BMJ Open

Effects of smartphone-based chatbot intervention to increase influenza and COVID-19 vaccine uptake among South Asian ethnic minorities in Hong Kong: protocol for a randomised waitlist-controlled trial

Cho Lee Wong , Winnie Kwok Wei So, Carmen Wing Han Chan , Kai Chow Choi, Huiyuan Li

To cite: Wong CL, So WKW, Chan CWH, *et al*. Effects of smartphone-based chatbot intervention to increase influenza and COVID-19 vaccine uptake among South Asian ethnic minorities in Hong Kong: protocol for a randomised waitlist-controlled trial. *BMJ Open* 2024;**12**:e080725. doi:10.1136/bmjopen-2023-080725

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-080725).

Received 09 October 2023
Accepted 30 September 2024

The Nethersole School of Nursing, The Chinese University of Hong Kong, Faculty of Medicine, Hong Kong, Hong Kong

Correspondence to
Dr Huiyuan Li;
huiyuanli@cuhk.edu.hk

ABSTRACT

Introduction Protecting non-native ethnic minority groups against cocirculation of influenza and COVID-19 is crucial, and vaccination could be a viable option. Smartphone-based chatbots offer promising opportunities for improving vaccine knowledge and addressing barriers encountered by ethnic minorities. This trial aims to evaluate the effects of smartphone-based chatbot intervention on influenza and COVID-19 vaccine uptake, intention to receive vaccination and vaccine hesitancy among South Asian ethnic minorities in Hong Kong.

Method and analysis An assessor-blinded, cluster-randomised, waitlist-controlled trial will be conducted. This study consists of two phases. In phase I, a smartphone-based chatbot intervention will be developed, including designing a simple chatbot called 'Ali' to deliver prewritten educational text messages and vaccination reminders as well as respond to users' questions, and on-demand option for communication with research assistants. An expert panel will be invited to review the designed chatbot, and pilot testing will be performed. In phase II, a total of 612 South Asians will be recruited from each of the six participating non-governmental community centres or ethnic minority associations. They will be randomly allocated to intervention (n=306) or waitlist control group (n=306). The intervention group will receive in-app notifications related to the education text messages and vaccination reminders via the smartphone-based chatbot twice a week for two weeks. The waitlist control group will receive usual care only. Evaluation will include vaccination uptake, intention to receive vaccination and vaccine hesitancy. Assessments will take place at baseline (T0), immediately postintervention (T1) and 3-month postintervention (T2).

Ethics and dissemination This study has been approved by the Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee (CREC Ref. No.: 2021.688). The findings will be disseminated in peer-reviewed journals and through local or interventional conference presentations.

Trial registration number ChiCTR2200061503.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The content of educational text messages within a simple chatbot was underpinned by the 5C model to understand antecedents of vaccination behaviours.
⇒ To enhance rigour, this study incorporates cluster sampling, single-blinding and randomisation.
⇒ Due to the nature of the intervention, blinding of participants and the interventionist will be impractical.

INTRODUCTION

Influenza is a common cause of morbidity and mortality worldwide. It can cause serious diseases in high-risk groups and even healthy people.[1] In Hong Kong, the influenza-associated hospital admission rate during the peak season was 0.92 admissions per 10 000 population and resulted in 169 adults being admitted to the intensive care unit in 2020.[2] Meanwhile, the recent COVID-19 pandemic has had an unrivalled impact on the global healthcare system. Hong Kong is no exception. As of 27 July 2023, 1 226 467 COVID-19 cases have been recorded, and 9287 patients have died from the disease.

Influenza and COVID-19 share many common features, and the fifth wave of COVID-19 has been coincided, at least in part, with the circulation of seasonal influenza in the next few years. The cocirculating influenza and COVID-19 viruses likely intensify the burden on hospitalisation and intensive care unit admission.[3] This highlights the importance of optimising measures to manage both respiratory infections simultaneously and effectively.[3]

Vaccination is one of the effective ways to prevent the unnecessary spread of

vaccine-preventable diseases and promote herd immunity. Despite these benefits, the influenza vaccination rates in most countries are still less than 50%[4] of the expected coverage. A more worrisome problem is the even lower vaccine uptake among ethnic minorities.[5] A cohort study including a database of 12 million people in England observed low vaccine coverage in people from South Asian backgrounds.[6] A recent study corresponded to these findings revealing that the COVID-19 vaccination rate among ethnic minorities (20.5%) was much lower than that of the general population (42.5%).[7]

In Hong Kong, the government has launched a seasonal influenza programme and a territory-wide COVID-19 vaccination programme to provide eligible Hong Kong residents with free/subsided seasonal influenza vaccination and free COVID-19 vaccine. However, the overall uptake of influenza vaccine and the acceptance rate of COVID-19 vaccine among the local population was only 29.1%[8] and 37.2%,[9] respectively. Although there is a lack of publicly available vaccination rates among South Asians (from India, Nepal and Pakistan), one of the largest (14%)[10] and one of the fastest growing ethnic minority groups in Hong Kong, international data,[8 9] have already provided some insights into the significant risks of their low uptake rates of both vaccines.

