Towards a Design Framework for Conversational Agents for Diabetes Prevention

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Type 2 diabetes (T2D) has emerged as a significant catalyst for various health conditions. The availability and cost of health professionals pose challenges, limiting access to personalised lifestyle support. To address this issue, utilising Conversational Agents (CAs) presents an opportunity to improve scalability and adoption by improving efficiency and engagement. Thus, this study focuses on the potential impact and response to T2D. This paper aims to develop a framework for designing CA functions that support individuals at risk of T2D to be more active and raise their awareness. The study involves a mixed methods approach, including a survey conducted among 30 participants in Sydney and Jeddah, followed by semi-structured interviews conducted with 10 participants. While descriptive statistics were used to analyse the survey, the interviews were analysed using thematic analysis. Drawing upon the interviews and relevant literature, this study proposes developing a preliminary framework to help design CAs that support individuals with prediabetes to adopt a more active lifestyle.

Additional Key Words and Phrases: conversational agents, chatbot, diabetes, framework, physical activity, CA, T2D

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1 INTRODUCTION

Type 2 diabetes (T2D) is one of the world's top ten most chronic severe conditions due to its negative effect on the quality of life and it is one of the significant causes of death worldwide. In 2021, there were 537 million people who had diabetes worldwide. A projected expectation shows that diabetes is one of the chronic diseases that will affect 643 million people worldwide by 2030 [26]. All that leads this work to focus on diabetes.

T2D is a more common type with a robust genetic component besides its association with obesity and sedentary lifestyles [26]. T2D often goes undiagnosed for many years, leading to impaired glucose tolerance or a prediabetic state. People with type-2 diabetes often have other conditions, such as obesity, hypertension, and dyslipidaemia, that increase the risk of cardiovascular disease [9]. 90% of diabetes results from being overweight and physical inactivity [25]. Compared to type 1, type 2 diabetes is preventable through lifestyle changes, while type 1 requires lifelong insulin replacement.

Prediabetes is when glucose levels are higher than usual but not high enough for a T2D diagnosis. Preventing the progression from prediabetes to T2D is crucial to avoid long-term consequences. Supporting people with prediabetes through programs, including health coaching and information technologies, has shown some positive outcomes [4]. However, such programs on a large scale can be challenging for the health system. Preventing T2D requires challenging behaviors, lifestyle changes, self-care, and personalised treatment [35]. There is no single cause for T2D, but well-known risk factors exist, such as people with prediabetes or over 44 with high blood pressure [36].

Adopting a healthy lifestyle, proper nutrition, regular exercise, and maintaining an optimal weight can prevent up to 60% of T2D cases [9]. However, many individuals struggle to meet these prevention recommendations due to barriers, such as motivation, support, and the need for consistent reminders. As a cost-effective and efficient approach, conversational agents offer a tailored response to these challenges.

Conversational agents (CAs), also known as chatbots, are "a class of technologies behind automated messaging and speech that offer interaction between human and computer" [21, 22]. Utilising CAs presents a promising opportunity to enhance Human-Computer Interaction (HCI), such as handling inquiries, conserving human efforts and offering immediate replies [20, 24].

In the last two decades, conversational agents have illustrated multiple benefits in healthcare. They are used to deliver scalable, lower-cost healthcare support solutions that can help anytime. Regarding diabetes prevention using CAs, there is limited research [33, 37]. The main findings of the work are that framework can provide a suitable customisable response to the challenges of preventing and managing T2D. The potential implications for the HCI domain are that conversational agents can offer scalable, lower-cost healthcare support solutions that can help at any time and can be used to deliver personalised, engaging, and on-demand health promotion interventions. Also, it can provide additional information on the application of conversational agents in health care for chronic diseases [32]

2 LITERATURE REVIEW

2.1 Examining Conversational Agents in the Context of Health

CAs have prompted substantial attention to tackling some health issues and encouraging healthier lifestyles [31]. Table 1 highlights the characteristics of diverse CAs in some health concerns, showcasing varied technologies, Artificial intelligence (AI) methods, and system input/output.

Baptista et al. [5] evaluated a smartphone app with an embodied conversational agent (ECA) utilising a multi-modal user interface involving natural language processing. The app employed a finite-state system for dialogue management,

enabling CAs to provide verbal, written, and visual input/output. The ECA was seen as a valuable tool for enhancing self-management skills and improving engagement with diabetes management.

Beaudry et al. [6] explored a chatbot-driven text messaging platform employing machine learning, NLU, NLP, deep learning, and speech recognition. The dialogue management used a finite-state system, with CAs contributing input and output. The chatbot was perceived as helpful and engaging by adolescents with special health needs. It provided support and guidance during the transition to adult healthcare. Bott et al. [7] examined an ECA platform incorporating text-to-speech and NLU. They employed a framework-based dialogue management method, where CAs utilised written, verbal, and visual signals for input and output. The study found that the CAs were effective in supporting nurse teams and mitigating risks of hospitalisation in older adults. It improved communication, enhanced patient safety, and reduced adverse events.

Chaix et al. [8] researched a mobile and web chatbot that used NLP and ML. A finite-state system was employed in the conversation management technique. The CAs have written and visual input and written output. The study found that the chatbot provided emotional support, information, and guidance and helped patients manage their symptoms and side effects.

Easton et al. [14] investigated a web-based conversational AI that utilised NLP and speech recognition. They employed a frame-based approach for dialogue management, incorporating oral, written, and visual input and output. The study found that the chatbot was acceptable and helpful for supporting individuals living with physical and mental comorbidities.

