Public perceptions of diabetes, healthy living and conversational agents in Singapore: A needs assessment

Lorainne Tudor Car, Dhakshenya Ardhithy Dhinagaran, Sathish Thirunavukkarasu, Tobias Kowatsch, Konstadina Griva, James Donovan Best

Table of Contents

Public perceptions of diabetes, healthy living and conversational agents in Singapore: A needs assessment

Lorainne Tudor Car[1, 2] MD, MSc, PhD; Dhakshenya Ardhithy Dhinagaran[1] BSc (Hons); Sathish Thirunavukkarasu[3] MBBS, MPH, PhD; Tobias Kowatsch[4, 5, 6] MSc, PhD; Konstadina Griva[7] PhD; James Donovan Best[8] MD, MBBS

[1]Family Medicine and Primary Care Lee Kong Chian School of Medicine, Nanyang Technological University Singapore Singapore SG
[2]Department of Primary Care and Public Health School of Public Health, Imperial College London London GB
[3]McMaster University Hamilton, ON, CA Hamilton CA
[4]Future Health Technologies programme Campus for Research Excellence and Technological Enterprise (CREATE) Singapore-ETH Centre Singapore SG
[5]Center for Digital Health Interventions Department of Management, Technology, and Economics, ETH Zurich Zurich CH
[6]Center for Digital Health Interventions Institute of Technology Management, University of St Gallen St Gallen CH
[7]Centre for Population Health Sciences Lee Kong Chian School of Medicine Nanyang Technological University Singapore Singapore SG
[8]Lee Kong Chian School of Medicine Nanyang Technological University, Singapore Singapore SG

Corresponding Author:
Lorainne Tudor Car MD, MSc, PhD
Family Medicine and Primary Care
Lee Kong Chian School of Medicine, Nanyang Technological University Singapore
Clinical Sciences Building
11 Mandalay Rd
Singapore
SG

Abstract

Background: The incidence of chronic diseases such as type 2 diabetes is on the rise in countries worldwide, including Singapore. Health professional-delivered healthy lifestyle interventions have been shown to prevent type 2 diabetes. Yet ongoing personalised guidance from health professionals is not feasible or affordable at the population level. Novel digital interventions delivered using mobile technology such as conversational agents are a potential alternative for delivery of healthy lifestyle change behavioural interventions to the public.

Objective: We explored Singaporeans' perceptions on and experience of healthy living, diabetes and mobile health interventions (apps and conversational agents). This survey was done to help inform the design and development of a conversational agent focusing on healthy lifestyle change.

Methods: This qualitative study was conducted over Aug and Sept 2019. 20 participants were recruited from relevant healthy living Facebook pages and groups. Semi-structured interviews were conducted in person or over the telephone using an interview guide. Interviews were transcribed and analysed in parallel by two researchers using Burnard's method, a structured approach for thematic content analysis.

Results: The collected data was organised into four main themes: (1) use of conversational agents, (2) ubiquity of smartphone applications, (3) understanding of diabetes and (4) barriers and facilitators to a healthy living in Singapore. Most participants used health-related mobile applications as well as conversational agents unrelated to healthcare. They provided diverse suggestions for future conversational agent-delivered interventions. Participants also highlighted several knowledge gaps in relation to diabetes and healthy living. In terms of barriers to healthy living, frequent dining out, high stress levels, lack of work-life balance and dearth of free time to engage in physical activity were mentioned. In contrast, discipline, pre-planning and sticking to a routine were important for enabling a healthy lifestyle.

Conclusions: Participants in our study commonly used mobile health interventions and provided important insights into their knowledge gaps and needs in relation to healthy lifestyle behaviour change. Future digital interventions like conversational agents focusing on healthy lifestyle and diabetes prevention should aim to address the barriers highlighted in our study and motivate individuals to adopt habits for healthy living.

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

Original Manuscript

Public perceptions of diabetes, healthy living and conversational agents in Singapore: A needs assessment

Dhakshenya Ardhithy Dhinagaran[1], Sathish Thirunavukkarasu[2], Tobias Kowatsch[3,4,5], Konstadina Griva[6],

James Best[7], Lorainne Tudor Car[1,8]

[1]Family Medicine and Primary Care, Lee Kong Chian School of Medicine, Nanyang Technological University Singapore, Singapore

[2]McMaster University, Hamilton, Ontario, Canada

[3] Centre for Digital Health Interventions, Department of Management, Technology, and Economics, ETH Zurich, Zurich, CH

[4] Future Health Technologies Programme, Campus for Research Excellence and Technological Enterprise, Singapore-ETH Centre, Singapore, SG

[5] Centre for Digital Health Interventions, Institute of Technology Management, University of St Gallen, St Gallen, CH

[6]Centre for Population Health Sciences Lee Kong Chian School of Medicine Nanyang Technological University Singapore, Singapore SG

[7]Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore
[8]Department of Primary Care and Public Health, School of Public Health, Imperial College London, London, United Kingdom

Corresponding Author:

Lorainne Tudor Car

Family Medicine and Primary Care

Lee Kong Chian School of Medicine, Nanyang Technological University Singapore

11 Mandalay Road, Level 18, Clinical Science Building, 308232, Singapore

Email: lorainne.tudor.car@ntu.edu.sg

Abstract

Background: The incidence of chronic diseases such as type 2 diabetes is on the rise in countries worldwide, including Singapore. Health professional-delivered healthy lifestyle interventions have been shown to prevent type 2 diabetes. Yet ongoing personalised guidance from health professionals is not feasible or affordable at the population level. Novel digital interventions delivered using mobile technology such as conversational agents are a potential alternative for delivery of healthy lifestyle change behavioural interventions to the public.

Objectives: We explored Singaporeans' perceptions on and experience of healthy living, diabetes and mobile health interventions (apps and conversational agents). This survey was done to help inform the design and development of a conversational agent focusing on healthy lifestyle change.

Methods: This qualitative study was conducted over Aug and Sept 2019. 20 participants were recruited from relevant healthy living Facebook pages and groups. Semi-structured interviews were conducted in person or over the telephone using an interview guide. Interviews were transcribed and analysed in parallel by two researchers using Burnard's method, a structured approach for thematic content analysis.

Results: The collected data was organised into four main themes: (1) use of conversational agents, (2) ubiquity of smartphone applications, (3) understanding of diabetes and (4) barriers and facilitators to a healthy living in Singapore. Most participants used health-related mobile applications as well as conversational agents unrelated to healthcare. They provided diverse suggestions for future conversational agent-delivered interventions. Participants also highlighted several knowledge gaps in relation to diabetes and healthy living. In terms of barriers to healthy living, frequent dining out, high stress levels, lack of work-life balance and dearth of free time to engage in physical activity were mentioned. In contrast, discipline, pre-planning and sticking to a routine were important for enabling a healthy lifestyle.

Conclusions: Participants in our study commonly used mobile health interventions and provided important insights into their knowledge gaps and needs in relation to healthy lifestyle behaviour change. Future digital interventions like conversational agents focusing on healthy lifestyle and diabetes prevention should aim to address the barriers highlighted in our study and motivate individuals to adopt habits for healthy living.

Key words: conversational agents; chatbots; diabetes; pre-diabetes; healthy lifestyle change

Introduction

The growing burden of diabetes is a matter of global concern. Among developed countries, Singapore has the second highest prevalence rate with 1 in 9 people aged between 18-69 having the condition [1].

Singapore's life expectancy increased from 83.2 in 2010 to 84.8 in 2017 however, when adjusted for time in perfect health (health adjusted life expectancy), Singapore's life expectancy drops to 74.2 [2]. The main contributors to this drop are chronic conditions like diabetes, hypertension and high cholesterol levels – largely due to unhealthy lifestyle and habits [2]. Around 440,000 Singapore residents (aged 18 and above) were diagnosed with diabetes in 2014 and this number is expected to reach 1,000,000 in 2050 [3].

Prediabetes is a precursor of type 2 diabetes and is also becoming increasingly common. Lifestyle interventions, including promotion of physical activity and healthy diet, delivered by trained health professionals can reduce the incidence of type 2 diabetes in those with prediabetes [4-6]. Yet personalised guidance and attention from expert healthcare professionals is not feasible or affordable on a large-scale. A potentially more accessible alternative to in-person support could be digital initiatives for information and intervention delivery, such as conversational agents. Moreover, health programs delivered over the internet have shown success, as exemplified by online interventions to reduce smoking [7] and alcohol intake [8], and to improve sexual health [9], cancer screening [10], physical activity [11] and diet [12]. The ubiquity of the internet makes these programs easily accessible to a diverse group. Conversational agents, or chatbots, are computer programs designed to mimic human-human conversations either using text or speech. Conversational agent usage carries with it advantages such as easy access, a possibility of personalisation, greater efficiency, bi-directional interactivity, and a chance to build up a working alliance, highlighting the potential to improve patient care [13]. Applications of conversational agents in healthcare are gaining traction in a number of medical fields and for diverse age groups (from children to older adults). They have so far been employed in healthcare service provision, chronic disease management, patient education and can be delivered via existing messaging apps, individual apps or even standalone devices [14, 15].