Vaccine hesitancy, characterised by ambivalence or refusal to vaccinate, has been identified by the WHO as one of the top 10 global health threats in 2019.[11] Vaccine hesitancy is a complex and multifaceted construct that exists on a continuum, which encompasses a range of beliefs, attitudes and behaviours towards vaccination that can vary significantly between individuals and across different vaccine types.[11] On the basis of the Health Belief Model and Theory of Planned Behaviour, as well as the work of the WHO advisory group, researchers have posited the 5C model to understand antecedents of vaccination behaviours. 5C includes confidence (trust in vaccine effectiveness, safety and necessity and the system that provides it), complacency (perceived low risk of diseases), constraints (structural and psychological barriers), calculation (extensive information searching) and collective responsibility (willingness to protect others).[12] Ethnicity intersects with low literacy levels and language barriers accentuating the vaccination disparities.[13] For South Asians in Hong Kong, vaccine hesitancy towards COVID-19 and influenza vaccines may exhibit dynamic variance. While initial COVID-19 vaccine hesitancy may be high due to safety and trust concerns, acceptance increased as the vaccines proved effective. In contrast, influenza vaccine acceptance is relatively more stable and higher, as the community is familiar with its safety and perceived necessity, though individual factors like access and past experiences still impact acceptance levels.[13] Nevertheless, people who are hesitant can still be convinced of vaccination uptake with the provision of accurate information.[14] Thus, effective interventions aimed at promoting knowledge and awareness of vaccines and removing barriers are critical to the success of vaccination programmes.

A review of interventions to promote vaccination among ethnic minorities recommended multicomponent strategies.[15–17] Among various strategies, patient-focused interventions with education initiatives adjunct with vaccination reminders were the most effective.[15 16]

Providing educational information, as one of the effective strategies, has widely been used to increase knowledge and awareness of vaccination and reduce vaccine hesitancy.[15 18] A systematic review of 13 studies showed that it increased vaccine uptake by more than 25%.[15] In particular, the use of smartphones to deliver educational text messages seems to be an effective approach.[18] The vaccination reminder function can be integrated into educational text messages to remind patients to make vaccination appointments. Two randomised controlled trials (RCT) targeting ethnic minorities and a review showed that educational text messages adjunct with vaccination reminders can help increase influenza vaccine uptake and advance health literacy related to immunisations.[19–21]

However, the effectiveness of this educational-only text message approach is subjected to a decline in users' participation and engagement over time due to a lack of interactivity. In addition, a previous study has shown that the lack of interactive options may have the least beneficial effect on increasing vaccination coverage, as those who have not been vaccinated early may require an alternative approach to the information delivery to make vaccination decisions.[21] Chatbot, which can be built as part of smartphone-based interventions, may help improve interactivity and users' engagement.[22]

Chatbot is a computer programme designed to imitate human-like communications with users.[22] It covers a broad range from simple (simple rule-based systems) to smart (utilises artificial intelligence and machine learning techniques). Smart chatbots use machine learning (ie, training algorithms to identify patterns in data) and natural language processing (ie, the ability to understand and interpret human language input) to learn information from data without explicit programming.[22] Apple's Siri and Amazon's Alexa are examples. However, smart chatbots do not have complete human language capabilities, which can lead to misunderstandings and users' dissatisfaction.[22] By contrast, simple chatbots are rule-based and rely on prewritten keywords and programmed scripts, which allow providers to disseminate accurate educational information and reminders to users that simulate interactivity experienced by real-life conversation.[23]

The unique features of smartphone-based chatbots make it a promising tool for addressing barriers encountered by ethnic minorities. First, its technical capabilities allow audio and text-to-speech output in multiple languages to facilitate comprehension, which is ideal for ethnic minorities with low literacy levels. Second, the programmed scripts allow tailored information to meet

the needs of ethnic minorities, thereby improving the saliency and trustworthiness of the information delivered.[18 24] Third, the smartphone application platform can provide users with on-demand options for communicating with the human backend, so as to address specific questions from ethnic minorities that the chatbot is unable to answer. The live support component in the chatbots is also intended to build trust and rapport with participants, improving their engagement and adherence to the programmes and providing valuable feedback to inform future refinements to the chatbot's function.

A review of six studies indicated that chatbots have been used to disseminate health information and knowledge about COVID-19.[23] For instance, the WHO has developed a chatbot with several languages to provide information on a wide range of topics for users to ask and find answers related to COVID-19.[25] Likewise, the German government developed a 'flight COVID messenger bot'; in India, a smartphone application with parallel connection of a chatbot has been developed to enhance awareness of COVID-19.

A systematic review showed that smartphone-based chatbots have been developed to address adolescents' questions about sex, drugs and alcohol interactively; address mental health issues and promote the physical health of lay people, which achieved a moderate amount of evidence in supporting its acceptability and usability with messages sent twice a week.[24] Another meta-analysis that included 19 clinical and non-clinical RCTs reported the effectiveness of chatbots in improving health-related outcomes (such as pain management and weight loss). However, most studies aimed at evaluating chatbot interventions were quasi-experimental in design and lacked clear outcome measures.[22 24] Most importantly, no smartphone-based chatbot for promoting influenza and COVID-19 vaccine uptake has been developed and investigated to date.

In summary, smartphone-based chatbots offer promising opportunities for improving vaccine knowledge and addressing barriers encountered by ethnic minorities. To generate rigorous evidence, we propose a randomised waitlist-controlled trial to evaluate the effect of a smartphone-based chatbot intervention on the uptake of influenza and COVID-19 vaccines among South Asian ethnic minorities in Hong Kong. This innovative approach will likely provide practical significance in addressing needs and reducing barriers, thereby increasing the vaccination rate of South Asians. The ultimate impact of this project is to reduce the burden of influenza and COVID-19 by decreasing vaccination disparities.