Greer et al. [15] investigated a Facebook Messenger chatbot that utilised both written and visual input/output, though they did not specify the AI method employed. The study found that the chatbot was feasible and acceptable for delivering positive psychology skills and promoting well-being among young people after cancer treatment.

Hauser-Ulrich et al. [17] evaluated a mobile app with a chatbot. The AI method was not mentioned. The CAs had both written and visual input and output. The study found that the chatbot was feasible and acceptable for promoting chronic pain self-management. Neerincx et al. [24] explored a platform-independent system employing machine learning, deep learning, voice recognition, and speech synthesis. They utilised a finite-state dialogue management technique, with CAs processing visual input and producing spoken, textual, and visual outputs. The study found that was effective in supporting a child's diabetes self-management.

The table's findings highlight the growing interest in leveraging CAs to aid patients and those at risk of getting disorders, utilising advanced AI techniques, such as speech recognition, natural language processing, and deep learning. Various interaction methods, including spoken, written, and visual modalities, enhance user experience and engagement. The diversity of technologies, such as mobile apps, web apps, and messaging systems, facilitates broader accessibility for T2D assistance seekers. Previous research on CAs demonstrated their potential care and behavior change, benefiting knowledge, identity, medication adherence, symptom management, and mental well-being. CAs effectively provide diabetic patients with support, information, self-management tools, and personalised treatments.

2.2 Addressing Limitations and Bridging Gaps

While the existing literature shows promise for conversational agents in healthcare, it also reveals certain gaps and limitations. In this subsection, we underscore these limitations and highlight the importance of addressing them to propel the field forward.

Long-Term Assessments and Generalisation: Most research spans only weeks to months, necessitating long-term assessments to gauge CAs' lasting impact on behavior and health. Existing findings often pertain to specific groups or

Table 1. Existing works on CA in T2D

Author	Year	Technology	Method	Input	Output
Baptista et al. [5]	2020	ECA; Mobile App	NLP and SR	verbal	Textual and verbal
Beaudry et al. [6]	2019	Chatbot, messaging system	NLP, SR, NLU, ML and DL	Textual	Textual
Bott et al. [7]	2019	ECA	NLU	Visual, verbal	Visual, verbal and Textual
Chaix et al. [8]	2019	Chat bot, Web app, Mobile app	NLP and ML	Visual and Textual	Written
Easton et al. [14]	2019	Chatbot, Web app and avatar	SR and NLP	Textual and verbal	Textual, verbal and visual
Greer et al. [15]	2019	Chatbot and messenger	Not reported	Textual	Textual and visual
Hauser-Ulrich et al. [17]	2019	Chatbot and Mobile app	Not reported	Textual	Textual and visual
Neerincx et al. [24]	2019	Avatar, app, and robot.	DL, ML, SR, SS	Visual	Visual, verbal, and Textual
Rehman et al. [29]	2020	Chatbot and mobile app	NLU, SR, TTS, SS, ML, NLP and DL	Textual and verbal	Textual and verbal
Ryu et al. [30]	2020	Chatbot and mobile app	SR	Visual	Textual

* SR means Speech Recognition (SR), Text to speech (TTS), Machine learning (ML), Deep Learning (DL), Speech Synthesis (SS), Natural Language Understanding (NLU).

contexts, constraining broad applicability [3]. Further research should explore CAs' efficacy across diverse demographics and cultural settings.

Absence of comparison groups: Several studies on conversational agents did not include control or comparison groups, which makes it difficult to evaluate the exact impact of conversational agent treatments in contrast to other variables or interventions [18, 19, 28].

Technological limitations: CAs' voice recognition and natural language processing skills can be limited, hindering accurate interpretation of user input and responses. Further technological advancements are needed to enhance conversational agents' effectiveness and utility. Researchers are continuously working on improving voice recognition and natural language processing capabilities to overcome these limitations [34]. Advancements in machine learning, deep learning, and natural language understanding algorithms can contribute to developing more sophisticated conversational agents. Additionally, incorporating contextual information and expanding the knowledge base are focus areas for future improvements [3].

User experience and adherence: Efforts are needed to enhance continuous engagement and adherence to CA treatments. Research should explore methods to increase motivation and maintain long-term usage [27].

On top of that, the healthcare system faces challenges, such as resource constraints, patient disengagement, and personalised treatment obstacles. CAs offer solutions with immediate support, tailored education, and efficient data collection. Studies by Danieli et al. (2021) and Chinkam et al. (2021) show CAs' effectiveness in psychiatric and obstetric care. Community health workers are intermediaries in chronic illness management, connecting patients and professionals.

The research gap exists in the current literature regarding the insufficient emphasis on conducting long-term assessments involving diverse participant cohorts. Additionally, there is a lack of integration of appropriate comparison groups, limited exploration of advanced technological capacities, and a need to develop strategies to foster user engagement and compliance within studies. Addressing these limitations will improve employing CAs for diabetes control and behavior change advance.

3 METHODOLOGY

3.1 Research Design

This work will inform the prototype design for the CAs through a framework. The sequential mixed methods approach has been applied. Initially, a survey was conducted among 30 participants in Sydney and Jeddah. Subsequently, after analysing the survey responses, semi-structured interviews were conducted with the eligible 10 participants from the survey study. It is crucial to highlight the role played by the public health expert in its development. Her active involvement extended to formulating the survey and interview questions besides formalising the framework. While the level of detail about the expert's contribution in this paper may be limited, it is imperative to ensure that her input was fundamental in enhancing the framework's ability to effectively address the management of T2D in terms of physical activity.

