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# End-Users' Perspectives on Implementation Outcomes of Digital Voice Assistants Delivering a Home-Based Lifestyle Intervention in Older Obese Adults with Type 2 Diabetes Mellitus: A Qualitative Analysis

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## Abstract

Managing blood glucose levels and adhering to exercise is challenging for older adults with obesity and type 2 diabetes mellitus (T2DM). Digital voice assistants (DVAs) utilising conversation-based interactions and natural language may overcome barriers to accessing home-based lifestyle programs, but end-user perspectives are essential for implementation. This analysis investigated end-user perspectives on implementation outcomes of a DVA-delivered lifestyle program nested within a randomised controlled trial of 50 older adults (aged 50–75 years) with obesity and T2DM (DVA n = 25; control n = 25). Following trial completion, 10 DVA participants (mean ± SD age 67 ± 4 years) completed semi-structured interviews guided by the Practical Planning for Implementations and Scale-up guide and Proctor's implementation outcome taxonomy. Over half (60%) were willing to pay for the DVA-delivered program, indicating perceived value. DVA audiovisual and conversation-based modalities enhanced engagement and acceptability. Most end-users found the DVA program feasible as a modality for delivering lifestyle programs, but suggested greater personalisation to bolster sustainability. Overall, the intervention was identified as acceptable and appropriate, suggesting digitally delivered programs may be feasible and sustainable for long-term use. Findings should be interpreted cautiously, given the small sample size and short intervention period. Nevertheless, end-users' suggestions could inform the implementation of digital health interventions into healthcare systems.

**Keywords:** digital voice assistants; end-user perspectives; older adults; type 2 diabetes mellitus; home-based lifestyle program

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## 1. Introduction

Type 2 diabetes mellitus (T2DM) represents a significant global health challenge [1], requiring a comprehensive management approach with the main purpose of lowering blood glucose and improving cardiovascular risk factors [2]. This approach includes the use of medications, self-monitoring of blood glucose levels (BGLs), physical activity, and

a balanced nutrition program [3,4]. Indeed, sustained adherence to lifestyle programs incorporating physical activity and nutrition plays a crucial role in the prevention and management of T2DM, and has been shown to improve health outcomes such as quality of life, mental well-being, and physical function in older adults [5,6]. However, older adults with T2DM typically have poor musculoskeletal health [7] and often struggle to maintain adequate levels of physical activity and adherence to other lifestyle interventions [8–11]. This can be attributed to the fear of hypoglycaemia associated with exercise, the need for consistent monitoring of BGLs to engage safely in exercise, and limited access to centre-based lifestyle programs due to factors including lack of transportation and associated cost [12].

Digital health technologies may alleviate some of these barriers for older adults with T2DM [13,14]. Indeed, digital technology can deliver lifestyle programs, but older adults may encounter challenges relating to digital literacy, such as a lack of familiarity with technology, complex device interfaces, and visual/motor skill impairments [15]. Digital voice assistants (DVAs) may mitigate this because they incorporate the use of audiovisual hardware to provide automated, personalised two-way conversational interactions [16]. Recently, we successfully completed a randomised controlled trial (RCT) investigating the use of DVAs to deliver and monitor a home-based lifestyle intervention for 50 older adults (aged 50–75 years) with obesity and T2DM [17]. This RCT incorporated novel self-reported BGL monitoring before delivering a personalised lifestyle program, based on the Exercise and Sport Science Australia (ESSA) guidelines, ensuring participant safety during unsupervised home-based exercise [17,18]. Our findings demonstrated the feasibility of this approach, with the program reducing sedentary activity and increasing physical activity [17]. While DVAs show promise, their real-world implementation remains to be explored [19]. End-users provide critical insights on digital technology use and expectations for lifestyle program delivery [20,21]. End-user involvement and systematic exploration of implementation outcomes may increase the likelihood of successful real-world implementation of DVA-delivered lifestyle interventions for older adults with obesity and T2DM.

The aim of this study was to explore end-user perspectives on implementation outcomes (adoption, costs, appropriateness, acceptability, fidelity, feasibility, and sustainability) of a home-based lifestyle program for older adults with obesity and T2DM delivered by DVAs to inform future real-world implementation of similar digital health interventions.

## 2. Materials and Methods

### *2.1. Study Design*

This is a qualitative analysis of a 12-week RCT involving 50 older adults aged 50–75 years with obesity and T2DM, where participants were recruited from the 26 May 2021 to the 1 September 2021, and data collection was completed in early January 2022. The current qualitative analysis was performed following the quantitative analysis of the primary RCT, to enable interpretation of themes in the context of the findings from the RCT. The 12-week duration was pre-specified in the RCT protocol and is consistent with feasibility trial guidelines for lifestyle interventions. Participants from the RCT were randomised to either the DVA (n = 25) or control (n = 25) group. The DVA group was prescribed a DVA-delivered home-based lifestyle program, tailored by an accredited exercise physiologist (AEP), while the control group was prescribed general exercise and nutrition information via email. The methods and main findings from this trial have been previously reported [17]. All DVA group participants were invited and provided consent to participate in a qualitative interview after completion of the RCT. This qualitative analysis focused on implementation outcomes from the perspectives of 10 randomly selected DVA