Aim and hypothesis

The primary aim of this cluster-randomised, waitlist-controlled trial is to evaluate the effects of smartphone-based chatbot intervention on influenza and COVID-19 vaccine uptake among South Asian ethnic minorities in Hong Kong. The secondary aim is to assess the effects of such an intervention on the intention of influenza and COVID-19 vaccination as well as improve vaccine hesitancy.

Compared with the waitlist control group, South Asians in the intervention group are expected to exhibit the following outcomes on completion of the smartphone-based chatbot intervention:

1. Higher rate of influenza and COVID-19 vaccination uptake as evidenced by vaccination records.
2. Higher rate in expressing intention to receive influenza and COVID-19 vaccines as measured by two questions on the intention to receive vaccination.
3. Higher levels of confidence and collective responsibility and lower levels of complacency, constraints and calculation as measured by the 5C scale that measures vaccine hesitancy.

METHODS AND ANALYSIS

Design

A cluster-randomised, waitlist-controlled trial will be conducted. Figure 1 shows the study procedure. The protocol has been registered on the Chinese Clinical Trial Registry.

This study has two phases:

Phase I: development and validation of smartphone-based chatbot intervention.

Phase II: implementation and evaluation of the effects of the intervention.

IMPLEMENTATION

Phase I: development of smartphone-based chatbot

The smartphone-based chatbot intervention consists of two components: (1) a simple chatbot that is built into the smartphone application; and (2) on-demand option for users to communicate with trained research assistants (RAs).

A simple chatbot

A simple chatbot called 'Ali' (a commonly used name in South Asians) will be designed to deliver prewritten educational text messages and vaccination reminders as well as respond to users' questions in the smartphone application platform.

The content of educational text messages is developed based on the 5C model in the following topics: (1) influenza and COVID-19 incidence, mortality, risks, signs and symptoms and preventive measures (target complacency); (2) available options for vaccines, effectiveness, safety, necessity and benefits of vaccination (target confidence and collective responsibility); (3) myths and misconceptions of vaccines (target constraints); (4) vaccination programme offered by the department of health, as well as the contact number, address and global positioning system (GPS) of the clinics registered under the vaccination scheme and steps to book a vaccination appointment (target constraints and calculation).

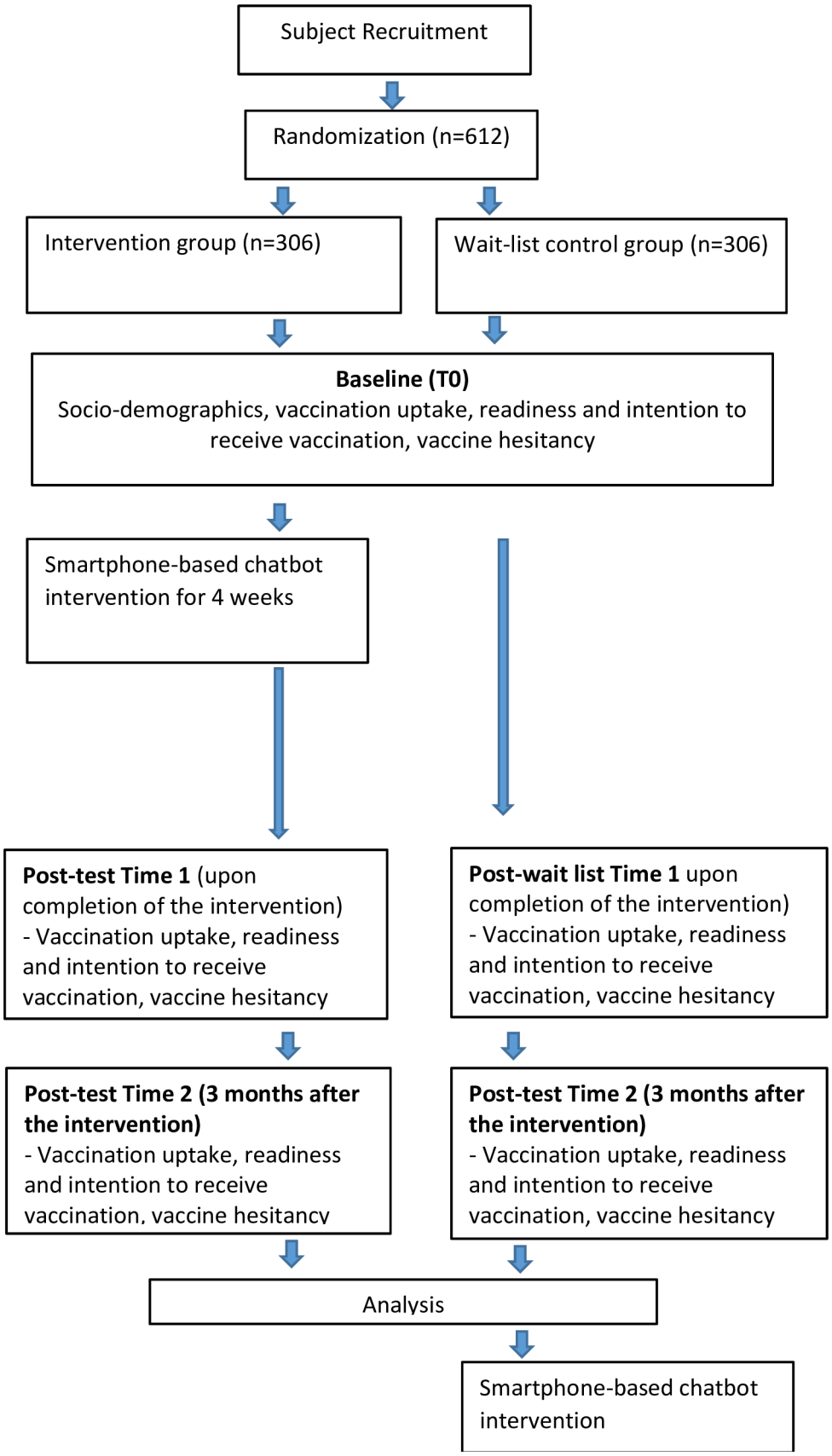

Figure 1 The flow diagram of intervention and data collection points.