People's knowledge of diabetes, prediabetes and the role and impact of healthy living can affect their lifestyle choices and ultimately health [16]. Before introducing a novel method of digital health delivery to a study population, a need's assessment study is required. This process will identify the challenges the population are facing, the essential components they wish to see and will gauge their likely acceptability of a new digital initiative for their health [17]. The evidence on conversational agent usage for healthy lifestyle promotion in different settings, including Singapore is currently limited. Singapore, being a technologically savvy country, has a high usage of mobile phones and messaging apps as evidenced by its high smartphone penetration rate of 82% in 2021 [18, 19]. Singapore's Ministry of Health has highlighted the increasing use of conversational agents in healthcare for tackling issues, such as the rising chronic disease burden, within an ageing population [20]. This situation makes Singapore an ideal candidate for the implementation and testing of novel mobile health interventions, such as conversational agents [21].

To address this need, we are designing and evaluating a conversational agent promoting healthy lifestyle behaviour change for the general population in Singapore. Education and widespread delivery of a healthy lifestyle intervention at the level of the general population can be pivotal in driving prevention from diabetes and prediabetes even before individuals get to a stage of high risk. To inform the development of such a conversational agent, we invited members of the public to share their views on and experience of diabetes, prediabetes and healthy living as well as digital health interventions, which we report in this study.

Methods

This qualitative study was conducted over August and September 2019. We invited 20 members of the public to participate in semi-structured interviews. The study was approved by the NTU (Nanyang Technological University) ethics committee (IRB-2018-11-032). All participants read a study information sheet before giving written consent. Specific consent was obtained for the recording of interviews. This study followed the consolidated criteria for reporting qualitative research (COREQ) guidelines [22] (multimedia appendix 1).

Participants and recruitment

Participants were volunteers initially recruited for a healthy lifestyle change conversational agent pilot feasibility study using a study poster on relevant healthy living Facebook pages and groups (figure 1). They all had to complete an eligibility questionnaire. We included adults aged 21 and above, fluent in English with a Facebook account. The following exclusion criteria were applied:

- individuals with history of major illness, such as cancer, heart disease, stroke, chronic liver disease, chronic kidney disease, neurodegenerative condition, hypertension
- individuals with physical disability that would prevent regular physical activity
- pregnant women
- participants younger than 21 years of age, illiterate or non-writing individuals (as all questions will be asked in English),

We recruited a purposive sample involving participants of different age and ethnic groups to include a wide range of perspectives.

Figure 1. The order of events participants underwent, from (1) recruitment, (2) interviews for needs assessment and subsequent participation in a 4-week feasibility study.

Data collection

Interviews were conducted by a female PhD student (DAD) in designated private meeting rooms at Lee Kong Chian School of Medicine, NTU, Singapore. An interview guide was employed, and interviews were either in person or over the telephone depending on the volunteer's preference. DAD was provided with sufficient details, resources, and exposure to online courses on qualitative research and conducting telephone interviews prior to study commencement. Field notes were made during the interview. The initial interview guide was informed by the literature on the development of digital and conversational

agent-delivered health interventions [23-26]. The interview was adapted further as the study proceeded, to take account of emerging themes and each interview came to an end when we reached saturation of novel topics (eg. on barriers and facilitators). The interview was an earlier phase in a larger feasibility study which all the participants were enrolled in (figure 1). This study aimed to test the feasibility and acceptability of a conversational agent for healthy lifestyle change in Singapore. Participants were compensated with a digital voucher of $25-35 upon pilot feasibility study completion and there was no extra incentive for taking part in the telephone interviews. Participation was entirely voluntary.

Basic demographic data were obtained from all participants including gender, age, ethnicity, marital status, monthly household income, number and age of children and occupation.

Their usage of conversational agents and feedback on these interactions and suggestions for future health applications (eg. tone, media, direction) were also explored. These insights would unveil their preferences which would we useful in directing our design and development of conversational agents for this population. Participants were also asked to share the types of messaging and health apps they have experience using and their opinions of them. Information on their usage of messaging apps was important to note as plenty of conversational agents are delivered via these platforms. Public preferences can direct the appropriate delivery platform for these agents. Naming and usage patterns of health apps would indicate how comfortable the population currently is with using technology to monitor their health and what applications they find mobile health solutions appropriate for.

Questions were asked about participants' knowledge of diabetes and prediabetes as well as their family history of these conditions. Identifying their knowledge gaps and awareness of being at risk could help in prevention and reduction of risk of developing diabetes and prediabetes. Finally, to best understand their needs on how to promote healthy living, questions were asked on what they think are the barriers and facilitators to a healthy lifestyle. The focus was on these topics: eating habits, physical activity, stress and sleep. Participants were asked about their current habits and their thoughts on what the ideal advice for these components should be. This would inform the content of future conversational agents educating the public on healthy lifestyle change.

Both short and long answer questions were asked. An example of short answer question is *"Do you use messaging apps such as Facebook Messenger?"* An example of a question which required a more comprehensive answer is *"Sometimes we do not always eat the way we would like to. Let's talk about some difficulties you experience with eating healthy."*

All in-person interviews were recorded using a portable audio recorder for transcription. Telephone interviews were conducted via speaker phone using the departmental iPhone and also recorded using the audio recorder placed in close proximity to the speaker phone and the interviewer. The duration of the interview lasted around 30 mins. The audio files were transcribed verbatim. All transcripts were checked with the corresponding sound files for accuracy, and they were subsequently corrected for

errors and cleaned.

Data analysis

The data were analysed using Burnard's method, a structured approach for thematic content analysis established in 1991 and still used today [27]. Firstly, two researchers familiarised themselves with the transcripts by reading them multiple times. Secondly, initial codes were proposed. Thirdly, themes were derived from the codes. Fourthly, the two authors discussed and combined their themes for comparison. Finally, they reached a consensus on the themes to be used and how to define them. The finalised codebook is presented in multimedia appendix 2.

Results

We approached the 60 participants enrolled in the conversational agent feasibility study (via email), looking for 20 volunteers to participate in a telephone interview (figure 1). We chose this number based on the recommendation that qualitative analysis tends to be based on data from 1-30 respondents [28]. Twenty participants responded and agreed to be interviewed. Seven interviews were conducted in person and 13 were over the telephone.

Participant demographics

80% of participants were female, the median age of participants was 30 (in complete years), the age range was 23 to 60 years and 50% were married. 65% were working, 25% were fulltime students (undergraduate or postgraduate) and 10% (n=2) were unemployed. More than half of the participants (55%) were Chinese, 25% were Indian, 15% were Malay and 5% (n=1) were Caucasian. The monthly household income was $6000-8000 for 25% of participants, S$8000-10,000 for 20%, S$10,000 – 15,000 for 20%, S$4000-6000 for 15%, <S$4000 for 15% and >S$15,000 for 5%. The median monthly household income in Singapore in 2019 was S$9425 [29].

Thematic Analysis

Figure 2.
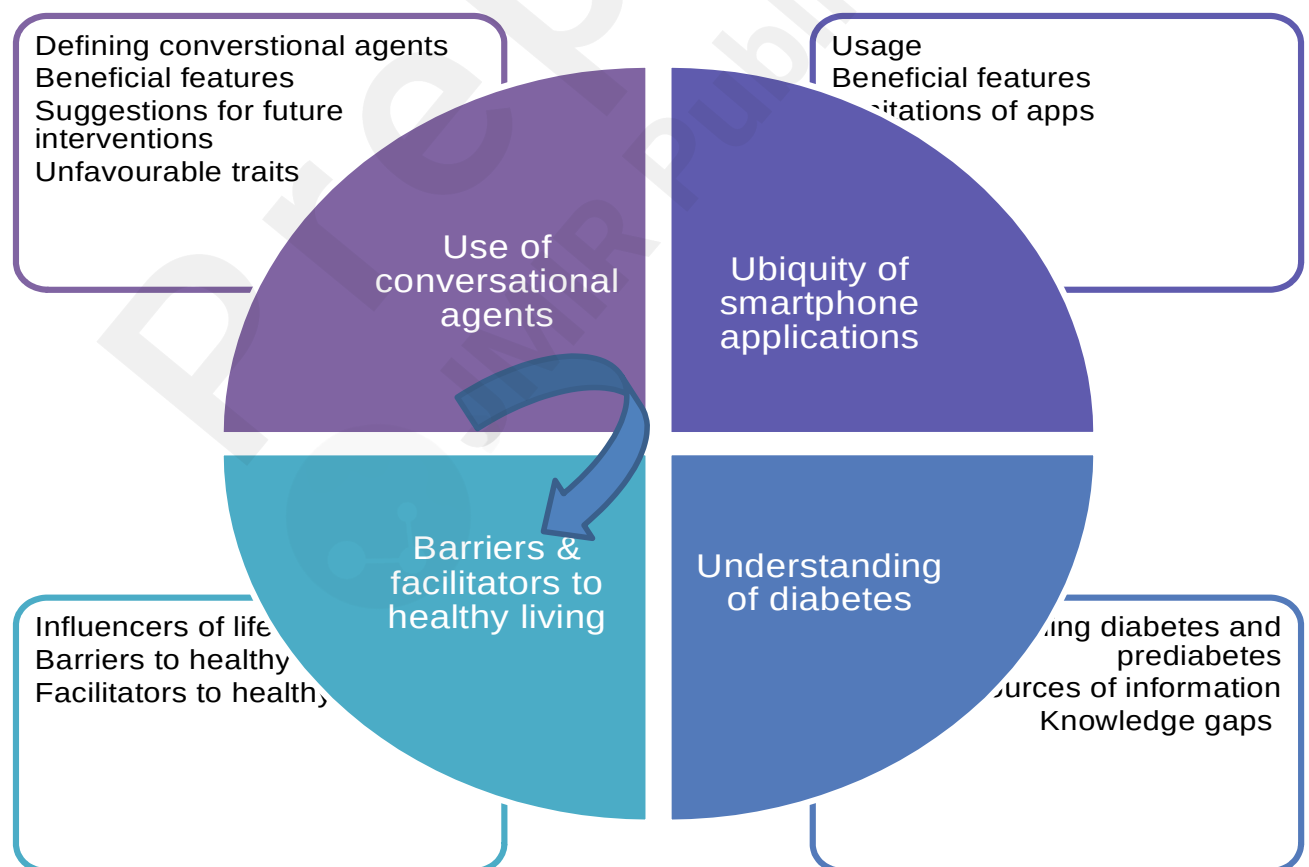
Themes and subthemes identified from analysis of interview transcripts.
Four main themes were identified (1) use of conversational agents, (2) ubiquity of smartphone