group participants who completed semi-structured interviews. Interviews were recorded, transcribed, and guided by implementation frameworks [20,22] to investigate key implementation themes of adoption, costs, appropriateness, acceptability, fidelity, feasibility, and sustainability. Qualitative descriptive methods and thematic analysis [23,24] were employed to explore end-user perspectives on the DVA-delivered lifestyle program and its implementation [17]. This formative research engaged end-users in implementation planning, a strategy proven to enhance program uptake in real-world settings [25]. The study was reported in accordance with the Standards for Reporting Qualitative Research (SRQR) [26]. The study was approved by the Deakin University Human Research Ethics Committee (HREC 2021-009), registered with the Australian New Zealand Clinical Trials Registry (ANZCTR) (Registration No. 12621000307808), and written informed consent was obtained from all participants.

### 2.2. Participants and Recruitment

To be eligible for the RCT, participants were required to be aged 50–75 years, treated with oral hypoglycaemic agent for T2DM, have a self-reported body mass index (BMI) $\geq 30\ kg/m^2$, English-speaking, residing anywhere in Australia, sedentary ($\geq$9 h/day self-reported sitting), able to walk across a room unaided, and have access to a smart mobile phone capable of making and receiving phone calls on an Australian network and home Wi-Fi network. The elements relating to participants' eligibility and recruitment methods have been reported in further detail in our previous RCT [17].

Ten DVA group participants identified through purposive sampling from the DVA arm of the RCT (n = 25) were invited via email to participate in this qualitative study. Invitations were issued in waves with follow-up reminders until ten interviews were completed and thematic adequacy was achieved (Figure 1). All ten participants consented to complete one-on-one semi-structured interviews with PJ. The number of interviews aligns with our previous research findings on sampling sufficiency [27,28].

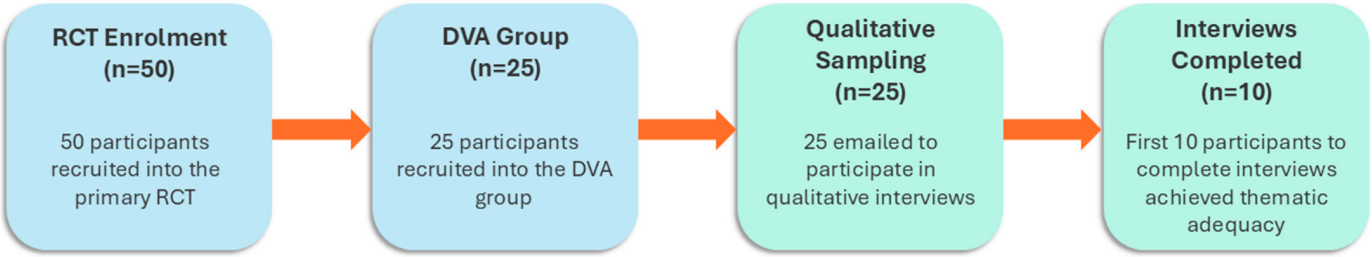



**Figure 1.** Participant recruitment and flow.

### 2.3. Intervention

Participants completed a 12-week, home-based exercise intervention prescribed by an AEP and delivered by Amazon Alexa Echo Show 8 devices. The AEP uploaded personalised content through the Buddy Link portal [29] throughout the 12-week program, which participants accessed via the pre-installed Alexa skill application (Teletrainer) [30]. Both Buddy Link (Version 1.0) and Teletrainer (Version 2.0) were developed and supported by Great Australian Pty Ltd. (Keysborough, Victoria, Australia) We developed a novel automated algorithm embedded within the Buddy Link software, which acts as a "decision-to-exercise tree" based on ESSA guidelines, ensuring participant safety during unsupervised home-based exercise [17,18]. Alexa required participants to report their BGLs prior to and after completing exercise sessions, and the "decision-to-exercise tree" then delivered the personalised exercise program only if the participant was within the recommended BGLs.

The AEP prescribed a personalised, weekly exercise program to DVA group participants. Exercises were selected by the AEP and individually broadcast to participants via Alexa at specified times throughout the day, using audiovisual demonstrations/instructions based on ESSA guidelines [18]. Participants performed 3 sets of 5 repetitions of 5 upper and 5 lower limb exercises at moderate intensity (4–6 on the 10-point rating of perceived exertion (RPE) scale) [31]. Sessions were 20–30 min in duration, and participants were encouraged to progress the load of the exercises while maintaining intensity. Following each exercise, Alexa broadcasted questions to determine whether the exercise was completed, the participant's RPE, and any adverse events. Voice responses were saved to the Buddy Link database, allowing the AEP to review the program weekly.