'Ali' will send in-app prewritten educational text messages and vaccination reminders to users twice a week (for a total of four weeks) related to the four developed topics. Each message with 'Ali' will follow the same basic structure. The users will receive a notification with a basic greeting from 'Ali' (Hello! Its' me, your buddy bot!). 'Ali' will then continue the conversation by asking questions related to each topic and proposing answers for it. This helps positively influence users' intention to continue the intervention, enhance users' knowledge and motivate them to receive the vaccinations.

On-demand option

On top of 'Ali', there will be an on-demand option for project participants to communicate with well-trained RAs of this project when needed. The research team will extensively train the RAs on the content and functionality of the chatbots as well as best practices for providing personalised and helpful support to participants. The RAs will have access to a preapproved content library that they can reference when responding to participant questions and concerns, which will help ensure consistency and accuracy in their replies. In addition, the RAs will be required to document the types of questions and issues raised by participants during the live support sessions. This documentation will be for systematic analysis by the research team to identify common themes and areas for improvement in the chatbot's content and functionality. This option serves as a backup in case users cannot find answers related to their inquiries from 'Ali'.

The educational modules, text messages and vaccination reminders are prepared in English, Urdu and Nepali (written languages commonly used by South Asians). Most importantly, users can choose the voice narration option (recorded by RAs), so that the content can be narrated in spoken languages commonly used by South Asians (English, Hindi and Nepali) to facilitate understanding and comprehension.[17 23] The smartphone-based chatbot is open to the public for free download. It will also include a 'members only' feature, designed as a private communication channel, to facilitate on-demand communication between project participants and RA of the same ethnicity. Within the 'members only' functionality, participants will have access to a variety of communication tools and collaboration features, including private one-on-one messaging, group messaging, sharing-relevant materials securely, a community forum for broader discussions and an integrated notification system for upcoming vaccine injection and other updates relevant to vaccination. Registration is required to become a member, and a password will be provided to the participants. The Android platform is chosen for its widespread popularity and availability on various devices and operating systems.

Validation and pilot study of the smartphone-based chatbot

A panel of experts (consisting of IT experts, healthcare professionals, educators and South Asian community leaders) will be invited to review whether the contents of educational modules, text messages and reminders, as well as the layout and design of smartphone applications and chatbot, are linguistically and culturally relevant to South Asians.

In addition, nine South Asians (three Indians, three Pakistanis and three Nepalese) will be invited to pilot test the smartphone-based chatbot intervention and provide comments and feedback. Their comments and suggestions will be incorporated to optimise the smartphone-based chatbot before it is officially launched.

Phase II: implementation and effects' evaluation of the chatbot-based intervention

Participants

Trained RAs will approach potential subjects while they are participating in various activities organised by the six participating non-governmental community centres or ethnic minority associations, which provide support programmes and services for ethnic minorities in different regions in Hong Kong. After the introductory presentation, South Asians who are interested in participating in the study will be screened for eligibility.

Inclusion criteria

Patients who are (1) South Asians (from Pakistan, India or Nepal); (2) aged 18 or older; (3) unvaccinated for influenza or COVID-19 in the past 3 years; (4) able to communicate with English, Hindi, Nepali or Hindi and read English, Urdu and Nepali and (5) have an Android smartphone.

Exclusion criteria

Patients who have (1) participated in any intervention related to influenza and COVID-19 in the past year; (2) known vaccine contraindications (eg, a history of severe hypersensitivity to any vaccine component or previous dose of influenza vaccine).

Sample size

The sample size is estimated on the basis of the outcome of the vaccine uptake rate. A recent local study found a low uptake rate of influenza vaccine (29%) in the general population in Hong Kong.[8] The vaccine uptake rate among ethnic minorities can be less than half as compared with the general population.[7] We anticipate that our smartphone-based chatbot intervention can increase the uptake rate in ethnic minorities to the level of the general population. By using the power analysis software GPower V.3.1, it is estimated that a sample size of 121 participants per each of the intervention and control groups will be required to achieve 80% power at a 5% level of significance (two sided) to detect at least a 15% difference in the uptake rate (30% in the intervention group vs 15% in the control group) between the two groups. To allow for up to a 20% attrition rate, a total of 304 participants, with 152 per group will be needed. Furthermore, to account for the clustering design by allowing for an intracluster correlation coefficient up to 0.01 in our proposed trial, at least 102 participants will be recruited from each of the

six participating non-governmental community centres or ethnic minority associations.