3.2 Survey

3.2.1 The development of the research instrument. The survey was used for two purposes. Firstly, descriptive analyses are to know the lifestyle habits of the participants. Based on the analysis, the second purpose is as an eligibility criterion to invite participants to the interview. The data is not to be used for any diagnostic purposes. The survey was split into three parts. Firstly, the Healthy Lifestyle and Personal Control Questionnaire (HLPCQ) [13]. HLPCQ measures lifestyle patterns and includes 26 items related to various aspects, such as diet, daily time management, organised physical exercise, social support, and positive thinking practices. The second part covers participants' use of apps, websites, or programs for managing their medical condition, their willingness to engage in an interview, and their interest in testing an upcoming chatbot. This demonstrates further involvement in the interview process and willingness to trial the chatbot. The last part seeks sociodemographic information: age, gender, health condition diagnosis, country and city, job type (desk or physical job), smoking status, height and weight.

Scaling and measurement. Participants were from Australia (Sydney) and Saudi Arabia (Jeddah), all aged between 40 - 55 years old. All 26 items were measured using a four-point Likert-type scale (1 = Never or rarely, 2 = Sometimes, 3 = Often and 4 = Always). Through principal component analysis of 26 items, HLPCQ consisted of five factors. The factors represent an individual's ability to control the quantity and quality of their food (Dietary Healthy Choices), avoid unhealthy food temptations (Dietary Harm Avoidance), maintain a consistent schedule for meals and sleep (Daily Routine), follow organised physical exercise routines (Organised Physical Exercise), and balance socialisation and leisure time while adopting positive thinking to handle stressors (Social and Mental Balance) [13].

3.2.2 Data collection. The survey targeted participants from Sydney and Jeddah city based on two selection criteria. Aged between 40 - 55 years old. The second criterion is Speak, read and write English at a good level.

Survey implementation procedure. The Redcap platform was used as a tool to build up the survey [28]. Three individuals from each city tested the survey to identify problems before distributing the full survey to the participants. The researchers posted the survey on various online platforms, such as Teams, What's Up, and Facebook.

3.3 Interviews

3.3.1 Interviews data collection . This section presents three parts to be considered for interview data collection encouraged by Creswell [12]. These parts range from the aim to administrating the interviews as follows:

The aim of the interviews. This phase investigates how individuals with T2D, or prediabetes, manage their lifestyle, especially physical activity. It explores their knowledge and understanding of chatbots. Feedback on a proposed prediabetes-specific chatbot was gathered.

A purposeful sampling of participants. Based on the survey results, participants were selected for interviews using two specific inclusion criteria. Firstly, participants either belonged to the risk group for type-2 diabetes or had type-2 diabetes. Secondly, they demonstrated never/rarely or sometimes adherence to healthy lifestyle habits as per the survey scores (4.1 Descriptive statistics). Out of 30 participants from Sydney, 11 qualified and were selected, while one was excluded due to non-compliance with the criteria. In contrast, out of 30 participants from Jeddah, 14 qualified, with two being excluded for the same reasons.

Administering the interviews. The interview question draft was validated by four participants for data reliability. Participants received email invitations with information sheets and consent forms, and recording was done post-permission. 20 interviews were conducted – ten by a researcher in Jeddah, primarily in-person, with three held via Zoom and Teams. Another researcher conducted the remaining ten interviews in Sydney, all face-to-face. Interviews lasted 10-15 minutes each.

3.3.2 Data analysis and interpretation. The data was transcribed using Otter software [1]. To ensure accuracy, the transcriptions were cross-checked with the audio recordings. The process followed guidelines for thematic analysis by two researchers [10]

4 SURVEY ANALYSIS

4.1 Descriptive statistics

This section shows the results of descriptive statistics using the Statistical Package for Social Science (SPSS). The survey has been distributed to 30 from each city (Sydney and Jeddah). Survey responses were collected, and a separate analysis was conducted for each city. Descriptive characteristics of five subscales and the total HLPCQ score were measured using a four-point Likert, where never/rarely = 1 point, sometimes= 2 points, often= 3 points, and always= 4 points. Table 2 and Table 3 display the subscales and total HLPCQ scores in Sydney and Jeddah, respectively, where the range starts from the lowest score (rare commitment) to the highest score (always commitment), then the total score of HLPCQ for participants. The first column shows the item count for each subscale. The range column presents subscale score ranges. Mean indicates average scores, while SD represents standard deviations for each subscale. The scores were derived by dividing the score points by the subscale's item count. For example, the participant (41) has 14 points

Table 2. Descriptive characteristics of the five subscales and the total score of HLPCQ for participants from Sydney city

Subscales	Items	Range	Minimum	Maximum	Mean	SD
Dietary Health Choices	7	7 – 28	7	23	14.70	4.24
Dietary Harm Avoidance	4	4- 16	4	14	9.03	2.61
Daily Routine	8	8 - 32	10	25	17.40	4.72
Organised Physical Exercise	2	2 - 8	2	8	3.67	1.83
Social and Mental Balance	5	5 - 20	5	16	11.37	2.54
Total Score	26	26 - 104	38	76	56.17	11.21

*HLPCQ: Healthy Lifestyle and Personal Control Questionnaire, SD: Standard Deviation.