applications, (3) understanding of diabetes, (4) barriers and facilitators to a healthy living in Singapore (figure 2).

We present each theme below, along with subthemes and the excerpts that highlight different facets of the theme.

Theme 1: Use of conversational agents

Definition of conversational agents

Many participants were able to provide a definition for what a conversational agent was by mainly using the key words 'AI programme' or 'virtual call centre' with which one can communicate. Participants were also aware that conversational agents were readily available at all times of the day. Existing applications included car insurance, public transport, online shopping, banking and airline services. A couple of participants were unfamiliar with the term.

Beneficial features & suggestions for future interventions

They shared their views on what makes a conversational agent appealing. Conversational agent preferences included accuracy of information, interactivity, visual aids, text, pre-defined options, a group component, novelty, good reach, incentives, an appropriate tone, frequency, duration, and bidirectional communication. Participants showed a preference for visual aids (like images and videos) as well as text when communicating with the conversational agent.

Pre-defined options were preferred over artificial intelligence (AI) if the conversational agent was not sufficiently programmed to deal with more complex questions and requirements. Participants indicated a liking for peer support in a conversational agent intervention to support their behaviour change. Some participants wanted novelty to be introduced in the conversational agent's delivery method to avoid the routine from becoming too monotonous and boring to continue.

"But that one was not very good because they cannot... It becomes a pattern. Once they get used to it, then people will try to run away from the pattern." - (P15)

Novelty was proposed in the timings of message delivery and the format of messages. For example, some may provide educational information, or reminders for healthy behaviours, a quick tip for the day etc.

Conversational agents which had a good reach (ie. were relevant to a wide range of age groups) were most appreciated. Participants mentioned that online or digital health platforms like apps and conversational agents would be well received by the younger population. They indicated a need to present all the relevant information, advice and reminders on healthy living to older populations who may be less tech savvy by employing simple technology or supplementing with non-digital means too. Conversational agents which offered incentives in the forms of rewards or discounts were also of interest. Participants explicitly indicated greater interest to use those apps or conversational agents which, for example, provided discounts for grocery shopping, or coupons for redemption.

Participants had varied views on a suitable frequency and duration of interaction ranging from daily to once a week. Most participants suggested a 2-3 days a week frequency, for a duration under 20 minutes. Participants were generally indifferent to the tone of a conversational agent, They did mention that lay man terms should be adopted and generally, a friendly and informal tone was preferred. Bi-directional communication (where the user can respond and talk to the conversational agent) was preferred over unidirectional communication (where only the conversational agent talks, and the user consumes information). Participants shared that bidirectional communication would give them the option to ask questions to the conversational agent, clarify doubts or ask for more information on a topic of interest.

"I think two way should be an option. In case like there are any questions or anything you might want to follow up with. Or as well as like … you're interested in something, you can like ask for a contact or they could get you to a website for more information or somewhere that kind of thing." - (P05)

Unfavourable traits

Participants also shared instances where conversational agent usage was unfulfilling. Most mentioned that the conversational agents they encountered were unable to answer their questions or provided irrelevant answers.

"when I had questions, they were not answered appropriately. So, I had to resort to calling them." – (P09)

Others indicated that sometimes they were unsure of the conversational agent's level of intelligence and realised through the interaction that the agent was not sufficiently artificially intelligent to address their more complex questions. In such cases, they would then prefer a simpler agent (with pre-defined options) which could fulfil its tasks more seamlessly.

Theme 2: Ubiquity of smartphone applications (specifically messaging & health apps)

Usage of mobile applications

As conversational agents are frequently embedded in existing messaging applications or implemented as standalone apps, we explored participants' usage and opinions of messaging and health apps. All participants mentioned that they use messaging apps and 17 (85%) use health apps. Messaging apps used were WhatsApp, Facebook Messenger, Telegram, WeChat and LINE. These were used mainly for communicating and socialising, sometimes in large groups. Some use it as a means of sharing information for educational and professional purposes.

A variety of health apps were mentioned with 'Healthy 365' and Step Trackers being the most frequently used. Other apps were MyFitnessPal, AIA vitality, Fitbit, Samsung Health, HPB (Health Promotion Board) app, Nike Run Club, Chronometer (monitor nutrition) and Stride (habit tracker).

Beneficial features

Specific smartphone app features and functions which make the apps more favourable for usage were

discussed. Some mentioned that these messaging apps were a necessity. Others shared a very positive user experience based on ease of use, engagement (promoted by the availability of stickers) and their multifunctionality such as texting, calling and video calling.

Something else participants shared which promotes smartphone app usage, is the provision of incentives.

"And then for the Healthy 365 app by HPB (Health Promotion Board is a Singapore Government organisation)*, I use it to redeem the rewards and participate in their promotional activities and programmes." - (P17)*

Limitations of apps

Participants reported that sometimes the content and frequency of messages can be too overwhelming to deal with. The accuracy of the app content was sometimes questioned by participants, with different apps reporting different numbers for the same measure.

Participants' views on these beneficial and limiting features are highly relevant and should be considered when developing a health conversational agent for this population.

Theme 3: Understanding of diabetes

We explored participants' understanding and knowledge of diabetes, prediabetes and the sources of information that they use to obtain relevant information. Understanding their current level of knowledge and what information they need more exposure to, could be incorporated into a healthy lifestyle conversational agent to prevent diabetes and prediabetes in the general population.

Diabetes

All participants were able to give a definition of diabetes, some more comprehensive than others. Several mentioned insulin or the inability of the body to control one's blood sugar level which is too high. Some participants stated that diabetes requires one to reduce sugar intake.

They were also aware that there may be a need to take medication and that there is no cure for diabetes. Participants shared on the impact of diabetes on one's health. Participants were aware that diabetes can affect other parts of the body and lead to other illnesses including kidney failure, stroke, high blood pressure and limb amputations.

In terms of impact on one's life, participants mentioned that diabetes affects families, ability to exercise, breathing and can lead to higher medical expenses.

"Having good health to be drained away. And then, how does this affect families concerned" "… I was told that people with diabetes may not be able to exercise actively. Have to change the type of exercise that they do. Sometimes breathing will be affected, also. - (P14)

Prediabetes

Fifteen participants were able to define prediabetes stating that it was a condition where someone is at

a borderline risk of developing type 2 diabetes. Some mentioned that prediabetes is reversible.

"Basically, you are at risk of diabetes if you don't change the way you live your life, or your diet" - (P20)

Other participants were very unfamiliar with the term 'prediabetes' (n = 5) and acknowledged that diabetes was more commonly talked about.

"I always saw this like pre-type or something number 2 or something like that so I don't really understand it as well" - (P08)

Sources of information

Sources of information which they used to learn more about diabetes were varied. Some shared that their personal experiences with diabetic family members helped them to be educated on diabetes and its implications.

"And you know when she (mother) was around, there's a diabetes society or something we used to go and visit, attend talks and yea, somewhere in (…) it's quite near my place actually but after she passed away uh I'm not involved in anything anymore" - (P01)

Others mentioned the government's role in educating the public on diabetes, prediabetes and healthy living and how the government can further influence the public in the near future.