Randomisation and blinding

Six centres and associations agreed to participate in this study. Each centre or association will be randomly assigned to one of the two arms: an intervention group (n=3) that will receive immediate treatment (smartphone-based chatbot intervention) or a waitlist control group (n=3) that will receive delayed treatment (the same intervention but provided after the intervention group has completed the immediate treatment). Participants from each centre/association will be randomly assigned in a 1:1 ratio to either the control group or the intervention group to avoid 'contamination' across participants. The computer-generated randomisation scheme will be conducted by a statistician to maintain concealment. The group identifiers for each centre/association will then be placed in serially numbered sealed opaque envelopes. The patient's group allocation will be assigned according to the sequence of enrolment in the study and the group identifier contained in the corresponding numbered envelopes. Assessments of vaccination uptake and other secondary outcomes will be performed by an RA blinded to the group allocation.

Waitlist control group

Participants in the control group will receive usual care provided by the ethnic minority associations or centres. They will be offered with the smartphone-based chatbot intervention after their counterparts have completed the intervention.

Intervention group

Participants in the intervention group will receive the smartphone-based chatbot intervention developed in phase I. The details of the intervention have been detailed in a previous section. Two well-trained RAs (Nepali RA2 and Pakistani RA3) will first demonstrate to participants the smartphone-based chatbot as an easy-to-use and supporting application for vaccination while emphasising that they are chatting with an automated system but not a person. They will invite participants to access the smartphone application via the QR code printed on the card. Each participant will be linked to the personalised code printed on this card. This connection between the participants and their designated RA will enable 'Ali' to recognise the participants, so that it can link back to its assigned RA to answer inquiries as needed. The intervention will last for 4 weeks. The smartphone-based chatbot will send in-app notifications to participants related to the educational text messages and remind them to receive vaccination twice a week (a total of four weeks). In addition, it will answer questions raised by participants at any time. In case participants cannot find an answer from 'Ali', the on-demand options can help link the participant with well-trained RAs of this project to answer their questions.

Fidelity of the intervention

Strategies will be used to monitor the intervention fidelity. Standardisation in the delivery of the intervention will be implemented through the use of written protocol. The RAs (RA2 and RA3) who implement the interventions are required to strictly follow the protocol. They will also receive 3-day training by the principal investigator. The training aims to equip RAs with knowledge and competence. A package of training materials will be prepared in accordance with the latest vaccination guidelines. The training contains four modules that are the same as those in the smartphone application. In addition, the training will focus on the following strategies (1) initiate discussions about vaccination, (2) clarify misconceptions about vaccination, (3) strategies to overcome possible vaccination barriers and (4) access to various vaccination resources. Throughout the project, the principal investigator will supervise and closely monitor the on-demand responses that the RAs provide to participants' inquiries to assess their competence. The principal investigator will also meet with RAs monthly and provide feedback.

Outcome measurements

Primary outcome: vaccination uptake

Participants will be assessed whether they have received influenza and COVID-19 vaccination separately as evidenced by their vaccination records.

Secondary outcomes

Intention to receive vaccination

The intention to receive influenza and COVID-19 vaccines will be measured by two items asking participants how likely they will take influenza and COVID-19 vaccine separately when available on an 11-point Likert scale (0=definitely no; 10=definitely yes).[26]

Vaccine hesitancy

Vaccine hesitancy will be measured by the 5C Scale. It is a 15-item tool developed from a '5C model' of five psychological antecedents to vaccination.[12] The five antecedents comprise confidence, complacency, constraints, calculation and collective responsibility. It will be assessed by three rating items on a 7-point scale (1=strongly disagree; 7=strongly agree). Mean scores of items under each domain will be computed, with a high score indicating a high level of agreement with the corresponding antecedents. This scale has been used in a local study to assess vaccine hesitancy.[27] It will be translated into Urdu and Nepali by our research team.

Sociodemographic characteristics

The age, ethnic group, monthly household income, years of formal education, marital status, employment status, number of years of residence in Hong Kong, history of COVID-19 and health insurance status of participants will be collected. Cues to action to vaccination (eg, knowing where to go for vaccination) will also be collected.

Table 1 SPIRIT schedule of the trial

	Study period				
	Enrolment	Allocation	Post-allocation	Close-out	
Timepoint	$-t_0$	0		t_1	t_2
Enrolment:					
Eligibility screen	■				
Informed consent	■				
Demographics and clinical characteristics	■				
Random allocation		■			
Interventions:					
(Smartphone-based chatbot intervention)			⟷		
(Waitlist control)			⟷		
Assessments:					
Vaccination uptake				■	■
Intention to receive vaccination				■	■
5Cscale for vaccine hesitancy				■	■
Sociodemographic characteristics	■				

SPIRIT, Standard Protocol Items: Recommendations for International Trials; T0, baseline; T1, immediately post-intervention; T2, three months post-intervention.

Data collection procedures

With consent, the baseline characteristics of the participants, including the sociodemographic characteristics and research outcomes, will be evaluated at baseline (T0, that is, on entry to the study before randomisation and intervention during the face-to-face meeting at enrolment). The instruments will also be administered by the RA blinded to group allocation at the other two points: postintervention (T1, that is, telephone interview on completion of the intervention) and 3 months postintervention (T2, that is, telephone interview at three months after completion of the intervention). The data collection plan is shown in table 1.

The self-reported questionnaires are available in English, Nepali and Urdu. Content validity will be assessed by the expert panel. The blinded RA will contact the participants in both groups to complete the paper version of the questionnaire. All participants will receive a HK$200 coupon after completion of the baseline assessment and two postintervention questionnaires.