Table 3. Descriptive characteristics of the five subscales and the total score of HLPCQ for participants from Jeddah city

Subscales	Items	Range	Minimum	Maximum	Mean	SD
Dietary Health Choices	7	7 – 28	9	23	15.23	3.47
Dietary Harm Avoidance	4	4- 16	4	13	8.20	2.19
Daily Routine	8	8 - 32	9	29	17.30	5.39
Organised Physical Exercise	2	2 - 8	2	8	3.83	1.86
Social and Mental Balance	5	5 - 20	8	17	12.57	2.25
Total Score	26	26 - 104	34	72	57.13	9.44

*HLPCQ: Healthy Lifestyle and Personal Control Questionnaire, SD: Standard Deviation

in dietary health choices. The score is 2 (14/7), which indicates that he sometimes commits to a healthy lifestyle (This is not a medical diagnosis).

The participants' characteristics included age, gender, health condition, country and city, kind of job (desk or physical job), smoking status, height, weight and apps or websites to manage the condition. Figure 1 and Figure 2 illustrate the sociodemographics of participants (age, gender, health condition, job, smoking status) in Sydney and Jeddah, respectively. For instance, about 43% of the respondents in Sydney with no disease, followed by prediabetes and diabetes, with 27% and 6%, respectively. There were 15% with other health conditions (hypertension, heart disease). 9% were with other diseases. In terms of Jeddah respondents, Most of them with no disease (57%). There were 27% of the respondents have prediabetes, while 13% with diabetes. Hypertension and heart disease were equal to 7%. Only 3% with other diseases.

To sum up the major findings, the analysis result found that most respondents in Sydney and Jeddah were in the age range of 40-45 years old, with most respondents being male in Sydney and almost equally split between male and female in Jeddah. Most respondents in both cities had no disease, followed by those with prediabetes and diabetes. In terms of job type, most respondents in Sydney had a physical job, while most respondents in Jeddah had a desk job. The study also found that more than half of the respondents in Sydney were smokers, while most respondents in Jeddah were non-smokers. Some participants did not reveal their height and weight, and approximately 50% of respondents in Sydney and 63% in Jeddah did not use apps or websites to manage their health conditions. The reasons for not using digital tools vary, with some respondents citing a lack of need or difficulty finding a suitable tool.

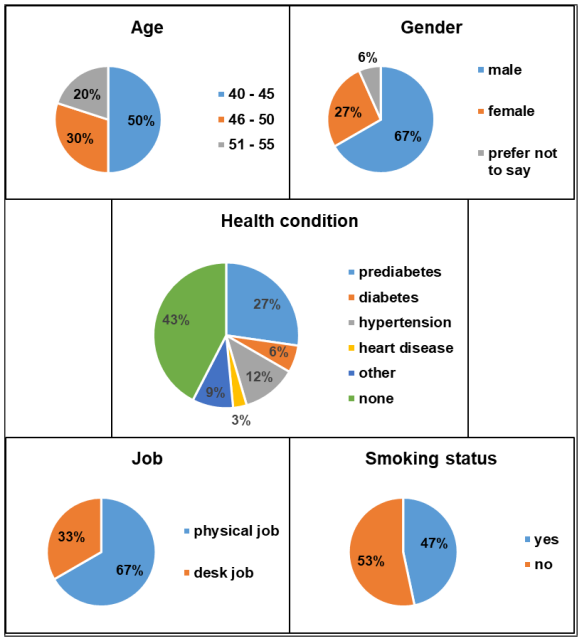

Fig. 1. Sociodemographic for Participants in Sydney (age, gender, health condition, job, smoking status)

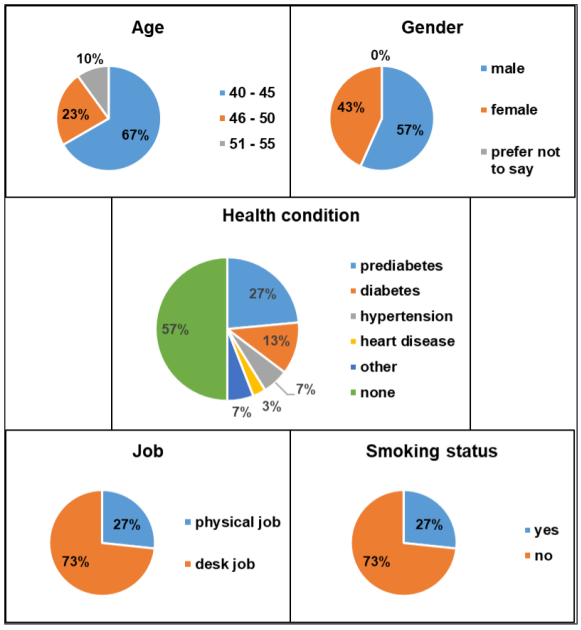

Fig. 2. Sociodemographic for Participants in Jeddah (age, gender, health condition, job, smoking status)

5 INTERVIEWS ANALYSIS

This section presents interview study outcomes from Sydney and Jeddah. These semi-structured interviews explore participants' perceptions of chatbots based on their backgrounds, informing the CA prototype design by developing a framework.

