Implementation of Chronic Disease Management Programme (CHAMP) for self-monitoring of hypertension: Protocol for 3 interlinked implementation studies

Laura Martinengo, Ngoc Huong Lien Ha, Eugene Tay, Shao Chuen Tong, Nick Sevdalis

Submitted to: JMIR Research Protocols
on: February 21, 2025

Table of Contents

Implementation of Chronic Disease Management Programme (CHAMP) for self-monitoring of hypertension: Protocol for 3 interlinked implementation studies

Laura Martinengo[1] MD, PhD; Ngoc Huong Lien Ha[1] MPH; Eugene Tay[1] PhD; Shao Chuen Tong[1] MHA; Nick Sevdalis[1] PhD

[1]Centre for Behavioural and Implementation Science Interventions Yong Loo Lin School of Medicine National University of Singapore Singapore SG

Corresponding Author:
Laura Martinengo MD, PhD
Centre for Behavioural and Implementation Science Interventions
Yong Loo Lin School of Medicine
National University of Singapore
10 Medical Drive MD11, Level 2 Clinical Research Centre
Singapore
SG

Abstract

Background: Hypertension affects 31% of the global adult population. AI-based chatbots may support self-management of hypertension and other chronic disorders. CHAMP (CHronic diseAse Management Program) is a digital health intervention to support chronic disease self-management, that consists of a patient-facing chatbot and an AI-augmented Clinical Decision Support System, linked to electronic medical records.

Objective: This project aims to optimize the deployment of CHAMP across primary care centers by developing implementation strategies and pilot-testing their appropriateness and effectiveness.

Methods: We report 3 interlinked studies: (1) Rapid overview of reviews to evaluate the factors influencing the implementation of mHealth and chatbot interventions in healthcare settings, and the strategies and processes used to implement them. We will follow Cochrane's methodology for rapid reviews. We will use the Consolidated Framework for Implementation Research (CFIR) and the Unified Theory of Acceptance and Use of Technology (UTAUT) frameworks to analyze the data. (2) Formative, multi-method, qualitative study, to inform the state of CHAMP deployment to date, the organizational structure of primary care centers, and the barriers and facilitators influencing the implementation and scale up of CHAMP in primary care centers. We will interview members of the CHAMP development and initial implementation team, healthcare providers, primary care centers leadership and patients who are using, and not using CHAMP; and conduct 1-day onsite visits to primary care centers. The findings from these studies and the overview of reviews will inform a process map to outline the patient journey and map the barriers and facilitators influencing the implementation of CHAMP. (3) Development of a set of implementation strategies to effectively implement CHAMP using the Expert Recommendations for Implementing Change (ERIC) taxonomy to define the implementation strategies, and the Action, Actor, Context, Target, Time (AACTT) framework to define the strategy implementation processes. We will also assess the readiness for change of the healthcare providers and leadership working in the primary care centers, and, leveraging behavioral science, we will test variations of the chatbot's messages to increase patient engagement with the chatbot.

Results: To date, the overview of reviews (Study 1) protocol has been registered in PROSPERO, we have completed the screening of title and abstracts and are currently in the full-text screening phase. For Study 2, we obtained ethics approval and conducted the semi-structured interviews with healthcare providers, primary care centers leadership and members of the CHAMP development and initial implementation team. We are awaiting IRB approval to start the interviews with patients.

Conclusions: The results from these studies will inform the further implementation and scale up of CHAMP across primary care centers in Singapore. The successful implementation of digital health interventions to support self-management of chronic disorders may improve healthcare delivery without further straining healthcare systems. Clinical Trial: The rapid overview of reviews has been registered in PROSPERO (CRD42024613653) on 2 December 2024.

(JMIR Preprints 21/02/2025:72942)
DOI: https://doi.org/10.2196/preprints.72942

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http
No. Please do not make my accepted manuscript PDF available to anyone.

Original Manuscript

Protocol

Implementation of Chronic Disease Management Programme (CHAMP) for self-monitoring of hypertension: Protocol for 3 interlinked implementation studies

Laura Martinengo MD PhD[1]; Ha Ngoc Huong Lien MPH[1]; Eugene Tay PhD[1]; Shao Chuen Tong MHA[1]; Nick Sevdalis PhD[1]

[1]Centre for Behavioural and Implementation Science Interventions, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

***Correspondence to:** Laura Martinengo, Centre for Behavioural and Implementation Sciences Interventions, Yong Loo Lin School of Medicine, National University of Singapore, 10 Medical Drive
MD11, Level 2 Clinical Research Centre, Singapore 117597. Phone: (+65) 65166155. Email: laumart@nus.edu.sg

Abstract

Background

Hypertension affects 31% of the global adult population. AI-based chatbots may support self-management of hypertension and other chronic disorders. CHAMP (**CH**ronic dise**A**se **M**anagement

Program) is a digital health intervention to support chronic disease self-management, that consists of a patient-facing chatbot and an AI-augmented Clinical Decision Support System, linked to electronic medical records.

Objective

This project aims to optimize the deployment of CHAMP across primary care centres by developing implementation strategies and pilot-testing their appropriateness and effectiveness.

Methods

We report 3 interlinked studies: (1) *Rapid overview of reviews* to evaluate the factors influencing the implementation of mHealth and chatbot interventions in healthcare settings, and the strategies and processes used to implement them. We will follow Cochrane's methodology for rapid reviews. We will use the Consolidated Framework for Implementation Research (CFIR) and the Unified Theory of Acceptance and Use of Technology (UTAUT) frameworks to analyse the data. (2) *Formative, multi-method, qualitative study*, to inform the state of CHAMP deployment to date, the organizational structure of primary care centres, and the barriers and facilitators influencing the implementation and scale up of CHAMP in primary care centres. We will interview members of the CHAMP development and initial implementation team, healthcare providers, primary care centres leadership and patients who are using, and not using CHAMP; and conduct 1-day onsite visits to primary care centres. The findings from these studies and the overview of reviews will inform a process map to outline the patient journey and map the barriers and facilitators influencing the implementation of CHAMP. (3) *Development of a set of implementation strategies* to effectively implement CHAMP using the Expert Recommendations for Implementing Change (ERIC) taxonomy to define the implementation strategies, and the Action, Actor, Context, Target, Time (AACTT) framework to define the strategy implementation processes. We will also assess the readiness for change of the healthcare providers and leadership working in the primary care centres, and, leveraging behavioural science, we will test variations of the chatbot's messages to increase patient engagement with the chatbot.

Results

To date, the overview of reviews (Study 1) protocol has been registered in PROSPERO, we have completed the screening of title and abstracts and are currently in the full-text screening phase. For Study 2, we obtained ethics approval and conducted the semi-structured interviews with healthcare providers, primary care centres leadership and members of the CHAMP development and initial implementation team. We are awaiting IRB approval to start the interviews with patients.