An accredited practising dietitian (APD) prescribed a healthy eating program to the DVA group via Buddy Link. This program was aimed at increasing whole grain, vegetable, and fruit daily intakes in line with the Australian Dietary Guidelines [32]. The exercise and healthy eating programs have been explained in further detail in our previous report on this RCT [17].

### 2.4. Frameworks

We adapted the Practical Planning for Implementation and Scale-up (PRACTIS) guide, which outlines four steps for successful implementation of physical activity interventions: defining implementation parameters (T2DM populations, delivery modalities); engaging end-users for program perspectives; identifying barriers (digital literacy, BGL management, tech issues) and facilitators (remote access, conversational interactions, natural language models); and addressing implementation barriers [20].

We incorporated a modified version of Proctor's implementation outcome taxonomy, utilising 8 of the 9 components (excluding the outcome 'penetration') to conceptualise distinct outcomes critical for understanding how interventions are adopted and sustained in real-world settings [22]. We selected this framework over determinant frameworks such as the Consolidated Framework for Implementation Research (CFIR) [33] or RE-AIM [34] due to its specific focus on measurable outcomes rather than implementation processes or determinants. While CFIR and RE-AIM offer robust constructs for examining contextual factors and public health impacts, respectively, they were less aligned with our exploratory, end-user focused study design. Proctor's taxonomy provided a more suitable structure for examining how users perceived and engaged with DVA devices across key implementation outcomes, allowing us to systematically assess adoption barriers and facilitators from the user perspective. Data collection and thematic analysis were guided by Proctor's taxonomy through predefined implementation outcomes: adoption, costs, appropriateness, acceptability, feasibility, fidelity, and sustainability. For this study adoption was characterised as the intention or initial decision to commit to participating in the intervention and utilise DVA devices; costs as the financial impact associated with the purchase and upkeep of DVA devices; appropriateness as the relevance or compatibility of social media as a method to reach older adults with T2DM and the suitability of conversation-based models as a means of communication, and method of delivery for lifestyle interventions; feasibility as the degree to whether DVAs could be utilised for the delivery of lifestyle interventions and T2DM management; fidelity as the extent of completion of lifestyle interventions by participants, and completion of the program through self-reported adherence via voice responses; sustainability as the degree to which DVAs could be used to adhere to lifestyle programs throughout the study and if possible, ongoingly in the future.

### 2.5. Data Collection and Analysis

Data collection involved 15–20 min semi-structured interviews administered through videoconferencing via Zoom (Zoom Video Communications Inc., 2016, San Jose, CA, USA) by PJ, who has extensive experience in conducting qualitative interviews. Interviews were developed by PJ by mapping study aspects to phases and outcomes outlined in PRACTIS [20] and Proctor's [22] guides to elicit end-users' perspectives on implementation outcomes and consisted of 11 open-ended questions and 20 prompts (Appendix A). PJ asked further questions/prompted participants where necessary to clarify or obtain further information. All interviews were recorded using a digital voice recorder and then transcribed verbatim by a transcription service (TranscribeMe Inc., San Francisco, CA, USA) [35], after which data were deidentified. Observations made by PJ during and after the interviews were documented in field notes, and no repeat interviews were carried out. Data were imported into NVivo version 14 (QSR International Pty Ltd., Doncaster, Victoria, Australia) software for management and analysis. Interviews explored end-user perspectives on design, engagement, and satisfaction with the DVAs.

A reflexive thematic analysis following the phases outlined by Braun and Clarke [23,24] was performed by CG. NVivo was utilised for coding, charting, and mapping the data. The analysis followed a six-stage process. Phase 1 was familiarisation, consisting of assessing the data through repeated revision of interview transcripts and an amalgamation of notes for each transcript. Phase 2 involved a combination of deductive and inductive coding. Initially, coding was done deductively, enforced by and within the PRACTIS guide and the analogy criterion based on Proctor's taxonomy, and data that was not deemed inclusive was then inductively coded (e.g., digital engagement, conversation-based interactions, etc.). Phase 3 consisted of searching for and establishing themes in addition to congregating sub-themes under the implementation outcomes (e.g., adoption, costs, feasibility, etc.). Phases 4 and 5 involved indexing and reviewing the data and establishing themes, and then clearly defining and naming them. Two authors (PJ) and (CG) compared content and themes, with any disagreement resolved by consensus moderation. Phase 6 consisted of writing up the results and anonymising and allocating written participant quotes to highlight themes (Supplementary Table S1). The research team discussed and refined the final themes in the context of the research questions. No form of member checking was utilised in the interest of time and to reduce participant burden.

### 2.6. Researcher Reflexivity

PJ is an AEP and research fellow conducting research in the field of digital health and physical activity, with an interest in developing digitally delivered lifestyle interventions to improve health and quality of life in older adults with comorbidities. PJ was involved in the design, development, and data collection for the DVA-delivered lifestyle program. PJ completed data collection and conducted the qualitative semi-structured interviews for the current study. We acknowledged that there is the potential for social desirability bias, given that the interviewer was also involved in the design and development of the intervention. However, during interviews, PJ emphasised that participants should give their own and unbiased perspectives regarding the implementation of the program.