5.1 Interviews analysis results

Raw interview data and transcripts were imported into NVivo 12 for coding and thematic analysis. Table 4 illustrates the seven themes. The analysis for participants from Sydney and Jeddah was conducted separately. Then the codes and themes were consolidated by the two researchers. In Sydney, the total number of participants was 10. Two of them had T2D, and the rest were at risk of developing it. In Jeddah, email invitations were sent to 12 participants due to the survey analysis. 7 participants responded to the invitation, and 3 were added to complete the total number of 10 participants. Three participants had T2D, and the rest were at risk of developing it.

Table 4. Themes and description

Theme	Description
The way the participants found out T2D/at-risk group	This theme relates to the different ways in which participants discovered that they had type 2 T2D (T2D) or were at risk of developing it.
Understanding of the condition	This theme involves the participants' understanding of the role of physical activity for people with T2D or at risk of developing it. Also, it may involve identifying some misconceptions or gaps in knowledge.
Self-management of Condition	This theme involves investigating participants with T2D or being at risk of developing it on the way to self-manage the condition into subthemes: participants with mobile applications and others with no use for mobile applications. Subtheme: Participants with mobile applications This subtheme involves exploring the use of a mobile application to manage the condition or their motivation to engage in physical activity. Subtheme: Participants with no mobile applications This subtheme involves exploring how participants without access to a mobile application manage their T2D or risk of developing it and what resources they use.
Usability	This theme includes the participants who are familiar with using chatbots and talk about their experience and others who are not familiar with using chatbots.
Desired features for a physical activity chatbot	This theme involves exploring the design and functionality of a chatbot designed to support physical activity in people with T2D or at risk of developing it. Qualitative analysis of this theme includes certain features, the information type either text, audio or mixed information besides what the participants' preference regard to the communication tone either formal, informal, friendly or factual tone.
Obstacles against doing physical activity	This theme explores the obstacles participants face in maintaining physical activity and what strategies they use to overcome them. In addition, participants with no difficulties keeping up with physical activity.
Recommendations	This theme contains advice for people with T2D or at risk of developing it besides anything participants would like to add to the topic.

5.1.1 Themes for Sydney and Jeddah participants. This section presents responses from Sydney participants (SP) and Jeddah participants (JP), categorised by themes.

(1) **The way the participants found out T2D/ at-risk group**

Sydney

Four participants consulted their General Practitioner (GP) for health issues. Then the GP recommended that they undergo a blood test, leading to their diagnosis or identification of being at-risk for T2D "I was gaining weight, and then I had difficulties. I was very tired every time I couldn't do physical activity. So, I went for a general checkup …" (SP9). Three participants (SP1, SP3, and SP6) mentioned a family history of diabetes as a reason for finding out that they are in the risk group of T2D. Two participants (SP3 and SP8) found out about their T2D or at-risk group during routine check-ups. One participant (SP4) found out after a friend suggested that it is better to check with the GP "I had not thought to find out until one of my friends advised me to check with my GP at that time".

Jeddah

Six were diagnosed they have T2D or at-risk group of developing it during a medical examination, such as "I went to the doctor and I found out" (JP6) or hospital visit due to symptoms, such as "three years ago. I had some problems when I was going to the toilet. … every 5 minutes, I was trying to get to the toilet. So, I went to one of the specialists, and he told me that I had it" (JP10) or high glucose level, such as "I found out in the last period of pregnancy" (JP8). One participant received advice from a relative about the risks of T2D (JP4), while another found out through blood test results "I found out I had the blood test, and they told me you need to take care …". Another participant was aware of being in the risk group due to a family history of T2D and an unhealthy lifestyle. "my father and mother both have T2D, so I'm addressed of having T2D. Also, I have a sedentary lifestyle" (JP1). The last did not want to talk about it (JP5).

(2) **T2D/at risk group understanding**

Sydney

Participants acknowledged the importance of physical activity in managing or preventing T2D and were ready to integrate it into their daily routines. Almost all the participants believe that doing exercise regularly, such as walking and swimming, is one of the vital parts of managing the condition "… one of these illnesses is diabetes. Some of these physical activities need to be a routine in our lives …" (SP4). Also, three of them acknowledge that physical activity helps to reduce blood sugar levels, prevent the condition from worsening, and lower complications "Physical activity is very important that intent to maintain controlled diabetes …" (SP10). This aligns with current health recommendations that regular physical activity improves insulin sensitivity, lowers blood glucose, and reduces T2D risk. Only one participant was uncertain about the understanding of physical activity for this condition "I don't understand what exactly physical activity they should do" (SP6).

Jeddah

Participants' perceptions of physical activity and its connection to T2D can be classified into three groups: regular exercise, daily routine integration, and motivation to reduce medication reliance. The majority fall into the regular exercise category, viewing physical activity as structured workouts, such as running or swimming, aiming for at least three sessions weekly to enhance health and manage blood sugar. This category includes JP1, JP4, JP3, JP5, JP7, JP8, and JP9. For instance, JP3 says, "running every day for an hour or more to organise and improve health and improve blood sugar level". Participants who fall into an integral part of daily routine participants prioritise continuous activity, incorporating actions, such as walking overusing a car. This category includes JP2 and JP9. For instance, JP2 says," … walking to the store instead of using the car or taking the stairs instead … is considered physical activity ...". Personal motivation is a crucial factor for participating in

physical activity, as a participant emphasises. This highlights the need to incorporate enjoyable activities into daily routines for improved health and reduced reliance on medication. JP10 is an example of someone in this category.