"But from what I used to experience, the government does have certain policies acting through MOE (Ministry of Education). For example, last time we used to have no fried food in canteen. I suppose they must be doing something with school canteens because of the diabetes." - (P17)

Additionally, participants mentioned a dearth of sufficient information being readily available to them, causing a barrier to awareness on healthy living. Some participants felt that the older generation may have less information due to lower levels of technological competency to search for information online.

Participants proposed some additional means to improving information availability and population awareness. Some of these methods include advertisements on the television and internet as well as a display of the number of calories for each food item at hawker centres (food courts with affordable local meals).

"and also there could be more awareness like you know when we go to restaurant or maybe hawkers more information could share like the calories. Because yea I know some hawker centres they do show but it didn't exactly show the number of calories for all the food." - (P08)

Knowledge gaps

Participants identified some areas where they thought societal understanding was low and should be addressed in the future. One such example was more information on physical and psychological changes for a healthier lifestyle.

"What the individual lifestyle changes that they can make or consider to make." – (P12)
"Yes. Definitely. I think when you are more stressful, then your sugar goes up too." – (P20)

"Mental health." – (P15)

They made specific references to education on the importance of healthy eating and physical activity. One participant felt that instead of learning more, it was more important to apply what is already known about diabetes.

Further information on symptoms, prevention, risk factors and awareness of being at risk were of interest. Also, the need for more information on the implications of diabetes, its management, and sources of support was also mentioned.

"Maybe even things like prognosis if you are diagnosed, how are you going to manage it" "If they need help, who can they look for." - (P11)

Theme 4: Barriers and facilitators to a healthy living in Singapore

Influencers of one's lifestyle choices

Participants shared their existing lifestyle habits and the factors which enable or hinder healthy living. These barriers are helpful indicators on what a future conversational agent can aim to address when administering advice, education and support for healthy lifestyle change.

They first discussed the relationship between their existing lifestyle choices and how this related to their perceptions of current body weight. Some participants reported a dissatisfaction with their current weight. They perceived themselves as either too heavy (n = 9), or underweight (n = 2).

Participants also highlighted the existing factors which drive their lifestyle choices.

Convenience was a big factor. This was relevant in terms of food available in the close vicinity as well as the convenience of having a gym or group exercise class easily accessible to them. Cheaper food was preferred for its affordability, over more expensive, healthier options. Participants also indicated a desire to engage in group exercise sessions if they were affordable.

"The biggest problem we have here is the price of healthy food. It's just infinitely more costly. For example, some salad can cost you six, $7, whereas chicken rice can cost you $3. You cannot possibly eat salad every day even if you are earning okay. But if you are one of those that are low income, definitely you will go for three-dollar chicken rice every day. And in the long run, it just causes a lot of problems." - (P17)

Individuals chose to eat foods based on their personal preferences. Similarly, they chose to engage in physical activities they enjoyed, or suited their schedule.

"Because I know that I'm not really hectic with the exercising, so I would tend to think that my house is three bus stops away from the interchange, so I will tell myself let's just walk from the MRT back home, so at least it's some walking activity for me." - (P18)

Participants chose what to eat based on the kinds of social activities they engaged in and the food available there. Furthermore, how active one's social life was, influenced the amount of exercise they could do since more time spent socialising left less time for physical activity.

Marketing of food was a big factor in influencing the kind of food they decided to eat in a day.

"It just depends on what I feel like eating or maybe a bit of marketing as well. For example, if McDonald's has a new menu, then I might just go for it." - (P17)

Nutritional value of food determined whether participants chose to eat it.

"If I look at the menu item and then it looks like this is 600 calories, which is top of the list out of the whole list of things that I'm looking at, I would think twice about eating it"

"It does have some sort of impact knowing that you are intentionally consuming so much. You will trigger some automatic response to self-regulate." - (P17)

Participants mentioned that their mood or state of mind largely determined the food they decided to consume. For example, when upset or stressed or in a bad mood, they gravitated towards food that was more comforting than healthy. Likewise, their state of mind also influenced how much physical activity they did.

"like after a long day of work, I'm not like oh I'm going to go to the gym you know? Like nah I just want to stay at home and relax" – (P05)

Barriers to healthy living

Participants shared some barriers to healthy living.

Having to dine out on a regular basis meant that participants had no control over the nutritional value of their food.

"Sometimes if you like to go to a restaurant and you hope that there's not so much MSG (monosodium glutamate – flavour enhancer) its really beyond your control to tell the chef hey I don't want more… I don't want the MSG or I want less salt. I mean you can tell them less salt. But pre-prepared stuff usually its hard." - (P06)

Participants mentioned that healthy foods tend to have an unappealing taste and texture which discouraged its consumption.

"Eating healthy, sometimes, they say is very bland, very tasteless. No fried is something without aroma. So, eating healthy sometimes lack of the aroma. And then they say it's either very too liquid, or so tasteless, that is the thought they have." - (P14)

One participant shared that a health condition caused her to deviate from healthy eating habits.

Participants also mentioned a fear of injury or internal damage to their bodies which may be caused by physical activity, preventing them from exercising. Hence, this fear became a barrier to a more active lifestyle.

"but there is also a fear that at a certain age there is some wear and tear in the body" - (P14)

Long working hours were associated with less free time and hence, less frequent exercising. This lack of work-life balance also exacerbated stress.

P023 "whether I have time to dock off for a run or not. It really depends because most of the time, I'm

actually working quite late…. I think for myself would definitely be work stress…. So myself sometimes I work 15 to 16 hours a day" – *(P08)*

Specific events such as unexpected incidents can disrupt an individual's equilibrium and cause stress. Similarly, events such as exams can impact negatively on one's sleep schedule. Changes in the weather, such as a hazy or wet period in Singapore, can prevent individuals from being physically active if there is a preference to exercise outdoors.

Lack of knowledge was mentioned by several participants as a barrier to healthy living. For example, some participants did not know how to fix their problem with sleeping early. Others were unsure about how to manage their stress and hence, the problem persists until they find or learn a solution.

"I'm having a bit of difficulty here because I'm experiencing a new sort of stress after coming back from my maternity leave. So, that's why I don't really know what to tell you because I think I haven't really learned how to manage the stress." – *(P13)*

Facilitators of healthy living

Participants shared some factors which can help to promote healthy living.

Building up knowledge on healthy living from a young age was stated as a promoter. Building further as an adult on existing knowledge of the importance of healthy behaviours could positively influence individuals. Whilst the knowledge may already be there, reminders were cited as a way to reiterate healthy eating behaviours. Participants also requested education on calorie counting which would promote healthier eating.

"So, maybe when it comes to before lunchtime, two hours, tell them this is a suggested meal, then it's a guideline. Because everybody like to hold their phone, and then the message pops up, and they say, oh, yes, why not, I go and try". – *(P14)*

Sourcing out alternative methods of reaching the recommended weekly level of physical activity and how to be more active in general were found to be helpful. These came in the form of efficient exercising or reducing the amount of time spent sitting after a meal.

"So, yes, I only exercise 15 minutes each time. But I try to keep it more vigorous. So, yes, I do HIIT kind of training. So I do that about four or five times a week maybe." "I think that there's more yield in doing vigorous exercise over moderate exercise. So in terms of the efficiency, the amount of time you need to spend, so I try to do more of HIIT." – *(P20)*

Empowering individuals to provide services for themselves as far as possible - for example, making homemade food was suggested to be an effective way of healthier eating. Engaging in exercise at home and setting up their own workouts, were also mentioned.

"So I have a treadmill at home and I use that. Like I walk as I'm doing some work on my laptop. So I try to incorporate that. Or I might do maybe like 10/15 minutes of yoga or cardio or something just around the house yea wherever I can." – *(P05)*

It was proposed by some participants that group support, to evoke a collaborative spirit could encourage more physical activity.

"If I did it with other people, like with friends and stuff yea, you could make it like a group effort. Then it'll be easier because then there are other people to monitor you, just for yourself." – (P05)

Healthy self-management of stress was cited as a good way to maintain a healthier lifestyle in the form of therapeutic activities, for example. Internal motivators, such as wanting to be healthy in the present and future encouraged individuals to take ownership and eat healthily too.

Enforcing some discipline with regards to eating on time, drinking enough water and planning the meals for the week were all suggestions for promoting a healthier diet.

"But personally, I do my own meal prep actually. So, I cook for three days, so three of the lunches is covered for me." – (P11)

Having good discipline and planning slots for physical activity were mentioned as effective methods for developing a more active lifestyle too. Discipline in developing and sticking to a bedtime routine which involves winding down, relaxing and reducing screen time as well as cutting down caffeine intake were proposed by participants to improve sleep habits. Recommendations for disciplining food intake through moderation involved a balance of healthy and unhealthy foods, controlling portion sizes (overall quantity and food pyramid recommended portions) and restricting unhealthy food items. These choices were cited as effective promoters of healthy living.

"For example, bubble tea right, everybody likes bubble tea, so to me I will limit myself to buy that maybe once every two months, take that as a reward for myself, yes, that's what I'd do." – (P18)

One participant recommended establishing some moderation at work to have more work-life balance to reduce stress levels.