C.G. is a Ph.D. candidate supervised by D.S., R.M.D., E.S.G., and P.J., who has undertaken data analysis and is the primary author of this manuscript. C.G. has extensive experience in qualitative data analysis and has conducted research in the field of digital health, physical activity, obesity, and T2DM.

The remaining co-authors were not directly involved with the data collection and analysis, although several were involved in the study design, and all participated in manuscript revision.

## 3. Results

### 3.1. Baseline Demographics

Baseline demographics for the 10 (50% female) DVA group participants are presented in Table 1. The mean age of participants was 67 years (SD 4; range 50 to 75 years), and all participants were obese (BMI > 30) and had at least one chronic health condition in addition to T2DM. Half (50%) of participants were educated at a university level or higher, and 40% were currently employed or self-employed full-time.

**Table 1.** Baseline demographics of interviewees in the digital voice assistant (DVA) intervention group.

| | **DVA (n = 10)** |
|---|---|
| Age—mean (SD) | 67 (4) |
| Gender (female)—n (%) | 5 (50%) |
| Parents' country of birth—n (%) | |
| Australia | 0 (0%) |
| Other | 5 (50%) |
| Not Answered | 5 (50%) |
| Highest level of education—n (%) | |
| Secondary/high school | 1 (10%) |
| Technical or further educational institution | 4 (40%) |
| University or other higher educational institution | 5 (50%) |
| Current employment status—n (%) | |
| Employed/self-employed full-time | 4 (40%) |
| Employed/self-employed part-time | 2 (20%) |
| Unemployed | 0 (0%) |
| Retired | 3 (30%) |
| Home duties | 0 (0%) |
| Pension (including disability or sole pension) | 1 (10%) |
| Medical conditions—n (%) | |
| Coronary heart disease [a] | 2 (20%) |
| Hypertension | 6 (60%) |
| Hypercholesterolaemia | 2 (20%) |
| Asthma | 3 (30%) |
| Chronic bronchitis or emphysema | 1 (10%) |
| Osteoarthritis | 1 (10%) |
| Other major illness [b] | 4 (40%) |
| Reported chronic health conditions other than T2DM | 10 (100%) |

[a] Coronary heart disease included angina, stroke, peripheral vascular disease, and myocardial infarction. [b] Diverticulitis, epilepsy, hypothyroidism, peripheral neuropathy, polymyalgia rheumatica, and sleep apnea.

### 3.2. Qualitative Outcomes

Each interview took approximately 30 min. Following thematic analysis and coding, 14 sub-themes and seven themes were identified (Figure 2). The seven major themes were: Adoption, Costs, Appropriateness, Acceptability, Fidelity, Feasibility, and Sustainability. Furthermore, sub-themes coded inductively include improvements to health and research, traditional vs. non-traditional, willing to pay, unwilling to pay, communication, health care programs, challenges and recommendations, engagement, barriers to completion, facilitators to completion, deployability, suggestions and improvements, continuity, and usability.




**Figure 2.** Themes and sub-themes constructed from qualitative participant data.

#### 3.2.1. Theme 1: Adoption

End-users were interested in participating in the study to improve their health status and T2DM self-management, as well as assist in furthering research in the field.

> *'Health-wise, I felt that it would keep me interested in exercising, and if it could help with diabetes, I really was interested in trying to help myself, because left alone, it's easy just to fall back into old habits.'* (Participant 5; Age 71 years)

Participants trusted and valued recruitment methods involving healthcare professionals and community/lifestyle centres, deeming them appropriate for older adults. Some endorsed social media as a viable recruitment tool, provided privacy was ensured.

> *'(Recruitment) through a doctor, or general practitioner. . . (Because you can) speak to a doctor and get onto a program to help you, making you more aware of the foods, exercise (involved in the program).'* (Participant 47; Age 65 years)

> *'Whether it's Facebook or (other forms of social media). Getting permission from some of the Facebook groups would be a good one, like if you had a diabetes or a metabolic website. . .because you're not selling anything; you're actually doing something that'll help.'* (Participant 11; Age 64 years)

Participants gave some alternative options for recruitment, including healthcare institutions such as Diabetes Australia.

*'Diabetes Australia. . ., or the [National Disability Insurance Scheme (NDIS)] would be valued, perhaps sign up at doctors and the dietitian's nurse or even podiatrists because often with diabetes, you're going to podiatrists.'* (Participant 5; Age 71 years)

#### 3.2.2. Theme 2: Costs

A majority of participants expressed that they would pay for the device and program. Generally, participants agreed that they would be willing to pay for the DVA-delivered lifestyle program as a subscription-based service, through weekly or monthly instalments.