Conclusions

The results from these studies will inform the further implementation and scale up of CHAMP across primary care centres in Singapore. The successful implementation of digital health interventions to support self-management of chronic disorders may improve healthcare delivery without further straining healthcare systems.

Protocol registration

The rapid overview of reviews has been registered in PROSPERO (CRD42024613653) on 2 December 2024.

Keywords

chatbots, artificial intelligence, digital health, hypertension, chronic disease management, implementation science, barriers, facilitators, implementation strategies

Introduction

Hypertension is a leading risk factor for cardiovascular disease worldwide [1]. It is estimated that hypertension affects around 31% of the global adult population [2], and a similar proportion of people in Singapore, an island state in South East Asia [3]. Despite this high prevalence, around half of affected people are not aware of their condition [3,4]. Furthermore, of people with a known diagnosis of hypertension, around 25% percent are not treated, and two thirds of people receiving treatment are not well controlled [3-5]. Home blood pressure monitoring (HBPM) is an important component of effective treatments of hypertension [6-11], it is associated to improved blood pressure control [7,10,11], and it is cost-effective [12]. However, high-quality implementation of HBPM remains problematic. Recent studies reported a prevalence of HBPM among individuals with hypertension to be around 50% [12,13].

The use of Artificial Intelligence (AI)-based chatbots in healthcare settings is increasing, and has the potential to enhance healthcare delivery while decreasing costs. AI-based chatbots could support self-management of chronic disorders, such as real-time monitoring, supporting patient education and clinical decision support, and offer personalized services to patients and healthcare providers (HCPs) [14,15]. Recent systematic reviews offer preliminary evidence that AI-based chatbots promote healthy lifestyle change [16-19], smoking cessation [20,21], and self-management of chronic disorders [6,15,22]. Additionally, HCPs [23] and patients [24-26] seem to find chatbots acceptable and would be willing to use them, particularly if they complement clinical care [26], and are not used for severe conditions [26,27].

CHAMP (**CH**ronic dise**A**se **M**anagement **P**rogram) is a recently developed digital health intervention that aims to provide chronic disease management support to HCPs and patients. The intervention consists of a patient-facing chatbot deployed in WhatsApp®, a popular messaging platform, and an AI-augmented Clinical Decision Support System that is linked to electronic medical records (Figure 1). The current version of the chatbot sends regular reminders to patients to measure their blood pressure, share their readings and provides advice on follow-up actions if the blood pressure readings are outside the normal range for the patient. Future versions of CHAMP aim to include self-monitoring support for diabetes, hyperlipidaemia, and other chronic disorders. These reminders will incorporate insights from behavioural science to deliver messages (e.g., lifestyle advice) that are meaningful, personalised, and timely to encourage self-monitoring. CHAMP was developed within a large, academic health system serving the population of Western Singapore, and is currently being initially implemented in government funded primary care centres within the academic health system. However, implementation and scale-up of CHAMP across a large number of

primary care centres, requires a systematic, evidence-based approach to ensure the system is effectively integrated into existing workflows within the health system, and that patients are able and willing to use CHAMP.

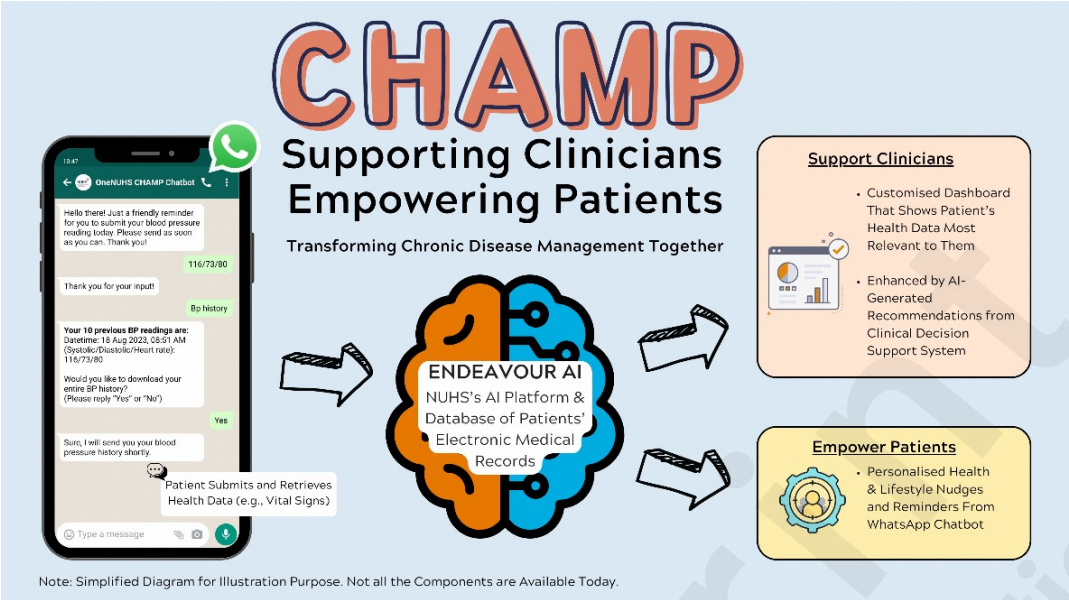


Figure 1: Diagrammatic view of CHAMP chatbot interface and functionalities (CHAMP = **CH**ronic dise**A**se **M**anagement **P**rogram)

This proposal outlines three interlinked research studies on the implementation and evaluation of CHAMP for hypertension self-monitoring in the Western Singapore region. This research tests the overall hypothesis that CHAMP's deployment is feasible and can be optimised at scale, such that it will benefit primary care centre operations by streamlining the management of patients with high blood pressure. The research aims to optimize the deployment of CHAMP across primary care centres in Western Singapore by developing implementation strategies and pilot-testing their appropriateness and effectiveness.

Methods

This project consists of three interlinked studies, as described in the sections below.

Study 1: Rapid evidence review

Study aims

This rapid review aims to assess the factors that influence the implementation of mHealth interventions in healthcare settings, and the implementation strategies and processes used to implement them. Specifically, we will focus on the factors, strategies and processes influencing the implementation of conversational agents (or chatbots) for chronic disease self-management. The research questions guiding this review are:

1. What are the barriers and facilitators influencing the adoption and implementation of conversational agents (or chatbots) for chronic disease management in healthcare settings?
2. What implementation strategies are currently used to facilitate the adoption and

implementation of the conversational agents (or chatbots) in healthcare settings?
3. What are the processes used to implement and evaluate these interventions?

Methods

This review will follow Cochrane Rapid Reviews Methods Group [28] methodology. We will register our review protocol in PROSPERO.

