message arose from the behaviour change strategy of 'reporting whether or not the behaviour was performed' [7,11,16]. All participants reported to query messages and most reported that they liked these messages (see Table 3 and Figure 2). All participants received the query messages and the response rate, to both text message and app notifications, was 100%, and this engagement score was maintained throughout the intervention, indicating high participant engagement with the digital intervention and acceptability of these messages to support medication adherence.

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 (e.g. "you've reported that you have taken 89% of your prescribed medication last week"). Participant found this data informative and reported using it to self-monitor their medication adherence and to reflect on their patterns of their medication-taking routine (see Table 2 quote code 6). 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).

Functions to tailor message delivery. This function allows the participant to re-schedule the frequency (e.g. by texting less to receive less messages or more to receive more) and the time of the reminder messages (e.g. by snoozing the reminder notifications). Participants tailored the delivery of the reminder messages on average 5 times when using the smartphone app, and none when using the text messages. This function was found useful to those participants who reported that were busy at the time the reminder message appeared and could not respond confirming whether or not they have taken their tablets. Patients have also the option to set and re-schedule the time and date of their refill prescription

reminders; and both patients set their refill reminders and used the app function to re-schedule the time and day of the refill reminder notification 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 additional tracking data using the smartphone technology.

All participants were asked about their views on the app using GPS, WiFi and accelerometer to automatically track their behaviours related to medication taking during the intervention. All participants reported having no concerns over the security of their behavioural patterns related to medication adherence being captured through the app sensing technology. Some of them they have also suggested that tracking technology could make medication adherence easier (see Table 2 quote 7 and 8).

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 9, 10, and 11, 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 12, 13, and 14). These findings suggested that reporting behaviour is a motivational behaviour 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 app testers checked this app functionality after successfully installing the app (see Table 3), with one of the participants attempting to view their adherence report six times in the first day of switching to the app. This could be explained by an initial exploration period after first installing the app, however both participants continued to check the functionality with feedback on behaviour at least once a day for four days after switching to the app. This finding implys that participants find this function interesting and an engaging feature of the app, and that feedback on the behaviour might be important to increase patients' motivation to change behaviour.

It was also found that knowing that 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 engagement with the intervention and on reflecting and possibly on 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. Participants reported that they found this message particularly useful as it establishes a sense of ownership over the condition and motivated participants to be more self-aware of the independent responsibility they have over their health condition (see Table 2 quotes 15, 16, 17, and 18).

All participants discussed the importance of the digital intervention including interactive elements and reported feeling motivated to continue taking tablets regularly and as prescribed after interacting with the intervention (see Table 2 quote 15).

Most participants expressed preferences toward the advice messages which included positive reinforcement to take their tablets (see Table 2 quote 17,18 and 19). The subject of advice messages came up multiple times during the interview, specifically in the context of increasing patients' motivation to take their medication to treat hypertension as a self-care process (see Table 2 quote 15, 19).

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). They have also made recommendations to improve intervention content, delivery and implementation procedures.

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 20). However, another participant recommended a solution to this problem, suggesting combining the medication reminders into morning, lunchtime and evening routines (see Table 2 quote 21).

Furthermore, one of the participants testing the app reported not using the additional app functions, which could be used to tailor the delivery of the medication reminder until a later time (see Table 2 quote 22). The participant recommended a help guide with interactive elements to explain all features of the app and how to use them when first installing the app (see Table 2 quote 23). A help guide to aid patients' navigation through the app would potentially increase accessibility and intervention engagement.

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 24, 25 and 26).

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 or those whose emotional state might overcome their medication-taking routine (see Table 2 quote 27).

Towards the end of the 28-days intervention, 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 28). However, one participant expanded upon this idea and suggested the impact of the advice messages decreased when receiving them daily (see Table 2 quote 29), 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, especially if the intervention was to be received for longer to support medication adherence.

Clear and honest communication is needed to explain the purpose and privacy of using tracking data when using the smartphone app of this digital intervention (see Table 2 quote 30). 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 31).

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 32 and 33, and Figure 3).

Discussion

This mixed methods study suggests that this novel digital intervention is acceptable by patients with high blood pressure, and that it may support medication adherence by improving motivation to take medications as part of a daily routine. It was found that the content of the highly tailored intervention was acceptable and that participants used and engaged with the intervention. The study also supported that all patients interacted with the query intervention messages to support their medication taking behaviour and they found the additional tracking functionalities of the smartphone technology acceptable, with few (17%) opting to use these additional tracking elements to support medication adherence.

The high response rate to the messages enquiring participant to report about adherence to medication demonstrates a promising projection of engagement that will be especially important for the future trial of this intervention, to provide information about how intervention usage associates with changes in behavioural and clinical outcomes. 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 is 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 feasibility at a randomised controlled trial.