"And I think having a good balance, life, social life, helps as well, that it's not just work." - (P11)

Participants also mentioned compensating with catch-up sleep over the weekends to moderate overall sleep quantity.

Discussion

Key findings

To our knowledge, this is the first qualitative study to investigate the public's perception of conversational agents for a healthy lifestyle change intervention in Singapore.

Participants' perceptions of conversational agents were discussed, where they offered definitions, usage experiences and preferential features. These are pivotal in informing the design elements for a feasible and acceptable conversational agent initiative in a healthcare setting in Singapore. Participants shared their views on the ubiquity of smartphone applications whereby messaging apps were a necessity for daily communication, social, educational and professional purposes. This is an important point as conversational agents can be embedded in those messaging app platforms which are most familiar to the target population for easy adoption. Health apps were used for a variety of purposes mainly step tracking, health tracking (nutrition, water-intake, habit tracking) or pairing with a Fitbit watch. The fairly diverse usage patterns indicate an inclination to adopt mobile health solutions for numerous purposes.

Participants shared their existing knowledge on diabetes, prediabetes and their existing sources of information. Additionally, they offered their views on what constitutes healthy living with a focus on diet, exercise, sleep and stress as well as thoughts on the barriers and facilitators to healthy living in Singapore. The culture of eating out in Singapore was said to be fuelled by affordable hawker centres and fast food as well as the fast-paced life which doesn't allow much time for food preparation at home. Frequent dining out, high stress levels, lack of work-life balance and dearth of free time to engage in physical activity were some of the common complaints hindering a healthier lifestyle. Additionally, work-related stress was implicated in poor sleep quality and quantity. Participants proposed that these barriers could be tackled with some self-discipline, pre-planning and sticking to a routine for healthier living patterns. Given the ubiquity of smartphones, the avid use of messaging apps and an inclination to use mobile health initiatives, awareness on these barriers and facilitators to healthy living could be communicated to the population, at large, via a conversational agent.

Comparisons with existing literature

Lim *et al.* explored the barriers and facilitators to healthy eating in Singapore in 2019 [30]. This study noted that components which encouraged healthy eating included: self-discipline, fear of disease complications, education by a health professional and mass media and health promotion campaigns [30]. Participants in our study also mentioned self-discipline as a strong facilitator and acknowledged the presence of health promotion campaigns but did not cite these as influencers of their lifestyle choices. Furthermore, fear of disease complications and education by health professionals was possibly more relevant in Lim *et al.* as participants were recruited from polyclinics and were already diagnosed

with prediabetes [30]. This also points out the need for possibly a more hybrid approach when it comes to more high-risk populations (such as those with prediabetes) since HCP involvement would be necessary in addition to a conversational agent. Furthermore, lack of skills to prepare and choose healthy food was shared as a difficulty in healthy eating [30]. This barrier was noted as a limitation to a healthy diet in our study too. Participants added that a lack of time to do grocery shopping, prepare and cook the meals was due to their hectic schedules, making dining out a more convenient, but often less healthy, compromise.

Another study noted that healthy eating and physical activity were the main preferred components for health education and communication for patients with prediabetes in Singapore [31]. A similar outcome was implicated in our study, but we also considered the components of sleep and stress for a more holistic view of healthy living. Other necessities for health communication were risk and prevention of diabetes [31]. These were also picked up in our qualitative analysis. Additionally, participants shared an interest for information on where to go for help if one is at risk or diagnosed with prediabetes/diabetes. Other existing studies have investigated novel conversational agent interventions, with some of them reporting on the acceptability and usability of these agents. However, an extensive needs assessment analysis, such as the one presented here, for a conversational agent intervention has not been done so far in the Singapore population. A scoping review of conversational agents showed that qualitative data was presented in some studies to show the acceptability and satisfaction for these interventions, namely, participants' opinions of an already developed intervention [14]. These parameters were often reported with Likert scale ratings but not comprehensively or thematically [32, 33].

In a study for behaviour change in overweight adolescents, high compliance to the conversational agent intervention was attributed to a rewarding game system [34]. This finding aligns with the suggestions from participants in this study that incentives will be well received and will contribute to their willingness to use the conversational agent. Other studies have examined the use of conversational agents for chronic conditions including diabetes and reported a preference for the features of the conversational agents which allowed for personalisation [35]. Personalisation was also noted as an advantageous trait by our study participants.

Griol *et al.* discussed an emotionally sensitive conversational agent for chronic respiratory disease patients and participants rated it highly for interaction rate and empathy [36]. This report contrasts with our study where participants were flexible when asked about their preferred tone of communication with the conversational agent (formal/informal). They did not elaborate on preferred personality types. Perhaps this feature was of less interest considering the application (healthy living) which may not demand emotional sensitivity or a specific personality over accurate and trustworthy information.

Implications for future work

Future digital interventions aiming to encourage diabetes prevention in the general population to promote and prolong healthy living, can aim to incorporate the content and delivery specific options highlighted in table 1.

These suggestions include furthering knowledge in areas directly relevant to diabetes prevention, building up an awareness of risk factors, symptoms, and prevention methods, as well as the complications and consequences of diabetes and prediabetes. Future applications can also explore expanding actionable advice on how to apply the knowledge participants acquire on healthy living.

It would be beneficial to help users improve skills relating to food choices, calorie counting, and stress management. Advice on healthy eating should be mindful of the Asian diet most Singaporeans are familiar with and have a preference for. In relation to calorie counting, the usefulness of sharing information on the number of calories in frequently consumed food items in Singapore hawker centres should be examined. Stress management techniques relevant to establishing a work-life balance would potentially be beneficial, as this is a common complaint in Singapore, as disclosed by our participants. Additionally, teaching participants time management skills may help to reduce overall stress, providing time and motivation for physical activity, meal preparation and a bedtime routine. Again, outcomes of this intervention would need to be evaluated.

Options to reach the weekly recommendation for physical activity, such as increased efficiency, safe exercise options or suggestions to see a doctor for more personalised advice can be made via a digital conversational agent. Regarding group exercise, cheaper options or even online options may be listed. This approach comes with the added benefits of convenience (no travelling) and likely affordability. Recommendations on alternative methods of exercising, which don't require participants to be outdoors could be suggested to overcome barriers related to the weather e.g. home workouts. A conversational agent could also reinforce the existing promoters of physical activity, eg. reminding them of the feelings of contentment they will experience.

Participants in our study also provided informative recommendations for the delivery of future digital health interventions, focusing on healthy lifestyle behaviour change. App/conversational specific recommendations were proposed. These are factors which have enhanced their user experience in the past. They also shared components they wish to see and would enjoy using in future applications.

Future developments should investigate personalising the conversational agent to the user's preferences (timings, advice etc.), enabling easy usage, making the exchange engaging and introducing some novelty to boost user experience. The tone, personality and language used by the conversational agent should also be adapted to suit the target population (e.g., being friendly, using language with a level of complexity familiar to the target population). Some additional considerations, which could be included are incentives, such as rewards or discounts for groceries, and group support, as participants

indicated a preference for these.

Table 1. Recommendations on content and delivery for future conversational agent interventions for healthy lifestyle behaviour change

CONTENT	
Furthering knowledge on:	Implications of diabetes and prediabetes
	Awareness of being at risk
	Symptoms and prevention methods
Actionable advice on:	How to apply the knowledge gained on healthy living
Further development of skills relating to:	Eating healthily
	Calorie counting
	Options available for meeting the weekly recommendation for physical activity
	Stress management
	Time management
Type of content:	Novel – up to date
	Trustworthy – evidence based
DELIVERY	
Personalisation of content	Advice on how to incorporate exercise into one's specific schedule, availability of facilities and preferences.
	Habit formation – how to discipline your healthy eating, drinking water, physical activity and bedtime routine
Suitable frequency and duration	Ask participants for their preference.
	Offer options for participants to choose from
Easy usage	Pre-defined options for better efficiency if AI is not yet maximised
Engaging	Use stickers and visual aids.
	Make the conversation bi-directional so the user can be part of the exchange and can ask questions if necessary
Relevant to target population	Tone, personality and language used by the conversational agent to be easily understood, relevant and appropriately tailored for the target population
*Additional considerations to keep users keen and engaged in the interventions.	- Incentives eg. rewards and vouchers. - Group support eg. chat channel for participants to communicate with others using the same conversational agent to share advice and motivate each other.

Based on the study reported here, we are developing a rule-based conversational agent pilot intervention, incorporating recommendations from the participants, including educational information on the definitions and implications of diabetes and prediabetes, as well as actionable advice on healthy eating, physical activity, stress management and healthy sleep patterns. All the information to be

included in the intervention will be evidence-based. We will also incorporate visual aids to supplement the text and pre-programmed options will be provided for the user to choose from, to introduce some degree of bi-directional communication.