Search strategy

We will develop a comprehensive, yet focused, search strategy combining terms from three concepts: conversational agents; implementation strategies; and chronic diseases. The last concept will be refined according to the number of retrieved papers to focus just on cardiovascular disease. The search will be restricted to evidence synthesis studies using a validated search filter [29]. Appendix 1 presents the Medline search strategy. The searches will be conducted in Medline, Embase and Web of Science.

Eligibility criteria

This rapid review will include evidence synthesis studies, such as systematic reviews, scoping reviews and mapping reviews; and non-systematic literature reviews. Papers reporting on primary studies, protocols, editorials, conference abstracts, or letters to the editor will be excluded. We will limit our search to articles in English, published since 2014.

Study eligibility for inclusion in the review will be defined according to the PICOS framework:
Population: people with chronic disorders such as hypertension, cardiovascular disease, diabetes, hypercholesterolemia, etc.
Interventions: we will include studies involving mHealth interventions, such as conversational agents (or chatbots) or apps delivered using a mobile digital device such as a smartphone, tablet computer or wearable device.
Outcomes: the included studies will report any of the following outcomes:
1. Barriers and facilitators influencing the implementation of conversational agents
2. Implementation strategies used in the implementation of conversational agents
3. Processes and process adaptations leading to the implementation of conversational agents

Setting: We will include studies describing interventions delivered in any healthcare setting, including community or primary healthcare facilities, the outpatient clinics of general or specialist hospitals, and secondary and tertiary healthcare institutions.

Data collection and analysis

The results of the database searches will be uploaded to EndNote 21 and duplicate citations will be removed. The resulting library will be uploaded to Rayyan, a web-based tool developed to facilitate screening of articles for systematic reviews [30]. The screening process will include two phases: title and abstract and full-text screening. Following rapid review methodology, the screening will be initially conducted by two reviewers working in parallel (10-20% of the library) to standardize the

screening process and agree on eligibility criteria. Subsequent screening will be conducted by one reviewer.

Data from the included studies will be extracted in a Microsoft Excel form developed by the research team. Two reviewers, working independently and in parallel, will extract data for about 10% of the included studies to pilot the data extraction form and standardize data extraction. Subsequently, data extraction will be performed by one reviewer. The data extraction form will be informed by two frameworks: the Consolidated Framework for Implementation Research (CFIR) [31,32] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [33]. CFIR [31] is a widely used framework in implementation science to determine the contextual factors influencing implementation [32]. UTAUT [33] is an encompassing framework widely used in digital health to evaluate the factors influencing the adoption of digital health interventions. Figure 2 describes the components of each framework.

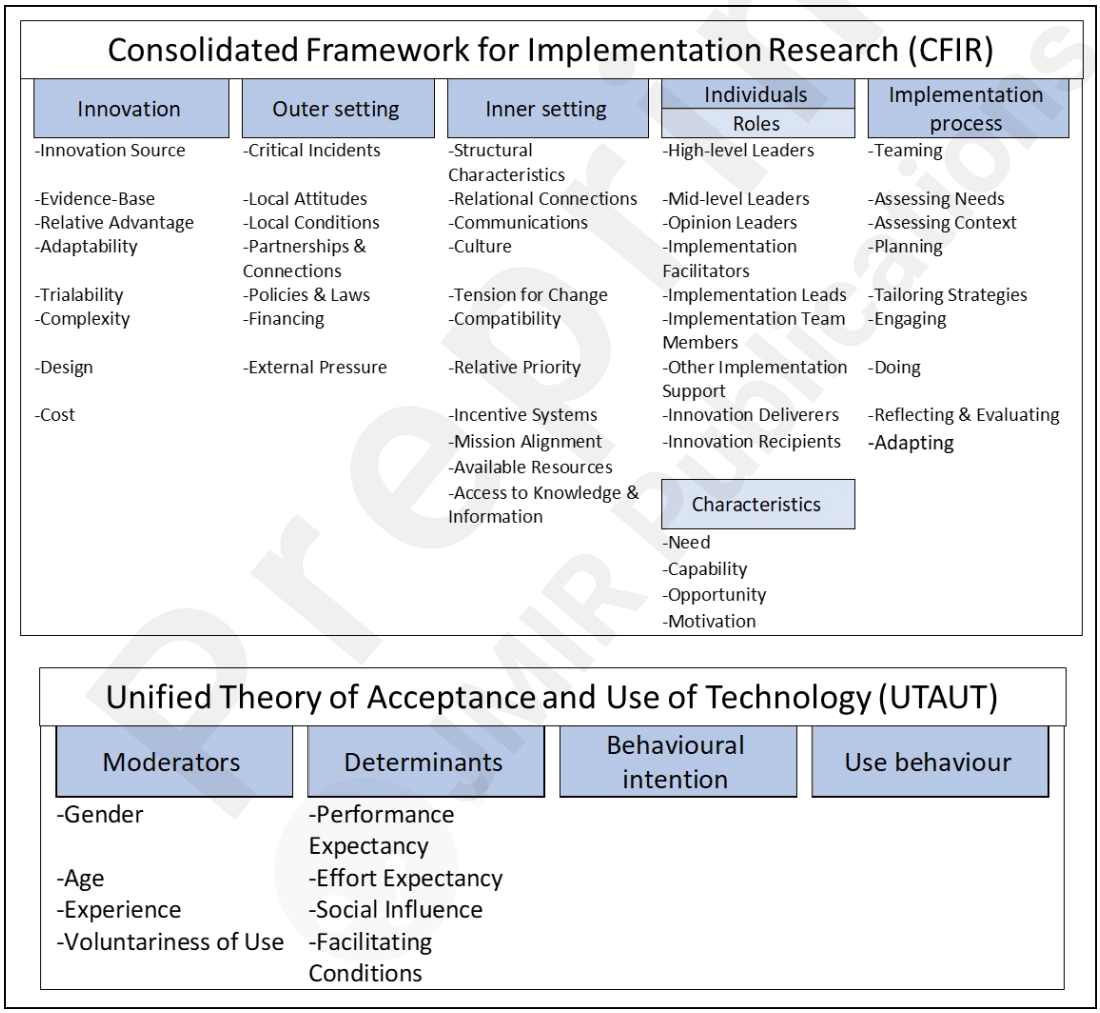


Figure 2: Components of the Consolidated Framework for Implementation Research (CFIR) and the Unified Theory of Acceptance and Use of Technology (UTAUT) frameworks – to be used to code retrieved evidence in Study 1

Data analysis will follow framework analysis methodology [34]. We will use CFIR and UTAUT to develop the framework that will guide data coding. We will follow a deductive coding approach for data analysis. Two reviewers (the first two authors) will perform the data analysis independently and

in parallel. Reviewers will meet regularly to revise their findings and discuss any disagreements. If the reviewers are not able to reach consensus, a third reviewer (last author) will act as an arbiter.