Data management

Information collected about the subjects will be kept strictly confidential, with only the research team able to access the encrypted data file. All hard copies of documents will be kept in a locked cabinet and will be destroyed within six years of the study's completion. The electronic data will be stored in a hard disk protected with passwords kept for ten years.

Patient and public involvement

Participants were involved in the development of the intervention. Before the start of the full-scale study, participants were first invited to participate in the main sessions of the study to ensure clarity and comprehension. After the intervention delivery, participants in the intervention group will be evaluated to explore their experiences on the intervention's usefulness and acceptability.

Data analysis

Data will be summarised and presented using appropriate descriptive statistics. The normality of continuous variables will be assessed using skewness and kurtosis statistics and a normal probability plot. Suitable transformations will be made on skewed variables before subjecting them to inferential analysis if needed. The homogeneity of participants' characteristics between the two groups will be assessed by independent t, χ^2 or Fisher's exact tests, as appropriate.

The effectiveness of the intervention will be assessed by comparing the uptake rate of COVID-19 and influenza vaccines separately between the two groups, and by comparing the between-group differences in the changes in vaccination intention and vaccine hesitancy on COVID-19 and influenza vaccines separately at T1 and T2 with respect to T0. The intention-to-treat principle will be adopted in the outcome evaluation between the two groups. The generalised estimating equations (GEE) approach, in conjunction with a small sample correction for sandwich variance estimate, will be used to compare the outcomes between the two groups. This approach can be used to account for the intercorrelation within the same cluster and intracorrelated repeated measure data in a cluster RCT with a small number of clusters. The GEE model will also handle the randomly missing data

with correlated data, which can provide valid parameter estimates and SEs while accounting for the missing data mechanism and the flexibility to model various correlation structures. The GEE analysis will be performed with the procedure GLIMMIX, implemented in the SAS (SAS Institute, Cary, North Carolina, release V.9.4). All statistical tests involved will be two sided with the level of significance set at 0.05.

ETHICS AND DISSEMINATION

Ethical approval has been sought from the Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee with reference number: 2021.688. The study complies with the Declaration of Helsinki. Eligible participants will be briefed on the study details, its aims and objectives and their rights to withdraw at any time. They will be given an assurance as to anonymity and confidentiality. An information sheet with details of the study and an informed consent form will be provided, and they will be available in English, Nepali and Urdu. Potential participants interested in the study will be asked to sign the consent form (online supplemental material 1) and return it to the RAs. It will be emphasised that their participation is voluntary and that they can leave the study at any time without giving a reason. The findings will be disseminated in peer-reviewed journals and through local or international conference presentations.

DISCUSSION

Influenza and COVID-19 vaccination uptake can vary among different demographic groups, including non-active ethnic minorities, due to various factors such as access to healthcare, language barriers, cultural beliefs and trust in the healthcare system. It is important for public health authorities to address any disparities in vaccination rates and ensure equitable access to vaccines for all communities, including ethnic minorities, to achieve widespread vaccination coverage and protect the entire population. This novel study is the first to develop and evaluate the effectiveness of the smartphone-based chatbot intervention in improving vaccination uptake, intention to receive vaccination and vaccine hesitancy among South Asian ethnic minorities in Hong Kong. This innovative approach will likely provide practical significance in addressing needs and reducing barriers, thereby increasing the vaccination rate of South Asians. The ultimate impact of this project is to reduce the burden of influenza and COVID-19 by decreasing vaccination disparities. It is anticipated that the chatbot 'Ali' will become a friendly using application in the community. The chatbot can be culturally sensitive and respectful of the diverse backgrounds and beliefs of ethnic minority communities, especially people with South Asian backgrounds. The language, tone and content are tailored to address cultural nuances and can avoid any potential misunderstandings or misinterpretations. The chatbot is also multilingual or provides language options for South Asians to accommodate their different language preferences. In addition, this study will be conducted collaborated with six non-governmental community centres or ethnic minority associations; the intervention implementation will provide a good opportunity for healthcare providers and cultural influencers in Hong Kong to engage ethnic minority populations effectively. This will also benefit the South Asian receive timely and effective medical services from the local health authorities, thus realising health equity and service generalisation.

Contributors CLW and HL contributed to the conception and design of the trial and acted as the guarantors. CWHC, WKWS and HL provided expert advice and commented on the intervention contents. KCC is responsible for sample size calculation and statistical analyses. CLW, WKWS, CWHC and HL wrote the manuscript, and all authors read and approved the manuscript.

Funding This work was supported by the Health and Medical Research Grant, Hong Kong (Grant Ref. Number: 05200198)

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Consent obtained directly from patients.

Provenance and peer review Not commissioned; externally peer-reviewed.

ORCID iDs

Cho Lee Wong http://orcid.org/0000-0001-6640-1323
Carmen Wing Han Chan http://orcid.org/0000-0003-0696-2369
Huiyuan Li http://orcid.org/0000-0002-0207-691X

REFERENCES

1 Iuliano AD, Roguski KM, Chang HH, *et al*. Estimates of global seasonal influenza-associated respiratory mortality: a modelling study. *Lancet* 2018;391:1285–300.
2 Centre for Health Protection. Recommendation on seasonal influenza vaccination for the 2020-21 season in Hong Kong. 2020 Available: https://www.chp.gov.hk/en/static/24008.html
3 Chotpitayasunondh T, Fischer TK, Heraud J-M, *et al*. Influenza and COVID-19: What does co-existence mean? *Influenza Other Respir Viruses* 2021;15:407–12.
4 Singh A, Lai AHY, Wang J, *et al*. Multilevel Determinants of COVID-19 Vaccine Uptake Among South Asian Ethnic Minorities in Hong Kong: Cross-sectional Web-Based Survey. *JMIR Public Health Surveill* 2021;7:e31707.