*'Yes, I would've paid for it. I think on a weekly basis, yes, I think if you paid—if you're a pensioner, I think about 15 a week.'* (Participant 5; Age 71 years)

*'Look, I would have paid maybe $50, $60 a month.'* (Participant 27; Age 63 years)

Some participants expressed reluctance to pay for the DVA-delivered lifestyle program, citing either financial constraints, a belief that healthcare should be free, or a lack of interest in investing in such technology.

*'No, I wouldn't (pay for the program). In the past I've always taken steps to try and mitigate any health problems by reaching out to my doctor and following his or her advice. And I got a feeling I had to do it. I shouldn't have to do anymore or spend any money.'* (Participant 34; Age 75 years)

#### 3.2.3. Theme 3: Appropriateness

Communicating with the DVA platform was seamless and acceptable for individuals who understood the technology. The incorporation of audiovisual modalities was valued, allowing for flexibility, increased uptake, and engagement. The portability of the DVA device was well regarded among end-users. The device was small enough to be moved but also incorporated an acceptable display size for older adults to both visualise without constraints and interact with.

*'(The DVA platform) visually and audio-wise, (is) excellent. To incorporate the two, I think it's very good. I think it's ideal. . . and it's pretty mobile. You can actually unplug it and put it somewhere suitable, for people to actually engage with it, so I think it's good. Size is a good size, so the 7-inch is more than good enough to see.'* (Participant 35; Age 67 years)

#### 3.2.4. Theme 4: Acceptability

In general, participants were overall satisfied with the DVA-delivered lifestyle program.

*'I was very satisfied. . . with the information that was being given. (The content delivered) was. . . reinforcing the ideas that I had in (my) mind of how to go about keeping my blood sugar down, and (completing) the exercises.'* (Participant 32; Age 66 years)

Participants valued conversation-based interactions as a way to engage with the DVA lifestyle program and enhance its delivery. Visual features improved feelings of involvement and connection to the program. These aspects allowed for the acceptance of the DVA-delivered lifestyle program among older adults and, thereafter, improved adherence to the intervention.

*'I'd say the conversations (with the DVA platform) were probably better than (the exercises, which were) the actual other part of the program, so it was good to hear and talk. . . rather than just sit back and listen. So, yes, I would say that would be a better way of delivering it too, from a conversational point of view.'* (Participant 16; Age 63 years)

Participants praised the comprehensive nature of the DVA-delivered lifestyle program, which included content around exercise advice. Some participants highlighted that the

exercise component was initially effective, but gradually became repetitive, leading to decreased engagement as the program progressed.

> *'As far as the exercise is concerned, I felt that it was great in the beginning, —but then it became very repetitive in its nature. . . I didn't engage as much because it was the same. . .'* (Participant 16; Age 63 years)

Some participants experienced technical difficulties while undergoing the DVA-delivered lifestyle program. However, these were generally resolved and did not pose a long-term issue.

> *'(The DVA platform) stopped and started, and froze a lot,—people my age find things like that rather annoying because we don't understand it.'* (Participant 47; Age 65 years)

#### 3.2.5. Theme 5: Fidelity

Most participants stated they completed all sessions of the DVA-delivered lifestyle program. Audiovisual analogues and conversation-based interactions allowed for improved adherence. Participants underscored the convenience and motivational benefits of the DVA-delivered lifestyle program for exercise reminders and integration into their daily routines.

> *'To tell you the truth, the reminders that used to come up (assisted me in completing the program). So, we set the reminders at 6:00 o'clock at night and that would prompt you to do it. I think that was a good thing and Alexa (the DVA platform) is great for that.'* (Participant 16; Age 63 years)

Conversely, barriers to adhering to and completing the DVA-delivered lifestyle program included unrelated illness and difficulties completing exercises.

> *'There were two times during this 12-week period when I fell ill. . .I think this week, I missed out a couple of days. . . I was on antibiotics and there was no motivation in me to get onto doing the exercises.'* (Participant 32; Age 66 years)

#### 3.2.6. Theme 6: Feasibility

Participants found the program to be feasible and realistic for older adults with obesity and T2DM. They emphasised that, provided individuals are in reasonable health and willing to commit to a DVA-delivered lifestyle program over a sustained period, they perceived that implementation within this population is feasible. One participant noted a potential limitation, indicating that the program might not be feasible due to a lack of education around the DVA devices.

> *'If you're in reasonable health, and you can manage the exercises, and as in my case you're retired or you're semi-retired. . . and you feel like you can make the commitment, I think it's generally doable.'* (Participant 48; Age 71 years)

Participants proposed several improvements to enhance the overall feasibility of the DVA-delivered lifestyle program, including reducing exercise monotony and tailoring the program to individual needs. Additionally, they recommended streamlining the system to improve usability.

> *'(Improving is) just a matter of whether their ability to do the exercises is there and if they're not getting bored of the exercise. If the exercises are less strenuous than they were expected to be, then they might get bored, so that has to be sorted out.'* (Participant 32; Age 66 years)

3.2.7. Theme 7: Sustainability

Participants reported that completing the program improved their motivation towards exercising and yielded positive results over the 12-week period. They generally highlighted that they will be continuing to use the DVA-delivered lifestyle program and identified various enablers that would sustain their usage. Moreover, they emphasised that the functionality and usability of the DVA-delivered lifestyle program, along with additional features such as reminders, may be crucial for sustained usage and longevity post-intervention.