Study 2: Formative, multi-method, qualitative study

Study aims

This study aims to assess the state of CHAMP deployment to date, the organizational structure of the primary care centres implementing CHAMP, and the perceived barriers and facilitators that may influence the implementation and scale up of CHAMP. We will address the following research questions:

1. What are the barriers and facilitators influencing the adoption and implementation of CHAMP in the primary care centres where the chatbot has been implemented at the time of the study?
2. What are the processes and implementation strategies used in the primary care centres to implement CHAMP to-date?
3. What were the most effective and locally appropriate strategies used to implement CHAMP in the primary care centres?

Methods

This study will comprise two complementary methods: semi-structured interviews with relevant stakeholders, and 1-day site visits to carry out in-site observation. This study requires ethics approval from two boards, and it is currently under review by Singapore's Ethics and Compliance Online System (ECOS), and has been reviewed (and approved) by the National University of Singapore Institutional Review Board (NUS-IRB-2024-669). The findings from this study, taken together with the Study 1 results, will be used to develop an implementation process map.

1. Semi-structured interviews

1. **Study population**: we aim to interview the following stakeholders:
    a. *Members of the development and initial implementation team* that developed and led the initial deployment in primacy care centres of CHAMP
    b. Primary care centres leadership
    c. *Healthcare providers, including general practitioners and care managers* who are participating, and not participating in CHAMP's roll-out
    d. *Patients* who agreed and did not agree to sign up to the service.

2. **Sample size**: We will aim to recruit between 5-10 healthcare providers, 5-10 patients, 3-5 members of the primary care centres leadership, and members of the CHAMP development and initial implementation team. The total number of interviewees will be determined by the eligible population (healthcare providers and members of the CHAMP team) and by reaching thematic saturation [35,36] (patients).
3. **Participants recruitment**: we will use different recruitment modalities according to the

participants' group:

a. *Members of the CHAMP development and initial implementation team, healthcare providers and primary care centres leadership* will be invited to participate in the interview via email. The place, time and modality (face-to-face or virtual) of the interview will be agreed with the participant prior to the interview. We will aim to interview healthcare providers involved, and not involved in patient recruitment for CHAMP.
b. *Patients currently enrolled* CHAMP will receive a message via the CHAMP's WhatsApp channel enquiring their willingness to participate in research associated to CHAMP.
c. *Patients who are not enrolled in CHAMP* will be recruited face-to-face during their regular check-up visits at the primary care centre

4. **Procedure**: we will conduct 1-to-1, semi-structured interviews following an interview guide. Interviews are estimated to last 30-45 mins and will be digitally recorded for subsequent analysis. The interviews will have a retrospective focus to try to understand CHAMP's implementation process to-date, lessons learnt, and the factors that influenced its implementation.

   The interviews will be developed by the research team and will be based on CFIR [31] and the UTAUT [33]. Appendix 2 presents the interview guides. These guides will be subjected to initial, piloting with 1-2 participants, to ensure content and context relevance, feasibility and suitable flow of questions. The topic guides will be subsequently edited, if and as required, prior to full deployment within the study.

5. **Data analysis**: recordings of the interviews will be transcribed verbatim. The interview data will be analysed using the framework analysis approach as outlined by Gale et al (2013) [34]. The analysis will be guided by CFIR [31] and UTAUT [33] domains. Two researchers working independently and in parallel will deductively code the data using codes developed in advance by the research team. If the interviews include relevant information that would not fit the codebook, the researchers will inductively develop new codes. The researchers will meet regularly during the data analysis process to discuss the codes and reach consensus on the final themes. We will use NVivo v14.0 to code the data.

2. One-day site visit

We will conduct a series of observations in the primary care centres to assess the its structure, staff:patient ratio, demographic of the patient population, number of research or implementation projects the primary care insitution is currently involved with, and other relevant information, complemented, if possible by informal interviews with the leadership team, administrators and healthcare providers.

Concurrently, we will aim to understand the current implementation workflow: number of healthcare providers involved in CHAMP's implementation, steps to enrol patients, type of HCP (doctor, care manager) enrolling and educating patients on the use of CHAMP, duration of

enrolment/education procedure, provision of written materials to reinforce learning, etc. If possible, the site visit will include the observation of 'live' patient enrolment into CHAMP.

3. Process mapping

The information obtained in the two previous steps, and Study 1 (rapid evidence review), will be used to develop a process map to outline the patient journey and map the barriers and facilitators influencing the current deployment of CHAMP. We will use the Implementation Research Logic Model (IRLM) [37] as a template to outline the process map. Once completed, the process map will be shared with relevant stakeholders (analogous to the groups where Study 2 interview participants are drawn from) for inputs and further refinement.

The iterative development of the process map will assist the research team in outlining the implementation strategies, mapping these strategies to the relevant influencing factors and the proposed theories of change/mechanism of implementation. The process map will be revisited at regular intervals during Study 3 (see section below) to evaluate the progress and success of CHAMP implementation. To evaluate the implementation success, we will attempt to compare the intended outcome/s of implementation, as outlined in the process map derived form Study 2, with the actual results of implementation and how stakeholders evaluate the outcomes and success of this exercise.

Study 3: Development of implementation strategies and implementation of CHAMP in primary care centres

Study aims

In this study, we aim to develop a set of implementation strategies to effectively implement CHAMP and evaluate the outcomes of implementation in the primary care centres. The research questions guiding this study are:

1. What is the readiness to change of HCPs and leadership teams at the primary care centres?
2. What are the most appropriate and effective strategies to implement CHAMP in the primary care centres of Western Singapore?
3. How and what aspects of CHAMP can be improved to increase patients' engagement with the platform and ultimately, more positive health outcomes?

Methods

1. Readiness to change assessment

1. **Study population**: we will include the following stakeholders, *leadership teams and healthcare providers, including general practitioners and care managers* working in chronic disease management teams in primary care centres. We will invite all eligible HCPs to participate in the study, and aim to collect responses from at least 50% of the eligible population.
2. **Study design**: readiness to change will be assessed using two brief self-reported questionnaires:
    a. *Organizational Readiness for Implementing Change (ORIC)* [38] is a reliable and valid questionnaire that evaluates readiness to change at an organizational level, by assessing the concepts of change commitment and change efficacy. This measure is based on Weiner's [39] theory of the determinants and outcomes of organizational readiness for change and consists of 12 statements rated using 5-point Likert scales.
    b. *Readiness Thinking Tool (or Readiness Monitoring Tool)* [40,41] assesses readiness at an organizational level. This validated tool contains a total of 19 elements grouped in three constructs: motivation (6 elements), innovation-specific capacity (5 elements) and general capacity (8 elements) – all rated 4-point Likert scales.
3. **Participants recruitment and study procedure**: participants will be invited to participate in the study via email. The invitation email will contain a link to the surveys for the participants to access if they agree to be part of the study.
4. **Data analysis**: we will use descriptive statistics to analyse the data. We will perform subgroup analyses to determine the readiness for change in specific HCP groups (doctors, care managers, nurses) and primary care centre leadership teams, and for HCPs working in each of the primary care centres included in the study. The results of these assessments will offer a perspective on the implementation context for CHAMP across sites and will be used to design site-specific targeted implementation strategies to optimize the implementation and scale-up of CHAMP.