5 Lu P, O'Halloran A, Williams WW, *et al*. Racial and Ethnic Disparities in Vaccination Coverage Among Adult Populations in the U.S. *Am J Prev Med* 2015;49:S412–25.
6 UK Government Scientific Advisory Group for Emergencies. Factors influencing covid-19 vaccine uptake among minority ethnic groups. 2020. Available: https://www.gov.uk/government/publications/factors-influencing-covid-19-vaccine-uptake-among-minority-ethnic-groups-17-december-2020
7 MacKenna B, Curtis HJ, Morton CE, *et al*. Trends, regional variation, and clinical characteristics of COVID-19 vaccine recipients: a retrospective cohort study in 23.4 million patients using openSAFELY (pre-print) [medRxiv]. 2021. Available: https://www.medrxiv.org/content/10.1101/2021.01.25.21250356v1
8 Sun KS, Lam TP, Kwok KW, *et al*. Seasonal influenza vaccine uptake among Chinese in Hong Kong: barriers, enablers and vaccination rates. *Hum Vaccin Immunother* 2020;16:1675–84.
9 Wong MCS, Wong ELY, Huang J, *et al*. Acceptance of the COVID-19 vaccine based on the health belief model: A population-based survey in Hong Kong. *Vaccine (Auckl)* 2021;39:1148–56.
10 Wong CL, Leung AWY, Chan DNS, *et al*. Psychological Wellbeing and Associated Factors Among Ethnic Minorities During the COVID-19 Pandemic. *J Immigr Minor Health* 2022;24:1435–45.
11 MacDonald NE. SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: Definition, scope and determinants. *Vaccine (Auckl)* 2015;33:4161–4.
12 Betsch C, Schmid P, Heinemeier D, *et al*. Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PLoS ONE* 2018;13:e0208601.
13 Amboree TL, Darkoh C. Barriers to Human Papillomavirus Vaccine Uptake Among Racial/Ethnic Minorities: a Systematic Review. *J Racial Ethn Health Disparities* 2021;8:1192–207.
14 COVID-19 vaccine deployment: behaviour, ethics, misinformation and policy strategies. The Royal Society, British Academy. 2020 Available: https://royalsociety.org/-/media/policy/projects/set-c/set-c-vaccine-deployment.pdf
15 Jarrett C, Wilson R, O'Leary M, *et al*. Strategies for addressing vaccine hesitancy - A systematic review. *Vaccine (Auckl)* 2015;33:4180–90.
16 Dubé E, Gagnon D, MacDonald NE, *et al*. Strategies intended to address vaccine hesitancy: Review of published reviews. *Vaccine (Auckl)* 2015;33:4191–203.
17 Hoppe KK, Eckert LO. Achieving high coverage of H1N1 influenza vaccine in an ethnically diverse obstetric population: success of a multifaceted approach. *Infect Dis Obstet Gynecol* 2011;2011:746214.
18 Atkinson KM, Wilson K, Murphy MSQ, *et al*. Effectiveness of digital technologies at improving vaccine uptake and series completion - A systematic review and meta-analysis of randomized controlled trials. *Vaccine (Auckl)* 2019;37:3050–60.
19 Stockwell MS, Kharbanda EO, Martinez RA, *et al*. Effect of a text messaging intervention on influenza vaccination in an urban, low-income pediatric and adolescent population: a randomized controlled trial. *JAMA* 2012;307:1702–8.
20 Dumit EM, Novillo-Ortiz D, Contreras M, *et al*. The use of eHealth with immunizations: An overview of systematic reviews. *Vaccine (Auckl)* 2018;36:7923–8.
21 Hofstetter AM, Vargas CY, Camargo S, *et al*. Impacting delayed pediatric influenza vaccination: a randomized controlled trial of text message reminders. *Am J Prev Med* 2015;48:392–401.
22 Tudor Car L, Dhinagaran DA, Kyaw BM, *et al*. Conversational Agents in Health Care. *Scoping Rev Concept Anal J Med Internet Res* 2020;22:e17158.
23 Milne-Ives M, de Cock C, Lim E, *et al*. The Effectiveness of Artificial Intelligence Conversational Agents in Health Care: Systematic Review. *J Med Internet Res* 2020;22:e20346.
24 Almalki M, Azeez F. Health Chatbots for Fighting COVID-19: a Scoping Review. *Acta Inform Med* 2020;28:241–7.
25 World Health Organization. WHO launches a chatbot on Facebook Messenger to combat COVID-19 misinformation. 2020 Available: https://www.who.int/news-room/feature-stories/detail/who-launches-a-chatbot-powered-facebook-messenger-to-combat-covid-19-misinformation
26 Kwok KO, Li KK, Wei WI, *et al*. Editor's Choice: Influenza vaccine uptake, COVID-19 vaccination intention and vaccine hesitancy among nurses: A survey. *Int J Nurs Stud* 2021;114:103854.
27 Yu BY-M, Lam JC-S, Lam SC, *et al*. COVID-19 vaccine hesitancy and resistance in an urban Chinese population of Hong Kong: a cross-sectional study. *Hum Vaccin Immunother* 2022;18:2072144.