> *'I'm definitely seeing results… besides doing the exercises that come up on the Alexa (the DVA platform), I try to do some crunches now that I've already started the exercises. (I) do a few more exercises of my own and I can see the benefits of it.'* (Participant 32; Age 66 years)

In contrast, a few participants identified extrinsic barriers to the continued use of the DVA-delivered lifestyle program. These barriers primarily involved comorbidities, which hindered both adherence to the program and sustained usage of the device.

> *'My peripheral neuropathy, and balance (affected me) … particularly at a couple of the stages during the process, I had a couple of dizzy spells, because of the extreme work I was doing… I tried, but some of the (exercises) where I was standing up, I couldn't balance. That's my physicality, that's not your program.'* (Participant 38; Age 69 years)

## 4. Discussion

This nested qualitative analysis revealed critical end-user perspectives on implementing a home-based lifestyle program for older adults with obesity and T2DM delivered and monitored by DVAs supporting conversation-based interactions. Consistent with previous literature, home-based DVA-delivered lifestyle interventions seem to be feasible for older adults [17,27,36–38]. Our findings indicate that end-users with T2DM and obesity perceive DVA-delivered lifestyle programs to be acceptable, appropriate, and sustainable, but barriers to implementation need to be addressed. Guided by the PRACTIS framework, we characterised DVA implementation parameters, engaged end-users, identified facilitators (conversation-based interactions, reminders), and highlighted barriers (exercise difficulties, technical issues). Additionally, we employed a modified version of Proctor's implementation outcome taxonomy to assess key implementation outcomes, enhancing future real-world implementation. The findings of this study could support the implementation of broader digital health interventions, which can be commercialised and introduced into larger-scale healthcare systems.

End-user adoption of a digitally delivered lifestyle intervention was primarily driven by potential health improvements and enhanced T2DM self-management. Participants favoured both traditional recruitment methods (in-person community outreach, healthcare professionals) and non-traditional approaches (social media), with traditional methods garnering higher trust among older adults. This aligns with previous findings that older adults prefer familiar face-to-face recruitment, perceiving it as more reliable [39,40]. However, our study identifies a shift in attitudes towards an expanding acceptance of digitally driven engagement modalities, provided privacy is ensured. While costs typically impact digital health adoption [41], contrary to existing literature [42–44], over half of our end-users expressed willingness to pay for a digital health program. This suggests that older adults with T2DM may value digital modalities for delivering healthcare and consider associated costs acceptable for potential health benefits, indicating a shift in attitudes towards digital healthcare in this demographic. It should be noted, however, that half of the participants were educated at a university level, and most were still employed either

full-time or part-time, suggesting they may represent a higher socioeconomic standing, and this could influence their attitudes to the acceptability of associated costs of digital health interventions. Furthermore, future trials should selectively target those with lower levels of education and at disadvantaged socioeconomic standings to determine the acceptability and cost-effectiveness of digital modalities. Although over half of the participants expressed willingness to pay for the DVA program, broader adoption requires widespread economic feasibility and cost-effectiveness. Previous studies investigating economic valuations of digital health interventions for chronic condition management have demonstrated the potential for cost reduction through reduced hospitalisations, improved self-management, and a decrease in reliance on primary healthcare services [45,46]. However, the cost-effectiveness and economic feasibility of DVA devices and interventions have not been explored. Future studies should examine whether DVA devices are cost-effective among older adults with T2DM, and thereby feasible for widespread commercialisation among this population.

The DVA-delivered lifestyle program was deemed appropriate by end-users, citing usability and acceptance. Audiovisual outputs enhanced flexibility, uptake, and engagement, providing a seamless user experience. These modes of delivery are not exclusive to DVA devices, given that multiple digital modalities have the ability to leverage audiovisual hardware to appeal to this population [47–49]. A recent meta-analysis on 26 articles delivering lifestyle interventions through digital health to older adults highlighted varying modalities leveraging audiovisual outputs, including mobile phone applications, websites, and DVAs [50]. Indeed, the inclusion of a range of modalities for accessing digital health interventions may increase accessibility and acceptability among older adults with obesity and T2DM.