2. Development of implementation strategies

The findings from studies 1 and 2, coupled with the readiness assessments above, will inform the development of implementation strategies to enhance CHAMP's implementation and scale-up. We will develop a set of evidence-informed, pragmatic, context-driven implementation strategies to address barriers and enhance facilitators of implementation. We will use the Expert Recommendations for Implementing Change (ERIC) taxonomy [42] to define the implementation strategies, and the Action, Actor, Context, Target, Time (AACTT) framework [43] to define the strategy implementation processes. The implementation strategies will be developed by the research team in collaboration with the CHAMP development and implementation team and the HCPs in the primary care centres. Examples of implementation strategies and how they could address specific barriers are shown in Table 1. The implementation strategies will be presented in the form of a

pragmatic research logic model booklet and will be used to guide subsequent implementation and scale-up of CHAMP.

3. Leveraging on behavioural science

Effective implementation of evidence-based practice depends on behaviour change. In relation to CHAMP, a key indicator of success rests on patients' interactions with the chatbot and compliance with the messages (e.g., reminders to submit BP, lifestyle advice) it conveys. To enable this, researchers have developed numerous frameworks for guiding the development, design, and implementation of behaviour change interventions, two of which feature prominently in the public health literature: (1) the Theoretical Domains Framework [44,45]; and (2) the Behaviour Change Wheel [46].

Drawing on the findings of Studies 1 and 2, we will employ these two frameworks [45,46] to systematically test variations of the chatbot's messages in effectively engaging patients. A meta-analysis Effective implementation of evidence-based practice depends on behaviour change. In relation to CHAMP, a key indicator of success rests on patients' interactions with the chatbot and compliance with the messages (e.g., reminders to submit BP, lifestyle advice) it conveys. To enable this, researchers have developed numerous frameworks for guiding the development, design, and implementation of behaviour change interventions, two of which feature prominently in the public health literature: (1) the Theoretical Domains Framework [44,45]; and (2) the Behaviour Change Wheel [46].

Drawing on the findings of Studies 1 and 2, we will employ these two frameworks [45,46] to systematically test variations of the chatbot's messages in effectively engaging patients. A meta-analysis [47] of 40 web-delivered health behaviour change programs has showed that tailored interventions (e.g., personalization, interactivity, frequency, convenience) resulted in significantly better health outcomes as compared with control conditions at post-test and at follow-up. However, what aspects to tailor with respect to CHAMP remains unknown. Hence, one of the aims of Study 3 is to improve the chatbot's ability to engage with patients and through this, improve patients' health outcomes. This not only supports evidence-based practice, but also highlights the value of CHAMP to clinicians, patients, and the larger community at large. [47] of 40 web-delivered health behaviour change programs has showed that tailored interventions (e.g., personalization, interactivity, frequency, convenience) resulted in significantly better health outcomes as compared with control conditions at post-test and at follow-up. However, what aspects to tailor with respect to CHAMP remains unknown. Hence, one of the aims of Study 3 is to improve the chatbot's ability to engage with patients and through this, improve patients' health outcomes. This not only supports evidence-based practice, but also highlights the value of CHAMP to clinicians, patients, and the larger community at large.

Table 1: Examples of barriers that their associated implementation strategies based on the ERIC and AACTT frameworks

Targeted barrier	ERIC Strategy	Actor	Action	Context	Target	Time

Lack of clear directive from the top management	Mandate usage	Head of Department	Mandates use of CHAMP	Primary care centre	HCPs who will prescribe CHAMP	At department meeting
Clinical team is not familiar with CHAMP	Conduct ongoing training	CHAMP team	Conducts workshop on CHAMP functionalities	Primary care centre	HCPs who will prescribe CHAMP	Before launching implementation study
Patients unsure about enrolment	Involve patients	HCPs who will prescribe CHAMP	Empower and activate patients to use CHAMP	Primary care centre	Patients	During clinical consultation
Patients who miss submitting BP readings	Intervene with patients to enhance adherence	HCPs who will prescribe CHAMP	Embed and test behavioural levers	Reminder messages	Patients	During stipulated self-monitoring period

Note: ERIC = Expert Recommendations for Implementing Change; AACTT = Action, Actor, Context, Target, Time framework

Ethics and dissemination

Study 1 is a review of published literature and does not require ethics approval. For study 2, interviews with the CHAMP development and initial implementation team, healthcare providers and primary care centres leadership has been approved by the National University of Singapore (NUS) Institutional Review Board (NUS-IRB-2024-669). For patients' interviews and on-site visits, we are awaiting approval by Singapore's Ethics and Compliance Online System (ECOS).

Findings from these studies will be shared with the funders and stakeholders involved in CHAMP's development, including patients using the platform. Research findings will be presented at conferences and published in relevant peer-reviewed journals.

Results

To date, the following aspects of the studies have been initiated: for Study 1, we registered the protocol in PROSPERO (CRD42024613653), developed the search strategy and conducted the search on 4th October 2024 in Medline, Embase, and Web of Science, retrieving 2,835 citations. After deduplicating the library, we completed title and abstract screening, and are currently conducting the full text screening. For study 2, we obtained ethics approval for the interviews to healthcare providers, primary care centres leadership and CHAMP development and initial implementation teams. We completed 31 semi-structured interviews. We are still pending ethics approval for patient interviews and on-site visits. Readiness for change survey have started on 3rd February 2025 and data collection is still ongoing.

Discussion

The results from these studies will inform the further implementation and scale up of CHAMP across primary care centres in Singapore, by providing relevant contextual information to better design targeted implementation strategies that aim to enhance the facilitators and overcome the current barriers to the implementation of CHAMP. The successful implementation of digital health interventions to support the self-management of chronic disorders, such as hypertension, may improve healthcare delivery without further straining healthcare systems.

Acknowledgments

This research is supported by the NUHS Seed Fund Grant NUHSRO/2024/083/RO5+6/Seed-Mar24/03, and the Practice Changing Innovation (PCI) Award for CHAMP (**CH**ronic dise**A**se **M**anagement **P**rogramme).

Conflict of interests

NS is the director of London Safety and Training Solutions ltd, which offers training and improvement and implementation solutions to healthcare organisations and the pharmaceutical industry. The other authors have no competing interests to declare.

Contributors

LM is the guarantor for the study and is responsible for the management of the study. HNHL, ET, SCT and NS were involved in the conceptualisation of the study and are the study coapplicants. All the authors were involved in writing and revising the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All authors will have access to the final datasets for the studies.