The Chinese University of Hong Kong
Faculty of Medicine
The Nethersole School of Nursing

Information sheet for participants (Phase II)

Title of the study

Effects of smartphone-based chatbot intervention to increase influenza and COVID-19 vaccine uptake among South Asians: a wait-list randomized controlled trial

Purpose of the study

The purpose of the study is to evaluate the effects of smartphone-based chatbot intervention on influenza and COVID-19 vaccine uptake amongst South Asians (from Pakistan, India, or Nepal) in Hong Kong.

Procedure

We are going to recruit 612 South Asians to join the study. Six community centers or ethnic minorities associations have agreed to participate the project will be randomly selected as 3 intervention groups and 3 control groups for the study. Potential subjects will be approached by the research assistant (RA) whilst they are participating in various activities organised by these six centers or associations. After the introductory presentation, South Asians who are interested in participating in the study will be screened for eligibility.

Eligible participants are:
(1) South Asians (from Pakistan, India or Nepal);
(2) aged 18 or older;
(3) unvaccinated for influenza or COVID-19 in the past year;
(4) able to communicate with English, Hindi, Nepali or Hindi and read English, Urdu and Nepali; and
(5) have a smartphone.

For those who (1) are South Asians from Bangladesh and Sri Lanka; (2) participated in any intervention related to influenza and COVID-19 in the past year; (3) have known vaccine contraindications (e.g. a history of severe hypersensitivity to any vaccine component or previous dose of influenza vaccine) will be excluded from the study.

If you are willing to participate in the study, you will be given this information sheet to keep and asked to sign an informed consent form.

Intervention group

A smartphone-based chatbot intervention is developed and introduced to the South Asians to

increase the influenza and COVID-19 vaccination uptake. It consists of two components: (1) a simple chatbot that is built in the smartphone application; and (2) on-demand option for users to communicate with trained research assistants. A simple chatbot called 'Ali' will be designed to deliver prewritten educational text messages and vaccination reminders as well as respond to users' questions in the smartphone application platform. Two well-trained RAs will first demonstrate to participants how to use the smartphone-based chatbot and access application via the QR code. Each participant will be linked to the personalised code and connected between the participants and their designated RA that enable 'Ali' to recognise the participants. The intervention will last for 4 weeks. The smartphone-based chatbot will send the in-app notification to participants related to the educational text messages and remind them to receive vaccination twice a week (total of 4 weeks). In case participants cannot find an answer from 'Ali', the on-demand options can help link the participant with well-trained research assistants of this project to answer their questions.

Control group
Subjects in the control group will be offered with the smartphone-based chatbot intervention after their counterparts have completed the intervention.

In order to evaluate the intervention study, you will be asked to complete the questionnaire at the study enrollment (T0), upon completion of the intervention (T1) and 3 months after the intervention (T2).
The questionnaire consists of socio-demographics, vaccination uptake, readiness and intention to receive vaccination, vaccine hesitancy.

If you decide to take part, you are still free to withdraw at any time and without giving a reason.

Risks and benefits
There is no potential risk for the participants. All participants will receive HK$200 for completing the questionnaires.

Confidentiality of participants
All information which is collected about you during the course of the research will be kept strictly confidential. Any information about you will be anonymized using a unique number identification so that you cannot be recognized from it. All hard copies of documents will be kept in a locked cabinet and will be destroyed within six years of the study's completion. The electronic data will be kept for ten years.

The Chinese University of Hong Kong
Faculty of Medicine
The Nethersole School of Nursing

Ethical review

The study has been reviewed by the Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Ethics Committee.

Inquiry

The study is organized by the Nethersole School of Nursing, The Chinese University of Hong Kong. If you have any questions about this study, please feel free to contact the following personnel:

Dr Jojo Wong
Assistant Professor
The Nethersole School of Nursing
Faculty of Medicine
The Chinese University of Hong Kong
Phone Number (852) 3943 8166
E-mail jojowong@cuhk.edu.hk

Thank you for taking part in this study

Remarks: The Urdu or Nepali version of this information sheet will be available upon request.

The Chinese University of Hong Kong
Faculty of Medicine
The Nethersole School of Nursing

PARTICIPANT CONSENT FORM (Phase II)

Code Number:

Title of Project:
Effects of smartphone-based chatbot intervention to increase influenza and COVID-19 vaccine uptake among South Asians: a wait-list randomized controlled trial

Organizer and funding body:
The study is organized by the Nethersole School of Nursing, The Chinese University of Hong Kong.

Principal investigator's name and contact number:
Dr Jojo Wong Phone Number: (852) 3943 8166

If I have any questions regarding the subject rights, I may contact the Joint CUHK-NTEC Clinical Research Ethics Committee at 3505 3935 for clarification.

	Please initial the appropriate boxes
1. I confirm that I have read and understood the information sheet dated __/__/__ for the above study and have had the opportunity to ask questions.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, legal rights being affected.	☐
3. I understand that all information collected during the course of the research will be kept strictly confidential and my identity will be anonymized.	☐
4. I understand that sections of any of my research record may be looked at by responsible individuals from regulatory authorities (including NTEC-CUHK Cluster REC/IRB) where it is relevant to my taking part in research. I give permission for these individuals to have access to my records.	☐
5. I understand that I will receive HK$200 upon completing the study.	☐
6. I agree to be contacted via the mobile number: _____ for future studies.	☐

Remarks: The Urdu or Nepali version of this consent form will be available upon request.

Name of participant	*Date*	*Signature*
Researcher	*Date*	*Signature*