A strength of this pilot study is that it utilised two digital delivery modes to maximize the reach of a highly tailored intervention even to those with low digital literacy and to provide with a choice of an automated

self-tracking advice to support medication adherence. To our knowledge, this is the first intervention that utilised a combination of text messages and smartphone app and has been pre-tested to address non-adherence to medication within the UK primary care setting. Another strength of this study was its unique data collection method of weekly interviews that allowed us to identify and solve any technical issues more explicitly and quickly than using the traditional hour-long interview at the end of the trial. This study also used a mixed methods analysis and synthesised qualitative and quantitative data from multiple sources to respond to our research questions.

This study is limited by the small number of patients as well as the short duration of the intervention. Another limitation of the study is the small proportion of patients switching to the Android smartphone app.

Conclusions

The findings of this study informed the acceptability of the upcoming trial of this digital intervention with patients prescribed medications to treat hypertension in primary care. This study provides evidence that this novel digital intervention is 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 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. A.K and S.S. developed the intervention. C.A.C drafted this study materials and assisted in recruitment and data collection and qualitative 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. Authors A.K. and C.A.C. contributed in writing this paper, and SS provided expert advice. All authors have provided advice 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: 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
5	"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 tablets."	Participant 9, M, age 60-69, TEXT AND APP
6	"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
7	"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
8	"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
9	"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
10	"Whereas, if it goes off in your pocket and you think I will get it after, but about 5 o'clock or something it goes off in your pocket and you think oh, I better get this. Have you taken your medicine? No, I haven't,	Participant 18, M, age 60 to 69,

	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."	TEXT AND APP
11	"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
12	"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
13	"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
14	"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
15	"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... 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
16	"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
17	"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
18	"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
19	"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

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

Quote	Participant ID, age, and tested

		delivery mode
20	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
21	"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
22	"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
23	"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
24	"I think help-wise, like a how to maybe, because it's obviously complicated, a how to guide maybe, that could probably help."	Participant 18, M, age 60 to 69, TEXT AND APP
25	"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
26	"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
27	"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?	Participant 14, F, age 60-69, TEXT

	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? P: Yes."	
28	"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
29	"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
30	"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
31	"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
32	"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
33	"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	15
weekly	9
Tailor messages delivery	
snooze reminder messages	5
update refill reminder day and time	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.

Key Messages Regarding Feasibility

- The acceptability of a digital intervention, combining a text message service with a smartphone app, to support medication adherence in patients with high blood pressure in the UK primary care, has not been evaluated

- This pilot study proved that the digital intervention is acceptable among patients with hypertension, and it recommended that an interactive intervention to enable patients track health-related behaviours might be the way forward to provide personalised and highly tailored advice and support for adherence in primary care

- Future trial should investigate the feasibility of the digital intervention to support medication adherence and associative blood pressure in patients with hypertension, as an adjunct to usual care consultations.