Abbreviations

AACTT = Action, Actor, Context, Target, Time
AI: Artificial Intelligence
CHAMP: **CH**ronic dise**A**se **M**anagement **P**rogram
CFIR: Consolidated Framework for Implementation Research
ECOS: Ethics and Compliance Online System
ERIC: Expert Recommendations for Implementing Change
HBPM: Home blood pressure monitoring
HCP: Healthcare provider
ORIC: Organizational Readiness for Implementing Change
UTAUT: Unified Theory of Acceptance and Use of Technology

References

1. GBD 2021 Risk Factors Collaborators. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990-2021: a systematic analysis for the Global

Burden of Disease Study 2021. Lancet. 2024;403(10440):2162-203. PMID: 38762324. doi: 10.1016/s0140-6736(24)00933-4.
2. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223-37. PMID: 32024986. doi: 10.1038/s41581-019-0244-2.
3. Liew SJ, Lee JT, Tan CS, Koh CHG, Van Dam R, Müller-Riemenschneider F. Sociodemographic factors in relation to hypertension prevalence, awareness, treatment and control in a multi-ethnic Asian population: a cross-sectional study. BMJ Open. 2019;9(5):e025869. PMID: 31110091. doi: 10.1136/bmjopen-2018-025869.
4. World Health Organization. Global report on hypertension: the race against a silent killer: World Health Organization; 2023. ISBN: 9240081062.
5. Epidemiology & Disease Control Division and Policy Research & Surveillance Group. Ministry of Health and Health Promotion Board. National Population Health Survey 2022 (Household Interview and Health Examination) Singapore2023. [Available from: https://www.moh.gov.sg/resources-statistics/reports/national-population-health-survey-2022. Accessed 17 April 2024.
6. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: a systematic review and meta-analysis. Hypertension. 2011;57(1):29-38. PMID: 21115879. doi: 10.1161/hypertensionaha.110.160911.
7. Cuspidi C, Meani S, Fusi V, Salerno M, Valerio C, Severgnini B, et al. Home blood pressure measurement and its relationship with blood pressure control in a large selected hypertensive population. J Hum Hypertens. 2004;18(10):725-31. PMID: 15103315. doi: 10.1038/sj.jhh.1001737.
8. Green BB, Cook AJ, Ralston JD, Fishman PA, Catz SL, Carlson J, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. JAMA. 2008;299(24):2857-67. PMID: 18577730. doi: 10.1001/jama.299.24.2857.
9. Parati G, Omboni S, Albini F, Piantoni L, Giuliano A, Revera M, et al. Home blood pressure telemonitoring improves hypertension control in general practice. The TeleBPCare study. J Hypertens. 2009;27(1):198-203. PMID: 19145785. doi: 10.1097/hjh.0b013e3283163caf.
10. Sheppard JP, Tucker KL, Davison WJ, Stevens R, Aekplakorn W, Bosworth HB, et al. Self-monitoring of Blood Pressure in Patients With Hypertension-Related Multi-morbidity: Systematic Review and Individual Patient Data Meta-analysis. Am J Hypertens. 2020;33(3):243-51. PMID: 31730171. doi: 10.1093/ajh/hpz182.
11. Tucker KL, Sheppard JP, Stevens R, Bosworth HB, Bove A, Bray EP, et al. Self-monitoring of blood pressure in hypertension: A systematic review and individual patient data meta-analysis. PLoS Med. 2017;14(9):e1002389. PMID: 28926573. doi: 10.1371/journal.pmed.1002389.
12. Shimbo D, Artinian NT, Basile JN, Krakoff LR, Margolis KL, Rakotz MK, et al. Self-Measured Blood Pressure Monitoring at Home: A Joint Policy Statement From the American Heart Association and American Medical Association. Circulation. 2020;142(4):e42-e63. PMID: 32567342. doi: 10.1161/cir.0000000000000803.
13. Springer MV, Malani P, Solway E, Kirch M, Singer DC, Kullgren JT, et al. Prevalence and Frequency of Self-measured Blood Pressure Monitoring in US Adults Aged 50-80 Years. JAMA Netw Open. 2022;5(9):e2231772. PMID: 36103183. doi: 10.1001/jamanetworkopen.2022.31772.
14. Milne-Ives M, de Cock C, Lim E, Shehadeh MH, de Pennington N, Mole G, et al. The Effectiveness of Artificial Intelligence Conversational Agents in Health Care: Systematic Review. J Med Internet Res. 2020;22(10):e20346. PMID: 33090118. doi: 10.2196/20346.
15. Schachner T, Keller R, F VW. Artificial Intelligence-Based Conversational Agents for Chronic

Conditions: Systematic Literature Review. J Med Internet Res. 2020;22(9):e20701. PMID: 32924957. doi: 10.2196/20701.
16. Lyzwinski LN, Elgendi M, Menon C. Conversational Agents and Avatars for Cardiometabolic Risk Factors and Lifestyle-Related Behaviors: Scoping Review. JMIR Mhealth Uhealth. 2023;11:e39649. PMID: 37227765. doi: 10.2196/39649.
17. Singh B, Olds T, Brinsley J, Dumuid D, Virgara R, Matricciani L, et al. Systematic review and meta-analysis of the effectiveness of chatbots on lifestyle behaviours. NPJ Digit Med. 2023;6(1):118. PMID: 37353578. doi: 10.1038/s41746-023-00856-1.
18. Li Y, Liang S, Zhu B, Liu X, Li J, Chen D, et al. Feasibility and effectiveness of artificial intelligence-driven conversational agents in healthcare interventions: A systematic review of randomized controlled trials. Int J Nurs Stud. 2023;143:104494. PMID: 37146391. doi: 10.1016/j.ijnurstu.2023.104494.
19. Aggarwal A, Tam CC, Wu D, Li X, Qiao S. Artificial Intelligence-Based Chatbots for Promoting Health Behavioral Changes: Systematic Review. J Med Internet Res. 2023;25:e40789. PMID: 36826990. doi: 10.2196/40789.
20. He L, Balaji D, Wiers RW, Antheunis ML, Krahmer E. Effectiveness and Acceptability of Conversational Agents for Smoking Cessation: A Systematic Review and Meta-analysis. Nicotine Tob Res. 2023;25(7):1241-50. PMID: 36507916. doi: 10.1093/ntr/ntac281.
21. Bendotti H, Lawler S, Chan GCK, Gartner C, Ireland D, Marshall HM. Conversational artificial intelligence interventions to support smoking cessation: A systematic review and meta-analysis. Digit Health. 2023;9:20552076231211634. PMID: 37928336. doi: 10.1177/20552076231211634.
22. Laranjo L, Dunn AG, Tong HL, Kocaballi AB, Chen J, Bashir R, et al. Conversational agents in healthcare: a systematic review. J Am Med Inform Assoc. 2018;25(9):1248-58. PMID: 30010941. doi: 10.1093/jamia/ocy072.
23. Palanica A, Flaschner P, Thommandram A, Li M, Fossat Y. Physicians' Perceptions of Chatbots in Health Care: Cross-Sectional Web-Based Survey. J Med Internet Res. 2019;21(4):e12887. PMID: 30950796. doi: 10.2196/12887.
24. Langevin R, Berry ABL, Zhang J, Fockele CE, Anderson L, Hsieh D, et al. Implementation Fidelity of Chatbot Screening for Social Needs: Acceptability, Feasibility, Appropriateness. Appl Clin Inform. 2023;14(2):374-91. PMID: 36787882. doi: 10.1055/a-2035-5342.
25. Nadarzynski T, Miles O, Cowie A, Ridge D. Acceptability of artificial intelligence (AI)-led chatbot services in healthcare: A mixed-methods study. Digit Health. 2019;5:2055207619871808. PMID: 31467682. doi: 10.1177/2055207619871808.
26. Luca S, Clausen M, Shaw A, Lee W, Krishnapillai S, Adi-Wauran E, et al. Finding the sweet spot: a qualitative study exploring patients' acceptability of chatbots in genetic service delivery. Hum Genet. 2023;142(3):321-30. PMID: 36629921. doi: 10.1007/s00439-022-02512-2.
27. Miles O, West R, Nadarzynski T. Health chatbots acceptability moderated by perceived stigma and severity: A cross-sectional survey. Digit Health. 2021;7:20552076211063012. PMID: 34917391. doi: 10.1177/20552076211063012.
28. Garritty C, Gartlehner G, Nussbaumer-Streit B, King VJ, Hamel C, Kamel C, et al. Cochrane Rapid Reviews Methods Group offers evidence-informed guidance to conduct rapid reviews. J Clin Epidemiol. 2021;130:13-22. PMID: 33068715. doi: 10.1016/j.jclinepi.2020.10.007.
29. Montori VM, Wilczynski NL, Morgan D, Haynes RB. Optimal search strategies for retrieving systematic reviews from Medline: analytical survey. BMJ. 2005;330(7482):68. PMID: 15619601. doi: 10.1136/bmj.38336.804167.47.
30. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev. 2016;5(1):210. PMID: 27919275. doi: 10.1186/s13643-016-0384-4.