(3) **T2D/at risk group Condition**

Sydney

Participants who use mobile applications to manage their condition often find them helpful and motivating. Only four out of ten participants use mobile applications to manage their T2D or risk of developing it. Mobile applications, such as MyFitnessPal and Samsung Smartwatch. MyFitnessPal provides users with the ability to monitor their food intake, calculate calories monitor food intake, and calculate calories, while the smartwatch tracks physical activity and monitors heart rate. “If you see my arm, you see that I have a Samsung smartwatch. That’s helped me a lot that I can watch my heart Beeping and also how much I get steps every day …” (SP8). Another example SP5 reports, “I use my fitness pal, … I can record my meals, and it calculates the calories for every day. Also, it records physical activity like how many steps I walk every day”. On the other hand, the rest of the participants do not use any mobile applications to manage their T2D or risk of developing it. Participants (SP2, SP3, SP6, and SP10) For instance, SP7 did not think of finding any mobile apps to manage his condition. SP4 did not use any apps to manage any illness.

Jeddah

Less than half of the participants (JP2, JP7, JP8, and JP9) utilised mobile apps to monitor their activity, glucose levels, and other health data. For example, JP9 states, “I use the Nike Run Club maybe to assess my running, and I also use the fitness app on my Apple Watch to keep track of my calories and … and the level of activity”. Participants benefit from mobile applications in managing their T2D risk or condition, enabling progress tracking and goal attainment. While some find mobile apps useful, others don’t use any for managing T2D or its risk. The rest of the participants do not see the need for such apps “I think I didn’t need it” (JP4) and have no knowledge of them (JP1). Additionally, a participant may rely more on external support to manage the condition “I have someone who cares about me”.

(4) **Usability**

Sydney

7 out of 10 mentioned that chatbots provide various benefits. Some use them to increase productivity and efficiency, making tasks easier and faster and allowing communication while multitasking. For example, SP1 states, "I use Siri to send text messages, make phone calls, set reminders and alarms, and provide directions". Another participant reports the convenience of chatbots, particularly in situations where it might be difficult or dangerous to use a phone, such as while driving."… it is a helpful way to communicate while driving or while doing something you cannot reach your phone" (SP5). One participant mentioned using chatbots to make shopping lists, schedule appointments, and call people (SP9). However, two of the participants mentioned that they have no interest in using chatbots and, thus, do not have any experience with them. This shows that while most people recognise the benefits of chatbots, there are some individuals who are less enthusiastic about their usage.

Jeddah

Two were not familiar with chatbots. JP3 stated that although she knew about Alexa, she did not have a device. On the other hand, JP10 was not familiar with the technology at all and asked for clarification. The remaining 8 participants were familiar with chatbot technology and found them useful for various tasks, such as controlling

smart home devices, shopping, and making phone calls. JP6 mentions, "Sometimes I use Siri to make some phone calls or search on YouTube". Additionally, it is useful while driving. For instance, JP7 reports, "I use Siri. It's like texting while driving. It is not a safe thing to do, so I usually ask Siri to play music for me or to make a phone call. Sometimes while eating, I can't take the phone. So, I use it on my Apple watch. So, it is really helpful for me". Siri was the most commonly used chatbot among the participants.

(5) **Design of chatbots for risk group of T2D to support physical activity**

Sydney

Participants' responses centred around features deemed valuable for a chatbot supporting physical activity in individuals with T2D or susceptibility to it. Noted features encompassed personalised exercise suggestions, activity-promoting reminders, motivational cues, educational content highlighting physical activity's diabetes management benefits, integration with diabetes tools, and monitoring of diabetes-related risks. "some useful features may include personally personalised exercise recommendations based on the user fitness level. Maybe also a reminder to reminders to encourage the user to engage in physical activity …, a motivational message to keep the user engaged and motivated … also educational content on the benefits of physical activity for diabetes management and tips for staying active daily." (SP1). The information type preferred by the participants is mixed, with some preferring text and others preferring audio "mixed information because sometimes I need more time to read text. Like when I'm driving or walking, audio will be preferred. … I'm not in a place where I can hear or play audio, so text is preferred" (SP10). The communication tone preferred by most participants is friendly, while two preferred a formal tone. Only one participant has no preferences (SP10).

Jeddah

In terms of desired features, the participants suggested various features for the chatbot to support physical activity in people with T2D or at risk of developing it. These features included medication reminders and motivation to do physical activity "… I need something to motivate me to go so far" (JP10). Also, recommendations for exercises based on their current situation and access to studies and videos "… It should have links to maybe some studies some videos" (JP5). Regarding information type, most of them had mixed preferences, such as "I prefer mixed information. Sometimes, I have something in my hand, and I can't grab my phone and hear that information" (JP6). A few prefer text "… I like to focus on things and read them quietly once or twice until I understand" (JP2) or audio "Audio I think is better. … I cannot read so much" (JP10). Regarding communication tone among the participants, almost all preferred a friendly tone "… It must be supported. I would prefer to go with the friendly option" (JP7). Only one participant preferred to be something in between "a little bit of both. I like facts … I really love the friendly one" (JP5).

(6) **Obstacles against doing physical activity**

Sydney

50% of the participants face obstacles in maintaining regular physical activity. SP5 deals with hindrances, such as a busy modern lifestyle, family commitments, and occasional laziness. SP7 struggles with back and knee issues due to excess weight, making exercise challenging. SP8 contends laziness and a big family by setting a daily step goal, turning it into a personal challenge against their smartwatch. "I make a challenge between me and my watch. I must finish 12,000 steps daily". SP9 lacks a routine and believes that establishing a daily 30-minute jogging regimen would help overcome this barrier. They also cite the modern lifestyle as a complicated factor. SP10 experiences motivational issues but suggests prioritising physical activity and forming a support group to conquer this obstacle. Conversely, the remaining half of the participants do not report any barriers or difficulties

that impede their engagement in physical activity.