Figures
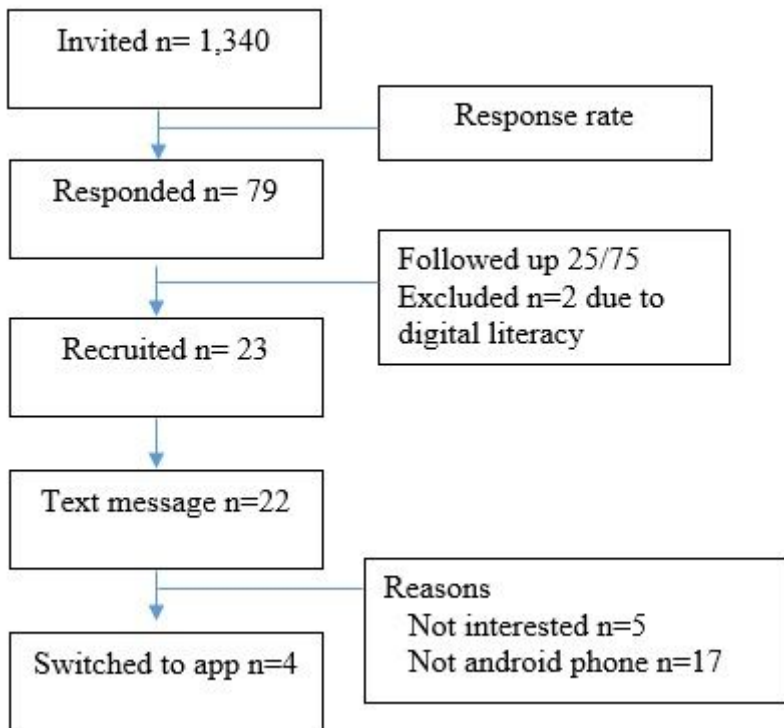
Figure 1

Study flow chart
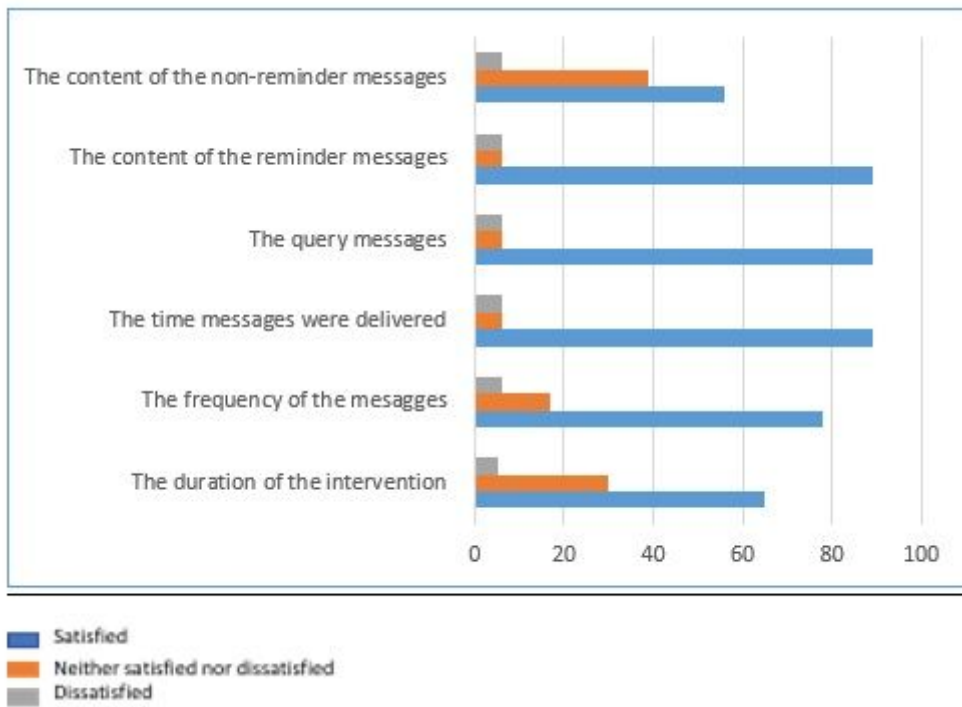
Figure 2

Satisfaction with the intervention N= 19 patients. Data collected by follow up questionnaires
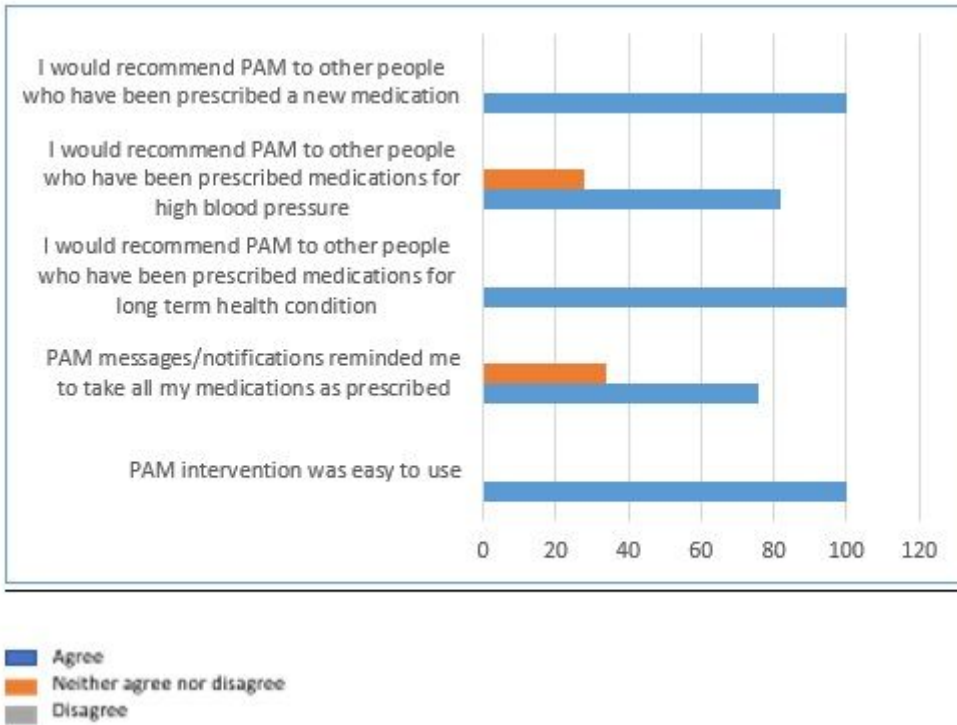
Figure 3

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