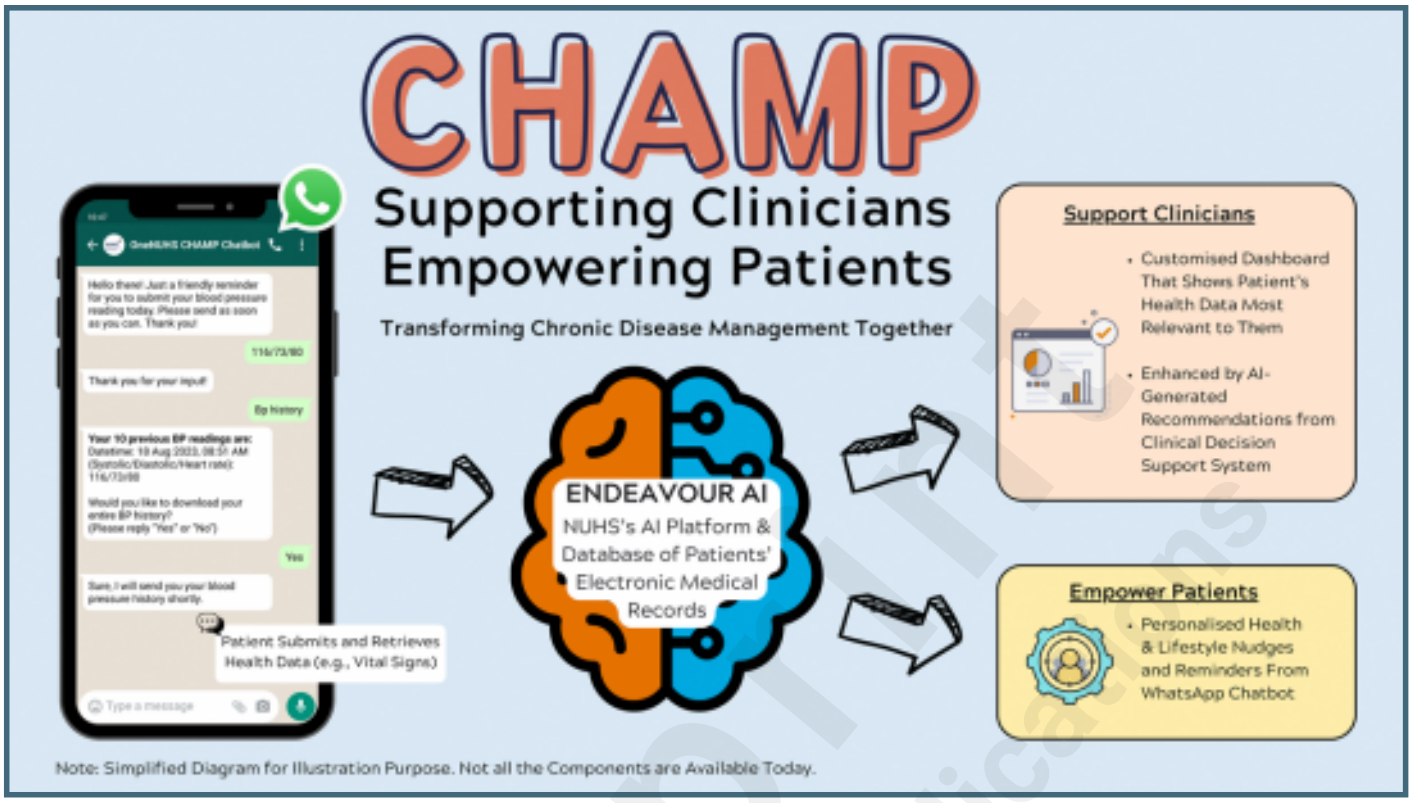
31. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009;4:50. PMID: 19664226. doi: 10.1186/1748-5908-4-50.
32. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated Consolidated Framework for Implementation Research based on user feedback. Implement Sci. 2022;17(1):75. PMID: 36309746. doi: 10.1186/s13012-022-01245-0.
33. Venkatesh V, Morris MG, Davis GB, Davis FD. User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly. 2003;27(3):425-78. doi: 10.2307/30036540.
34. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol. 2013;13:117. PMID: 24047204. doi: 10.1186/1471-2288-13-117.
35. Braun V, Clarke V. To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. Qual Res Sport Exerc Health. 2021;13(2):201-16. doi: 10.1080/2159676X.2019.1704846.
36. Vasileiou K, Barnett J, Thorpe S, Young T. Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period. BMC Med Res Methodol. 2018;18(1):148. PMID: 30463515. doi: 10.1186/s12874-018-0594-7.
37. Smith JD, Li DH, Rafferty MR. The Implementation Research Logic Model: a method for planning, executing, reporting, and synthesizing implementation projects. Implement Sci. 2020;15(1):84. PMID: 32988389. doi: 10.1186/s13012-020-01041-8.
38. Shea CM, Jacobs SR, Esserman DA, Bruce K, Weiner BJ. Organizational readiness for implementing change: a psychometric assessment of a new measure. Implement Sci. 2014;9:7. PMID: 24410955. doi: 10.1186/1748-5908-9-7.
39. Weiner BJ. A theory of organizational readiness for change. Implement Sci. 2009;4:67. PMID: 19840381. doi: 10.1186/1748-5908-4-67.
40. Hartley SN. The Readiness Monitoring Tool: Investigating The Psychometric Evidence For Group-Level Aggregation In Two Samples: University of South Carolina; 2018.
41. Scaccia JP, Cook BS, Lamont A, Wandersman A, Castellow J, Katz J, et al. A practical implementation science heuristic for organizational readiness: R = MC(2). J Community Psychol. 2015;43(4):484-501. PMID: 26668443. doi: 10.1002/jcop.21698.
42. Waltz TJ, Powell BJ, Matthieu MM, Damschroder LJ, Chinman MJ, Smith JL, et al. Use of concept mapping to characterize relationships among implementation strategies and assess their feasibility and importance: results from the Expert Recommendations for Implementing Change (ERIC) study. Implement Sci. 2015;10:109. PMID: 26249843. doi: 10.1186/s13012-015-0295-0.
43. Presseau J, McCleary N, Lorencatto F, Patey AM, Grimshaw JM, Francis JJ. Action, actor, context, target, time (AACTT): a framework for specifying behaviour. Implement Sci. 2019;14(1):102. PMID: 31806037. doi: 10.1186/s13012-019-0951-x.
44. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. Implement Sci. 2012;7:37. PMID: 22530986. doi: 10.1186/1748-5908-7-37.
45. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1):81-95. PMID: 23512568. doi: 10.1007/s12160-013-9486-6.
46. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6:42. PMID:

21513547. doi: 10.1186/1748-5908-6-42.
47. Lustria ML, Noar SM, Cortese J, Van Stee SK, Glueckauf RL, Lee J. A meta-analysis of web-delivered tailored health behavior change interventions. J Health Commun. 2013;18(9):1039-69. PMID: 23750972. doi: 10.1080/10810730.2013.768727.

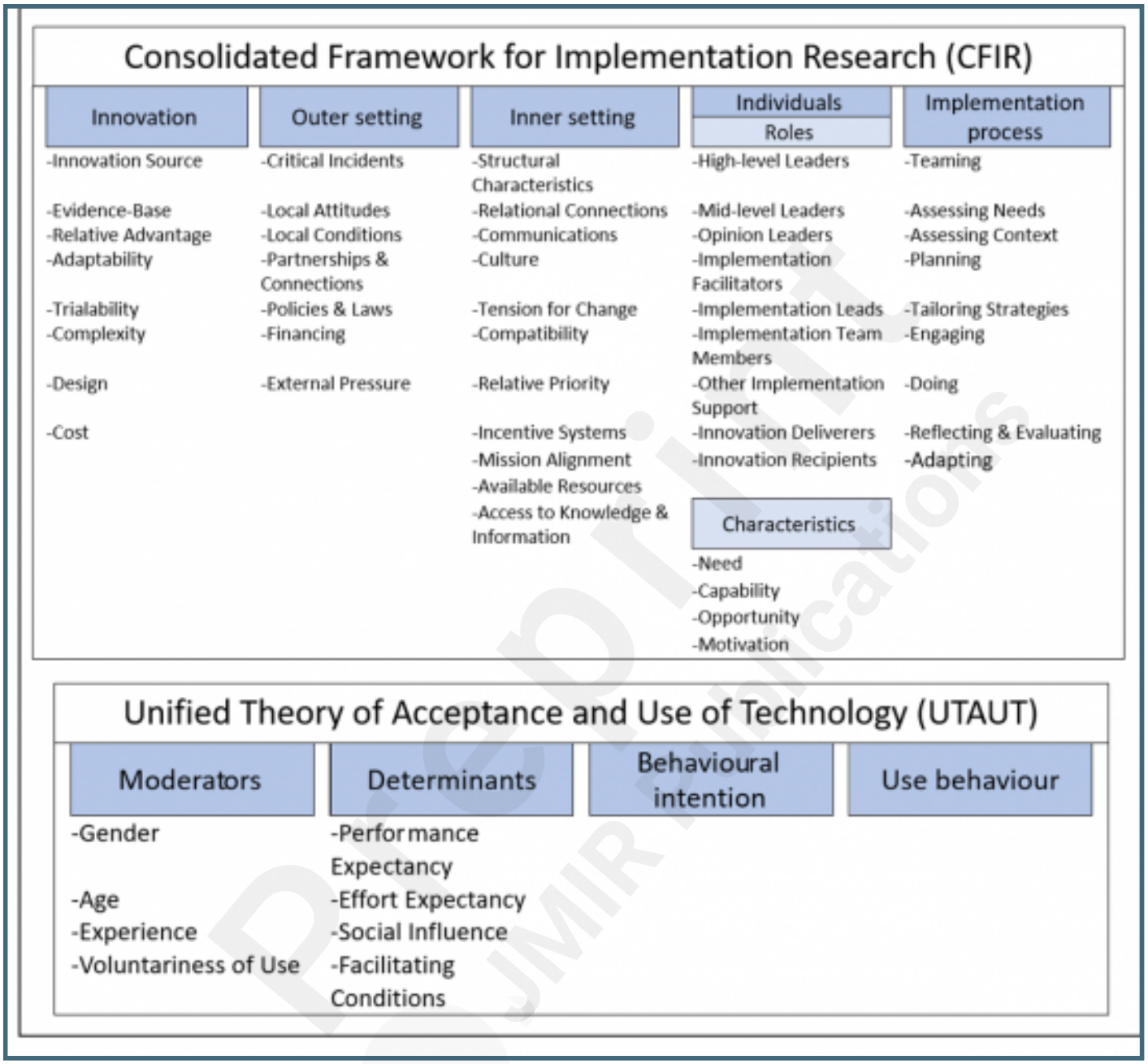
Supplementary Files

Figures

Diagrammatic view of CHAMP chatbot interface and functionalities.



Components of the CFIR and the UTAUT frameworks.



Multimedia Appendixes

Search strategy – Medline (4 October 2024).
URL: http://asset.jmir.pub/assets/da64c878ec6ff8d92718b3521b8e2d4b.docx

Semi-structured interview guides.
URL: http://asset.jmir.pub/assets/bbfcc94d8763ebe05bd0eaecb4e7dd50.docx