Strengths & Limitations

In our study, we recruited and interviewed a sample of 20 participants who were ethnically diverse and covered a wide age range (23-60). The collected data was coded in parallel by two researchers, with development and application of a common coding framework through a series of discussions. Our findings may also be applicable to other high income or technologically savvy Asian countries.

We extrapolated the focus in this study from healthy living to diabetes and prediabetes prevention too. In this way, we managed to provide suggestions on healthy living not just in the context of wellness, but also as a means of preventing conditions of great burden in Singapore – diabetes and prediabetes.

There is a possibility of some recruitment bias. Participants were all from Facebook groups and pages with an interest in healthy living. Their opinions may be somewhat skewed because they already come with some knowledge and interest in a healthy lifestyle and some technological competency – this situation may not be representative of the Singapore population at large.

Conclusions

Participants provided valuable insights on their existing knowledge and sources of information on healthy living and diabetes. They also shared their current usage patterns of messaging apps, health apps as well as their views on potential conversational agents, which are not yet in use for healthcare purposes in Singapore.

In addition, they offered opinions about the importance of healthy living and diabetes prevention, likely to be reflective of a significant part of the at-risk population. Preferences for conversational agent and smartphone app usage were also discussed. Finally, they shared views on barriers and facilitators to healthy living. Our findings can be used to inform the development of future conversational agent interventions and similar mobile health initiatives targeting healthy lifestyle behaviour change.

Authors' Contributions

LTC conceived the idea for this study. LTC and DAD developed and prepared the resources. DAD conducted all the interviews. LTC and DAD analyzed the data and interpreted the results with input from KG. DAD, LTC, ST, KG, TK and JDB were involved in writing the paper and approved the submitted version.

Conflicts of Interest

TK is affiliated with the Center for Digital Health Interventions, a joint initiative of the Department of Management, Technology, and Economics at ETH Zurich and the Institute of Technology Management at the University of St. Gallen, which is funded in part by the Swiss health insurer CSS. TK is also a cofounder of Pathmate Technologies, a university spin-off company that creates and delivers digital clinical pathways. Other authors declare that they have no competing interests.

Multimedia Appendix
Multimedia appendix 1 – COREQ 32-item checklist

Multimedia appendix 2 – Codebook from qualitative analysis

References

1.   SG HX. Diabetes: What Is It and What's the Singapore Scenario? Health Xchange SG2016 [cited 2020]; Available from: https://www.healthxchange.sg/diabetes/essential-guide-diabetes/diabetes-what-is-it-singapore-scenario#:~:text=Singapore%20has%20the%20second%2Dhighest,diabetes%20patients%20among%20developed%20nations.&text=Around%201%20in%209%20(or,aged%2018%2D69%20have%20diabetes.&text=1%20in%203%20Singaporeans%20have%20a%20lifetime%20risk%20of%20developing%20diabetes.

2.   Lee J. S'poreans life expectancy increased, but more living with diabetes & hypertension. Mothership2019; Available from: https://mothership.sg/2019/03/singaporean-life-expectancy-diabetes-hypertension/.

3.   Health Mo. Diabetes in Singapore. HealthHub SG2021; Available from: https://www.healthhub.sg/a-z/diseases-and-conditions/626/diabetes.

4.   Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. New England Journal of Medicine. 2001;344(18):1343-50.

5.   Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. The New England journal of medicine. 2002;346(6):393-403.

6.   Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar A, Vijay V. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). Diabetologia. 2006;49(2):289-97.

7.   Shahab L, McEwen A. Online support for smoking cessation: a systematic review of the literature. Addiction. 2009;104(11):1792-804.

8.   Khadjesari Z, Murray E, Hewitt C, Hartley S, Godfrey C. Can stand-alone computer-based interventions reduce alcohol consumption? A systematic review. Addiction. 2011;106(2):267-82.

9.   Bailey JV, Murray E, Rait G, Mercer CH, Morris RW, Peacock R, et al. Interactive computer-based interventions for sexual health promotion. Cochrane database of systematic reviews. 2010 (9).

10.   Lee EE, Brecht M-L, Park H, Lee J, Oh KM. Web-based study for improving Mammography among Korean American women. Journal of Cancer Education. 2017;32(2):257-63.

11.   Jennings CA, Vandelanotte C, Caperchione CM, Mummery WK. Effectiveness of a web-based physical activity intervention for adults with type 2 diabetes—a randomised controlled trial. Preventive medicine. 2014;60:33-40.

12.   Harris J, Felix L, Miners A, Murray E, Michie S, Ferguson E, et al. Adaptive e-learning to improve dietary behaviour: a systematic review and cost-effectiveness analysis. Health technology assessment (Winchester, England). 2011;15(37):1-160.

13.   Bickmore T, Gruber A, Picard R. Establishing the computer–patient working alliance in automated health behavior change interventions. Patient education and counseling. 2005;59(1):21-30.

14.   Tudor Car L, Dhinagaran DA, Kyaw BM, Kowatsch T, Joty S, Theng Y-L, et al. Conversational Agents in Health Care: Scoping Review and Conceptual Analysis. J Med Internet Res. 2020;22(8):e17158. PMID: 32763886. doi: 10.2196/17158.

15.   Schachner T, Keller R, von Wangenheim F. Artificial Intelligence-Based Conversational Agents for Chronic Conditions: Systematic Literature Review. Journal of

medical Internet research. 2020;22(9):e20701.

16.   Ang BW, Tan MY, Goh CM, Rahardja S, Lim BY, Chiew W, et al. Impact of Knowledge and Attitudes on Lifestyle Practices in Preventing Type 2 Diabetes Mellitus. Ann Acad Med Singapore. 2019;48:247-63.

17.   Kulandaivelu Y, Ward R, Zempsky WT, Breakey VR, Kirby-Allen M, Odame I, et al. Exploring the needs of adolescents with sickle cell disease to inform a digital self-management and transitional care program: qualitative study. JMIR pediatrics and parenting. 2018;1(2):e11058.

18.   Kwang K. Singapore tops mobile app use and downloads: App Annie2019. Available from: https://www.channelnewsasia.com/news/technology/singapore-tops-mobile-app-use-and-downloads-app-annie-11157124.

19.   Statista. Singapore smartphone penetration 2017-2023. 2020; Available from: https://www.google.com/search?q=smartphone+penetration+rate+singapore&rlz=1C1GCEB_enSG860SG860&oq=smartphone+penetration+rate+singapore&aqs=chrome..69i57.5116j0j4&sourceid=chrome&ie=UTF-8.

20.   Baker JA. Chatbots, robotics to help ease manpower crunch in healthcare sector. Channel News Asia. 2018 17 Jul 2018.

21.   Erickson GS, Rothberg HN. Chapter 8 - Knowledge and knowledge-related assets: design for optimal application and impact A2 - Liebowitz, Jay. Successes and Failures of Knowledge Management. Boston: Morgan Kaufmann; 2016. p. 113-27.

22.   Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care. 2007;19(6):349-57.

23.   Block G, Azar KM, Romanelli RJ, Block TJ, Hopkins D, Carpenter HA, et al. Diabetes prevention and weight loss with a fully automated behavioral intervention by email, web, and mobile phone: a randomized controlled trial among persons with prediabetes. Journal of medical Internet research. 2015;17(10):e240.

24.   Fukuoka Y, Gay CL, Joiner KL, Vittinghoff E. A novel diabetes prevention intervention using a mobile app: a randomized controlled trial with overweight adults at risk. American journal of preventive medicine. 2015;49(2):223-37.

25.   Wong CK, Fung CS, Siu S, Lo YY, Wong K, Fong DY, et al. A short message service (SMS) intervention to prevent diabetes in Chinese professional drivers with pre-diabetes: a pilot single-blinded randomized controlled trial. Diabetes Research and Clinical Practice. 2013;102(3):158-66.

26.   Ramachandran A, Snehalatha C, Ram J, Selvam S, Simon M, Nanditha A, et al. Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomised controlled trial. The lancet Diabetes & endocrinology. 2013;1(3):191-8.

27.   Burnard P. A method of analysing interview transcripts in qualitative research. Nurse education today. 1991;11(6):461-6.

28.   Fridlund B, Hildingh C. Qualitative research methods in the service of health: Studentlitteratur; 2000. ISBN: 9144012489.

29.   Chartered S. Are You Earning Enough? Singapore's Average Household Income Revealed. 2019; Available from: https://www.sc.com/sg/stories/financial-tips/are-you-earning-enough-singapores-average-household-income-revealed/#_ftn2.

30.   Lim RBT, Wee WK, Ananthanarayanan JA, Soh YH, Goh LML, Tham DKT, et al. Correlates, facilitators and barriers of healthy eating among primary care patients with prediabetes in Singapore—A mixed methods approach. Nutrients. 2019;11(5):1014.

31.   Lim RBT, Wee WK, For WC, Ananthanarayanan JA, Soh YH, Goh LML, et al. Health

education and communication needs among primary care patients with prediabetes in Singapore: a mixed methods approach. Primary care diabetes. 2020;14(3):254-64.