End-users found the DVA-delivered lifestyle program both feasible and realistic for older adults with obesity and T2DM, aligning with prior studies showing increased fidelity and feasibility of such interventions [36,51–53]. Our previous 12-week trial with older adults (60–89 years) demonstrated high adherence (115%, 95% CI; 84–147%) to a DVA-delivered home-based lifestyle program [36]. High levels of fidelity and inherent feasibility of DVAs may be attributed to their ability to exhibit human-like attributes through conversation-based interactions. A recent study examined the role of social and anthropomorphic interactions among 16 older adults (mean $\pm$ SD; age 85 $\pm$ 5 years) over an 8-week period using DVAs [54]. Similar to the current study's findings, they reported that older adults attribute human-like qualities to DVAs by classifying the devices as anthropomorphic and engaging with them socially, increasing feasibility [54]. These social and anthropomorphic interactions would not be possible without DVAs' conversation-based interactions. Moreover, another qualitative study which delved into human–computer-based interaction and para-social relationship theories among 12 end-users of DVAs revealed both functional and hedonic benefits, such as social characteristics and perceived enjoyment influence the uptake of DVAs [55]. Similar to our study, conversation-based models elicited a sense of social presence and fostered a trustworthy relationship with end-users [55]. Engaging and communicating with participants is vital to maintaining adherence to digital health interventions and improving participant satisfaction with digital modalities. Our findings, supported by previous studies [56,57], confirm that the use of DVAs to deliver such interventions is feasible. Natural language models and conversation-based interactions can emulate trusted in-person communication [39,40] and may help overcome traditional barriers to digital health adoption among older adults. While conversation-based interactions have generally been exclusive to DVA systems to date, new generative AI platforms can enable web- and mobile-based applications to leverage this functionality to increase overall fidelity and usage of digital health systems among older adults [58].

While multiple studies [59–62] report high levels of DVA usability, device setup often poses challenges [63]. Most of our participants, however, did not report setup difficulties, suggesting a potential sample of technologically proficient users. They did encounter voice recognition and internet connectivity issues, supported by previous findings where inadequate bandwidth discouraged engagement and frustrated users in digital health interventions [36,51,52]. In addition to these technical barriers, perceptual factors may also impact the feasibility of DVA interventions. Privacy concerns among older adults utilising digital health modalities are a substantial barrier to uptake due to insufficient control and unauthorised access to personal information [41,64]. Additionally, limited familiarity with digital interfaces and difficulties in interpreting voice outputs may hinder engagement with DVA devices. Older adults who have a lack of foundational technological skills and have not regularly interacted with digital platforms may require extensive support to develop competence for the usage of DVA devices. Without ongoing and adequate training and support, these skill gaps can lead to frustration with devices, reduced engagement, and eventual attrition from digital health programs [65,66]. Despite these challenges and concerns, 70% of participants in the current study completed all prescribed exercise sessions over the 12-week period, indicating that technical issues did not significantly impact adherence. As long as privacy concerns are met and training and support are provided, DVA devices, even with inherent technical issues, can maintain high engagement and adherence levels among older adults with T2DM. Future digital programs should include structured onboarding procedures, such as digital literacy evaluations, guides for device and program initiation, and troubleshooting consultations to support technological readiness and widespread implementation.

While we observed generally positive perceptions of digital health in our study, it is important to contextualise these findings within the broader array of digital literacy levels among older adults. Digital literacy varies widely in this population [67] and may be a significant determinant of overall DVA engagement and usability. The current study reflected a more digitally literate cohort, as evidenced by a lack of technical and initiation difficulties, alongside high levels of engagement. However, this may not be generalised to the broader population of older adults with T2DM, many of whom may face substantial challenges in engaging with digital modalities [68]. Previous studies have highlighted that limited digital literacy can compromise the usability of digital health modalities, reduce user engagement and confidence, and increase rates of attrition [40,69]. A lack of digital literacy may significantly impede the implementation of DVA interventions, particularly among socioeconomically disadvantaged groups or individuals with limited exposure to digital modalities [70]. Therefore, DVA implementation strategies should prioritise tailored onboarding protocols, training modules, and upskilling of older adults to minimise the challenges of a lack of digital literacy and accommodate varying levels of technological proficiency.

Addressing both the barriers to and facilitators of digital health may allow for the implementation of large-scale digitally driven programs to improve chronic disease management in older adults. Figure 3 depicts considerations relevant to the implementation of such programs to translate digital health into healthcare practice based on the findings from this study.

This study was limited by a small sample size (n = 10), which reduced the generalisability of findings to the broader population of individuals with obesity and T2DM. However, this sample size (n = 10) was pre-specified based on established guidelines and practices in qualitative research [71,72]. Participant demographics reflected relatively high levels of education and employment, which may have skewed the results of the cohort, as these individuals may have been more familiar with digital modalities. Additionally,

the absence of data saturation may have restricted the depth of emergent themes in the qualitative analysis, making it unclear whether further interviews may have yielded additional insights. The intervention period was only 12 weeks in duration, further limiting the ability to draw conclusions regarding the long-term usage and adoption of the DVA devices. Future research should address this limitation by extending follow-up periods to at least 6–12 months to evaluate maintenance of use and behavioural change, given that engagement with digital lifestyle interventions often declines over time. Another limiting factor of this study was that the collection and analysis of the qualitative data were performed by study investigators actively involved in the trial, introducing potential for social desirability and intellectual biases, which may have influenced the participants to provide more favourable responses to satisfy the study investigators. Furthermore, interviewer bias is also possible, as the interviewer contributed to the trial design, which may have shaped both participants' responses and our interpretations of these responses and subsequent themes of implementation. There may also be a question of credibility and trustworthiness, as member checking was not implemented, and transcripts and codes were not verified by the participants. Additionally, selection bias may be present because participants who volunteered for the study might have harboured positive sentiments or prior familiarity with DVAs. Finally, the possibility of a Hawthorne effect cannot be excluded, whereby participants may have engaged more actively with the intervention and DVA devices due to the novelty and perceived attention associated with the research.