Jeddah

Most of the participants faced barriers to physical activity, such as laziness (JP7), time constraints, and work/family commitments. "… Sometimes timing is wasted by working so hard looking for your children and for your family" (JP10), and environmental factors such as weather (JP5). Only one participant reported having no difficulties being active "I feel I don't have any issues being active" (JP6). Despite the challenges, participants also identified various strategies for overcoming obstacles to physical activity. These included time management, finding motivation, setting aside specific exercise time, using alarms, finding a suitable place to exercise, watching YouTube videos, making up for missed exercise on weekends, and rescheduling their day to fit in exercise time. However, one participant mentioned being unable to overcome the obstacle and just living with it (JP10).

(7) **Recommendations**

Sydney

The recommendations provided by the participants in these interviews generally focus on maintaining a healthy lifestyle, including a balanced diet, regular physical activity, and weight management. Some participants also suggest avoiding smoking and junk food, as well as undergoing regular checkups with healthcare providers. For example, SP1 mentions, "eating a healthy diet, a balanced diet that is rich with foods, vegetable Walls can help manage the blood glucose level, … and promote overall health. Also, staying physically active, regular physical activity can help control blood glucose levels. Also, manage weight, don't smoke, … regular checkups with your healthcare provider …". These suggestions align with diabetes management guidelines, emphasising lifestyle changes to lower T2D risk. Additionally, participants noted the potential of tech-based interventions for diabetes control and prevention.

Jeddah

The participants provide advice for individuals with or at risk of T2D. Key recommendations include adopting a healthy diet, regular exercise, monitoring blood sugar, and following medical guidance. Several participants highlighted the importance of exercise and physical activity, recommending activities such as walking, and swimming "Exercise more using the car. Take the stairs" (JP2). One participant suggested incorporating alerts to remind individuals to get up and exercise if they have been sitting for too long "Also if they will get alert to stop sitting, and exercise" (JP1). In terms of additional comments, most participants suggested using technology such as a chatbot or device to help individuals with diabetes or at risk of diabetes stay on track with healthy habits. Others emphasised the importance of education and support for individuals with diabetes.

Regarding the framework, Morrow et al. (2021) [23] develop a framework according to several studies. Self-care goals change throughout the course of an illness and can be divided into three main stages. The first stage involves accepting the illness, which requires the individual to learn about the illness and understand its severity in order to address it with self-care. The second stage is about establishing self-care routines in terms of physical activity, which involves learning how to perform self-care tasks, such as following a specific physical activity and integrating them into daily life. Finally, the third stage involves sustaining self-care over time, which can be challenging for older adults managing chronic illnesses and often requires support to maintain their self-care routines.

This work focuses on stages one and two, and the third stage will be included as future work. Figure 3 shows the preliminary framework for designing CAs to support people with prediabetes to be more active (Adapted from Morrow

et al. 2021). In terms of communication goals, Effective communication is crucial for motivating and guiding users through the different stages of self-care. Motivate self-care can help users accept their condition and understand the importance of self-care. Adapting this framework involves aligning the stages with the specific needs of individuals with prediabetes who aim to increase their physical activity. The interview findings were instrumental in refining the framework to meet these needs. User needs can be categorised into six main areas:

Knowledge from Educational Resources: Users want the chatbot to share information about T2D, healthy lifestyles, and medical check-ups and offer personalised exercise guidance and motivation.

Friendly Communication: The chatbot should communicate in a user-friendly tone, accommodating both tech-savvy and non-tech users, making it accessible and easy to engage with.

Mixed modality: It involves using both text and voice interactions in a chatbot to provide information and engage with users.

Personalisation: Users seek tailored recommendations based on their preferences, goals, and challenges, including personalised exercise plans and motivational content.

Planning Support: The chatbot should assist users in setting goals, tracking progress, and overcoming obstacles to physical activity while considering environmental factors.

Strategies for Overcoming Obstacles: Users want the chatbot to provide practical advice and support to tackle barriers, such as lack of time, motivation, or resources, while offering personalised exercise suggestions and reminders.

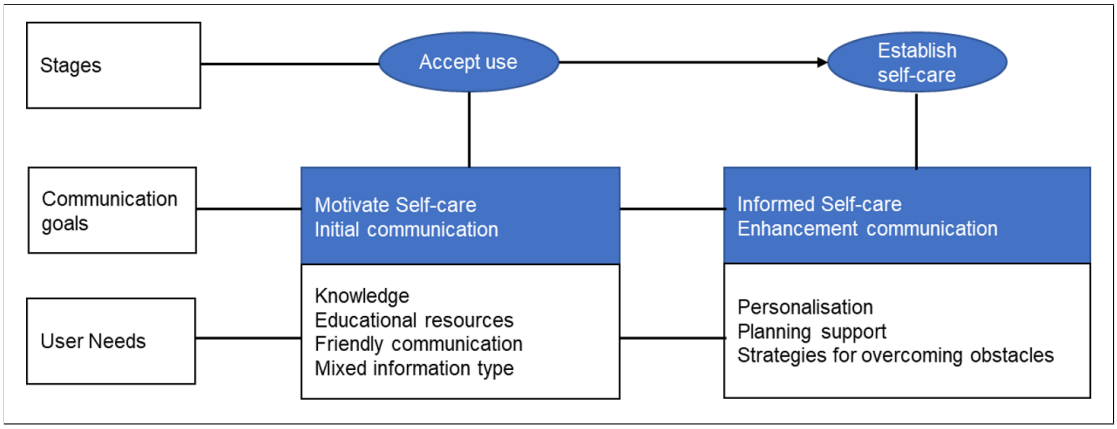

Fig. 3. Preliminary framework for designing conversational agents to support people with prediabetes to be more active (Adapted from Morrow et al. 2021)