32.   Comendador BEV, Francisco BMB, Medenilla JS, Mae S. Pharmabot: a pediatric generic medicine consultant chatbot. Journal of Automation and Control Engineering. 2015;3(2).

33.   Kowatsch T, Volland D, Shih I, Rüegger D, Künzler F, Barata F, et al., editors. Design and evaluation of a mobile chat app for the open source behavioral health intervention platform MobileCoach. International Conference on Design Science Research in Information System and Technology; 2017: Springer.

34.   L'Allemand D, Shih C, Heldt K, Buchter D, Brogle B, Ruegger D. Design and interim evaluation of a smartphone app for overweight adolescents using a behavioural health intervention platform. Obesity Reviews. 2018 (Suppl 1):102.

35.   Cheng A, Raghavaraju V, Kanugo J, Handrianto YP, Shang Y, editors. Development and evaluation of a healthy coping voice interface application using the Google home for elderly patients with type 2 diabetes. 2018 15th IEEE Annual Consumer Communications & Networking Conference (CCNC); 2018: IEEE.

36.   Griol D, Molina JM, Callejas Z, editors. Towards emotionally sensitive conversational interfaces for E-therapy. International Work-Conference on the Interplay Between Natural and Artificial Computation; 2015: Springer.
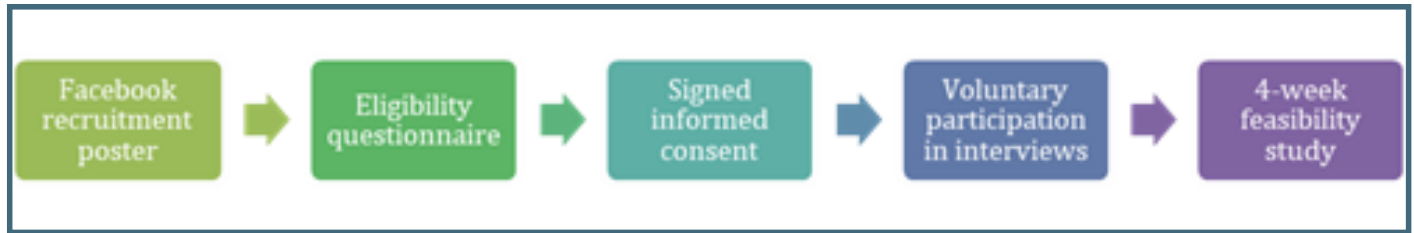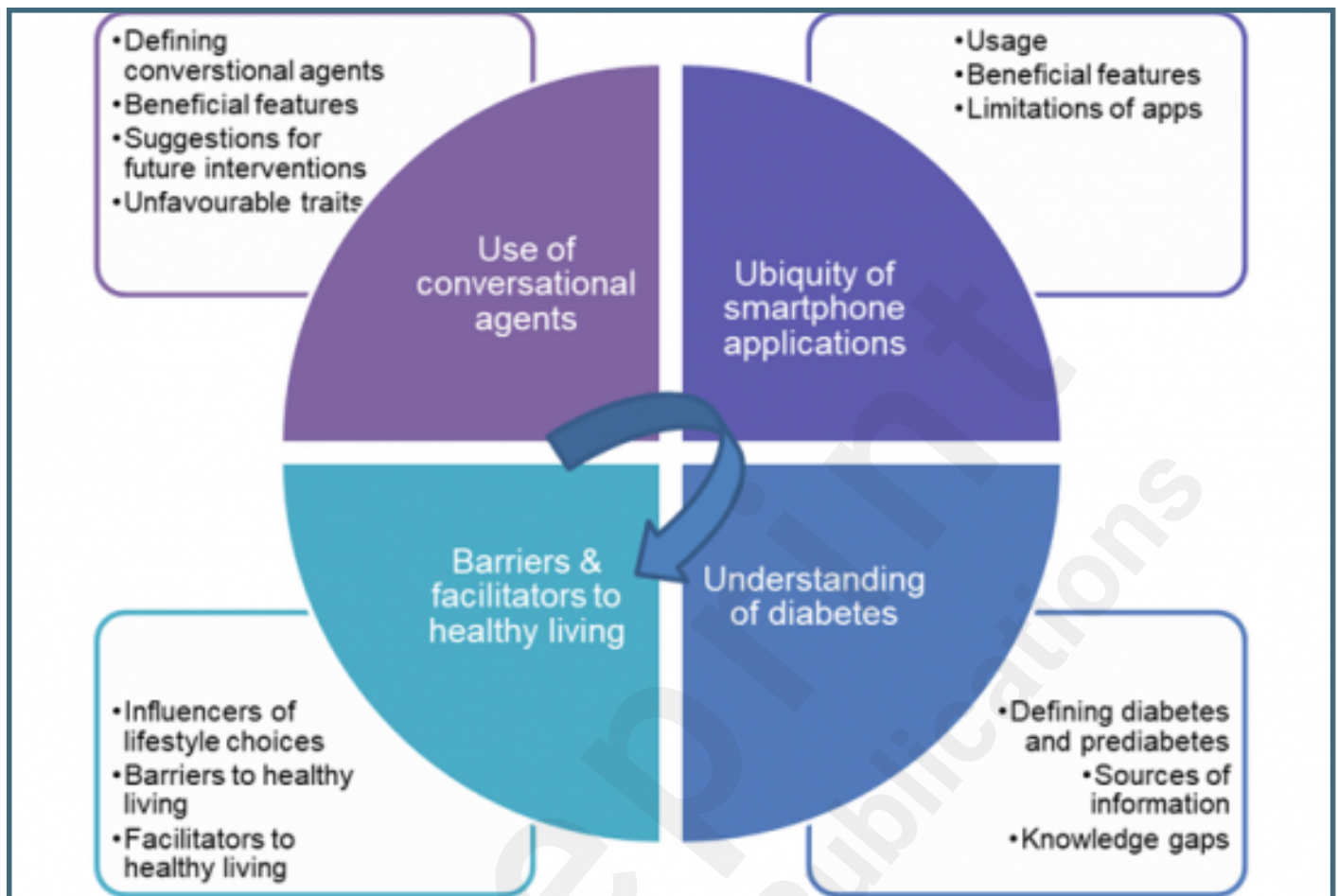
Supplementary Files
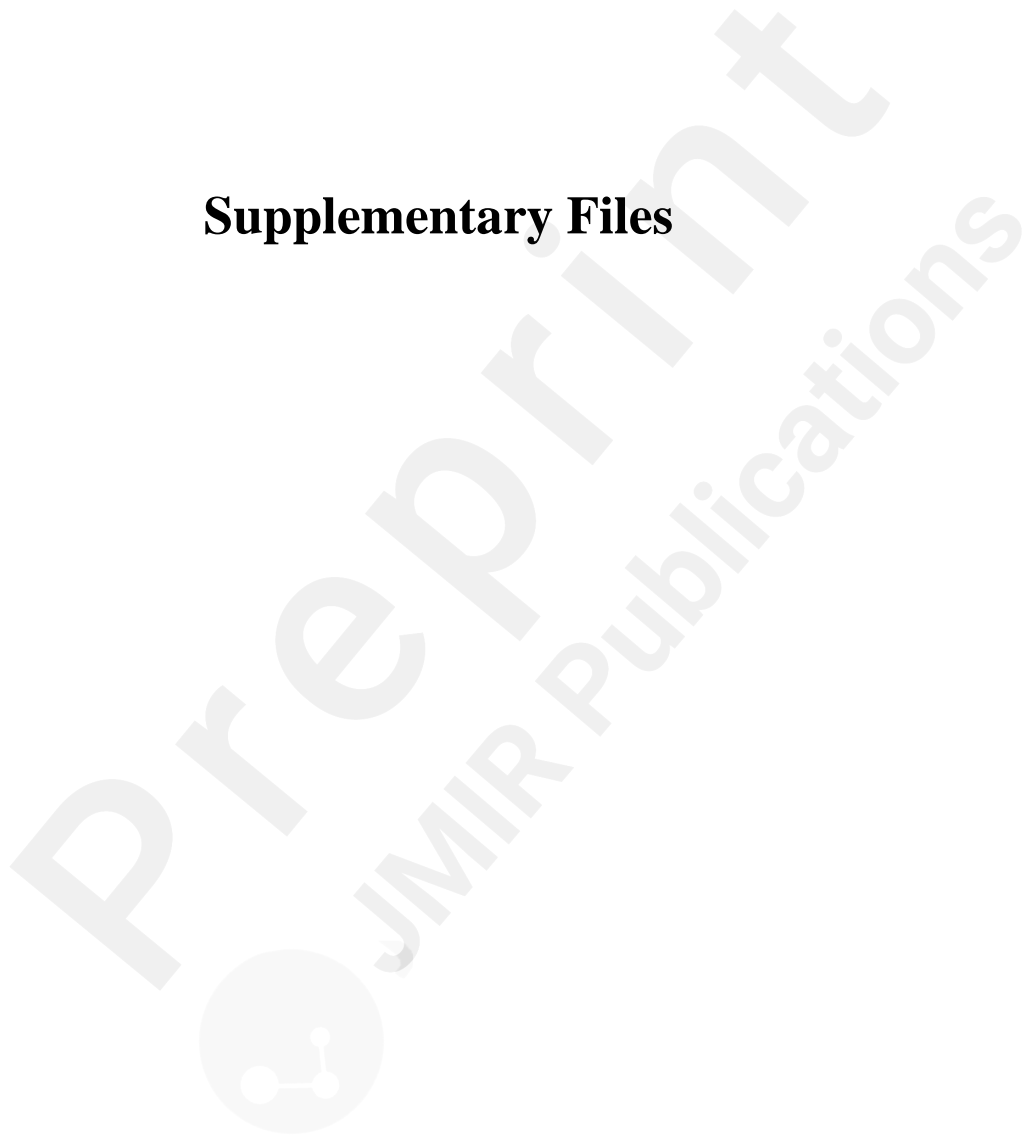
Figures
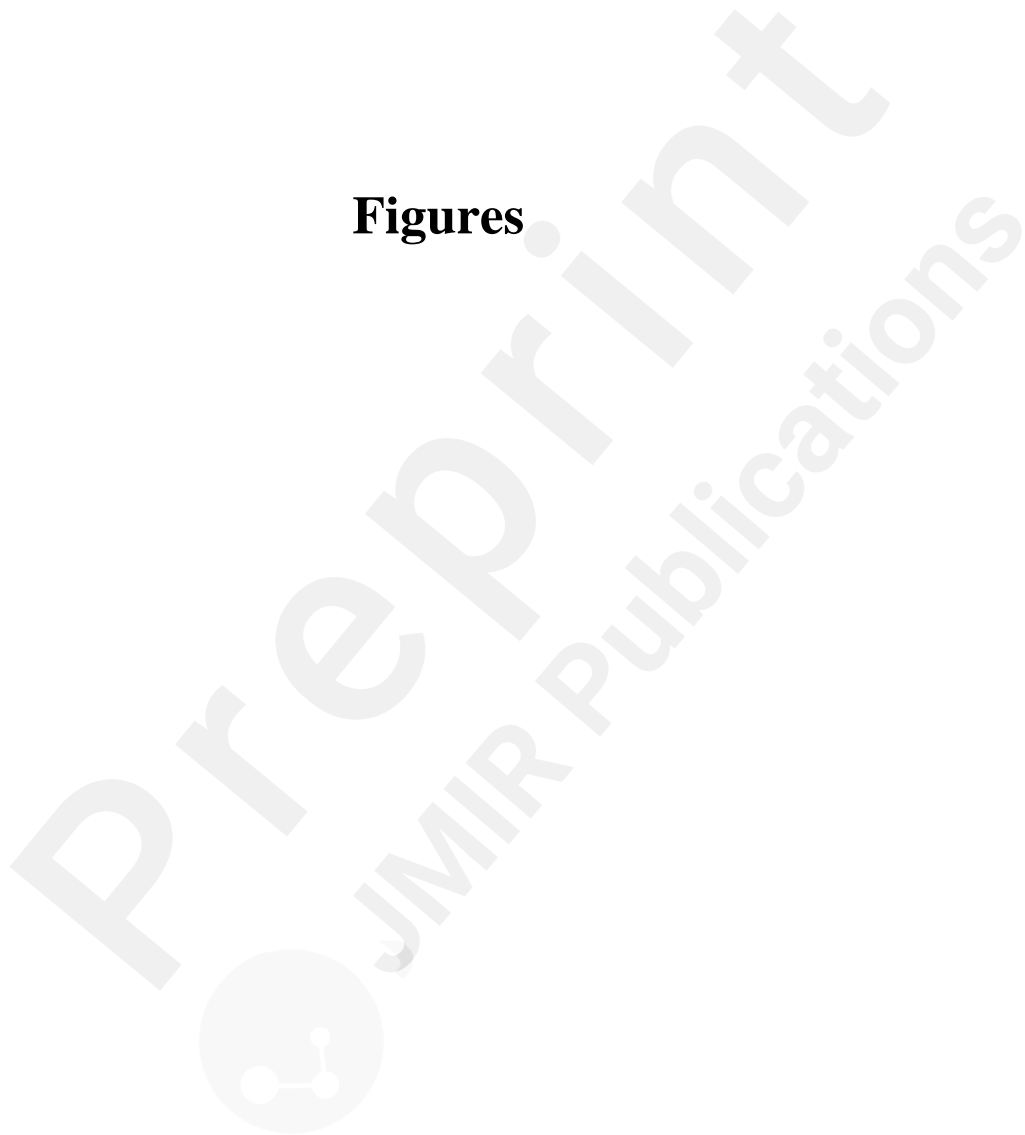
The order of events participants underwent, from (1) recruitment, (2) interviews for needs assessment and subsequent participation in a 4-week feasibility study.
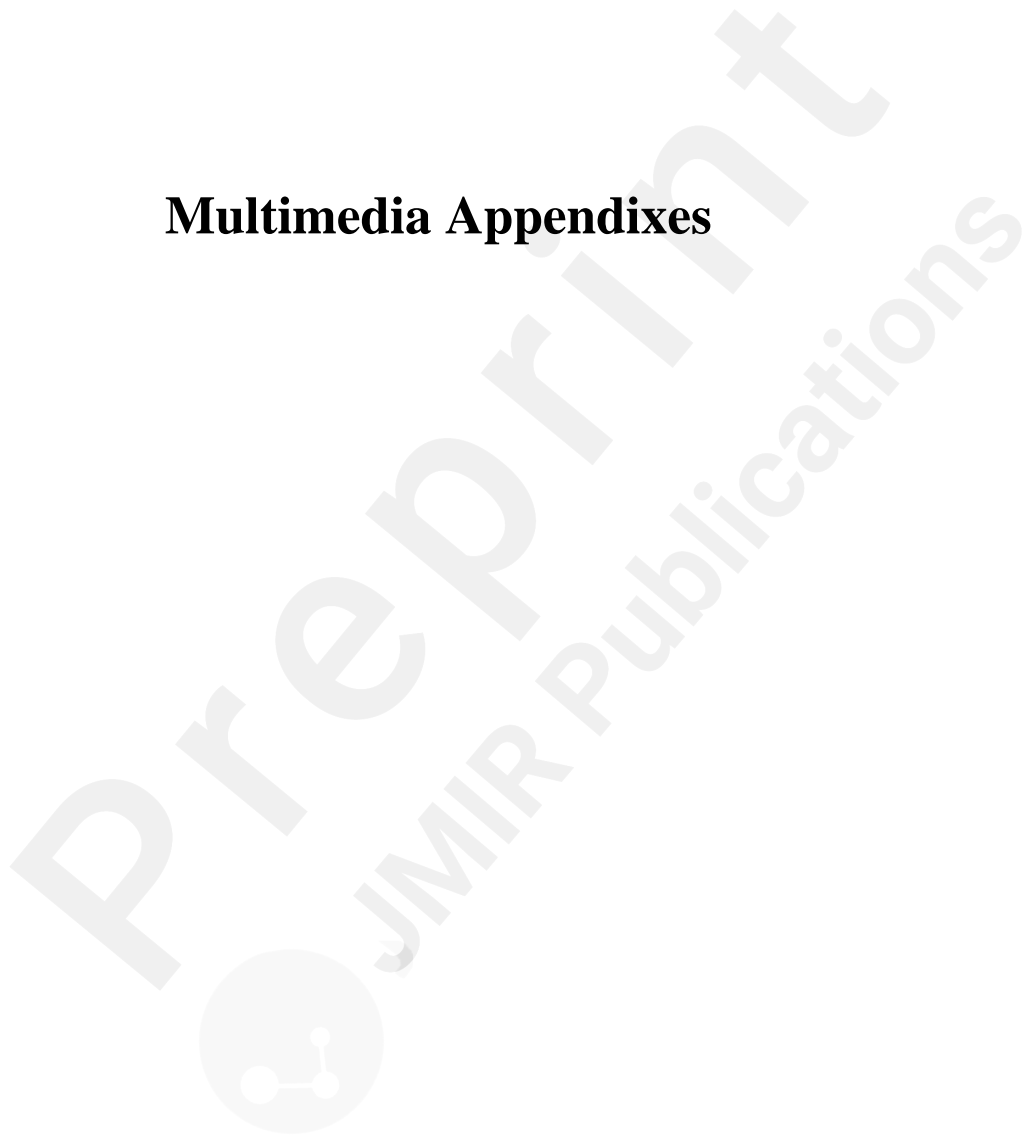
Themes and subthemes identified from analysis of interview transcripts.

Multimedia Appendixes

COREQ 32-item checklist.
URL: http://asset.jmir.pub/assets/53a3ae98a905f69c826d11583a66ad83.docx

Themes and subthemes generated from qualitative analysis.
URL: http://asset.jmir.pub/assets/bf161483f17323d29170bcf7dd193927.docx