6 DISCUSSION

This section presents the overall comparison between Sydney and Jeddah participants' responses in terms of each theme which informed the design of the framework.

(1) **The way the participants found out T2D/ at risk group**

Medical examinations and blood tests emerge as vital tools for identifying T2D and potential risk groups. In Sydney, General Practitioners (GPs) play a pivotal role, while Jeddah health issue-related visits are significant. Notably, family history and sedentary lifestyles in Jeddah underscore the value of lifestyle-oriented interventions.

An optimal framework accentuates the necessity for medical reviews, promotes healthier living, and furnishes guidance for T2D or at-risk individuals.

(2) **T2D/at risk group understanding**

Both groups agree on the importance of physical activity for managing T2D and preventing complications, as well as its role in controlling blood sugar levels. However, Sydney participants have a broader perspective, focusing on activities such as walking, running, and gym workouts, while Jeddah participants have a more specific view, classifying it as either structured exercise or part of daily routines. These differences highlight the need for personalisation in the conversational agents' framework. For instance, a chatbot could offer detailed insights into specific beneficial physical activities for T2D management to users with general knowledge. Conversely, it could provide personalisation based on motivations and preferences to users with a deeper understanding of physical activity.

(3) **T2D/at risk group Condition**

The disposition towards app utility for T2D management appears ambivalent in both cities. While some appreciate the app's role, others are indifferent. The framework must be flexible, recommending apps to enthusiasts while suggesting alternative resources, such as caregiver insights, for the sceptical.

(4) **Usability**

The results show that most participants in both cities are familiar with chatbot technology and find it useful for various tasks. The data reflects that chatbots can potentially improve productivity, efficiency, and convenience. However, it is also important to note that not all individuals are enthusiastic about chatbot usage. To design a framework that covers both groups, it would be beneficial to focus on providing functionalities to suit different user needs. Also, it should be easy to use and accessible to those who lack familiarity with the technology.

(5) **Design of chatbots for risk group of T2D to support physical activity**

Participants from Sydney and Jeddah provided insights on designing a chatbot for supporting physical activity among those with T2D or at risk. Both groups favored personalised exercise suggestions and motivational reminders. Some stressed the importance of tailored exercise ideas based on their situation. Most participants preferred a mix of modalities, including text and audio, suggesting a need for personalised information delivery. This aligns with user-centred design principles that prioritise understanding user preferences [2]. Building on these findings, an effective chatbot should amalgamate exercise insights, diversified information delivery, and a congenial tone while curating content as per user nuances. To enhance the chatbot's effectiveness, a personalised approach is crucial. Personalised chatbots have been shown to boost user satisfaction, engagement, and dialogue quality [33]. The chatbot should integrate exercise recommendations, reminders, and motivation for physical activity. Mixed information delivery options and a friendly communication tone should be provided. Additionally, the chatbot should offer exercise suggestions based on the user's circumstances and provide links to studies and videos for further information.

(6) **Obstacles from keep doing physical activity**

Barriers to regular physical activity are prevalent, albeit varying in intensity, across both cities. Shared strategies to surmount these challenges include time management and motivational tools. While Jeddah residents advocate for home workouts and YouTube-inspired sessions, Sydney residents lean towards communal strategies like support groups. These reflections underscore the chatbot's need to furnish versatile strategies, weaving in context-sensitive solutions like home-based exercises or outdoor activities.

(7) **Recommendations**

The recommendations provided by both Sydney and Jeddah participants focus on the importance of maintaining a healthy lifestyle, including a balanced diet and regular physical activity, in reducing the risk of developing T2D and managing the condition. In addition, both groups of participants emphasise the need for education and support for individuals with T2D or at risk of developing it. The framework should incorporate features that address the unique concerns and preferences of participants from both locations, such as reminders for physical activity, educational resources, and support for healthy habits. These needs can guide the design and development of conversational agents to support people with prediabetes to be more active. By addressing these needs, the chatbot can effectively support and motivate users to engage in self-care and prevent T2D.

Regarding the limitations of this work, the current framework primarily emphasises the end-user perspective only. Future work can be expanded to include healthcare professionals and their roles. Additionally, it is worth acknowledging that prior research identified a range of ethical implications, including privacy, security, and trust [11, 16]. While these aspects were not within the scope of this study, future work should delve deeper into these ethical dimensions.

7 CONCLUSION

The major goal of this study is to raise awareness of type-2 diabetes and help people at risk make required interventions in their lives by delivering conversational agents to support people at risk of T2D to be more active. The interview findings were instrumental in refining the framework to meet the users' needs. For future work, it is essential to conduct testing on the functions and features of the CAs developed using the framework proposed in this study. The primary objective of this testing phase will help identify areas for improvement and guide further design considerations for enhancing the CAs.

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