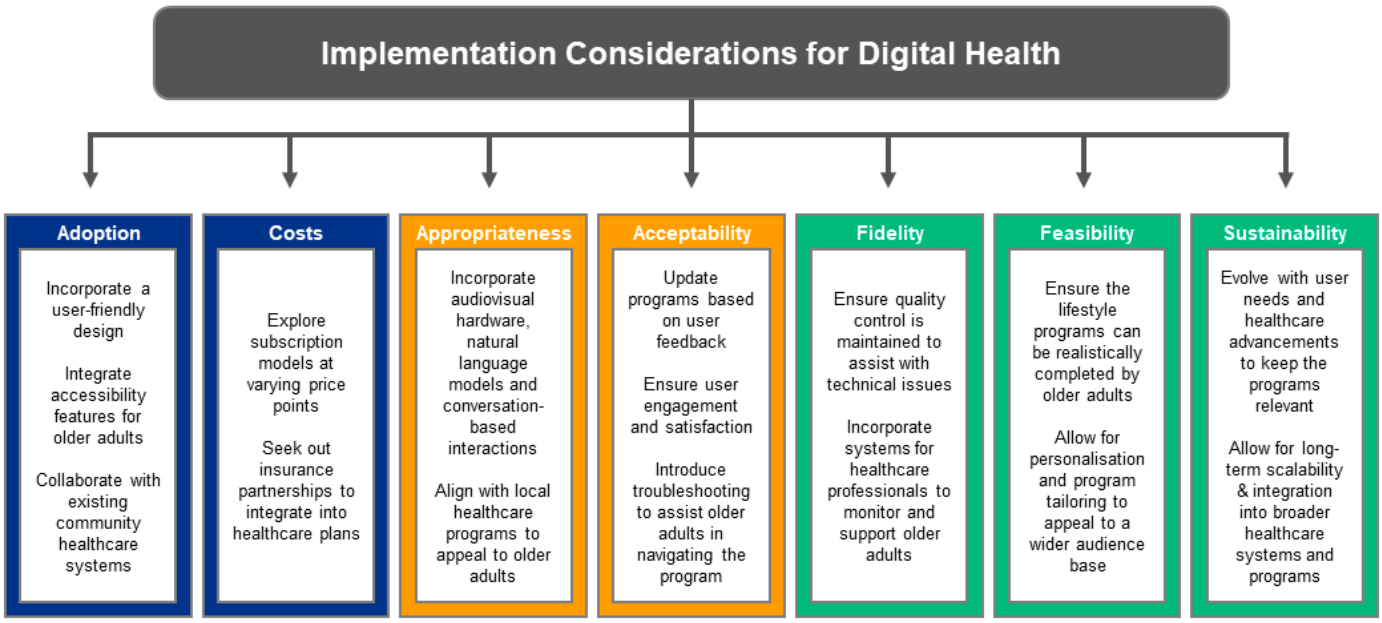



**Figure 3.** Considerations for the design and deployment of a commercialised digital health program for older adults with obesity and T2DM.

## 5. Conclusions

Overall, a DVA-delivered lifestyle program for the management of T2DM was accepted amongst this cohort of end-users. Key considerations for implementation include user-friendly interfaces to address digital literacy challenges, robust technological support, conversation-based models to mitigate visual/motor impairments, and tailored approaches for diverse older adult needs. The positive reception, adoption, and feasibility observed in the current study indicate the potential for integration into wider commercialised healthcare systems and may allow for long-term sustained usage amongst older adults with obesity and T2DM. Future research should explore the effectiveness of the implementation of

digitally delivered lifestyle programs, their real-world scale-up and commercialisation into healthcare settings through fully powered longitudinal type 2 hybrid implementation trials. Understanding implementation outcomes is imperative in quantifying the usability of these programs and how they can be effectively implemented for older adults with obesity and T2DM.

**Supplementary Materials:** The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/technologies13110511/s1. Table S1: Implementation themes with illustrative quotes.

**Author Contributions:** Study design by C.G., D.S., S.S., E.S.G., R.M.D., B.d.C., J.M., P.J. and C.G. drafted the manuscript and conducted the thematic analysis. C.G. and P.J. were responsible for reviewing, discussing, and interpreting the themes that were discovered by the analysis. D.S., S.S., E.S.G., R.M.D., E.G., B.d.C., J.M. and P.J. were responsible for the manuscript revision and preparation of this review. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki and approved by the Deakin University Human Research Ethics Committee (HREC 2021-009; 9 March 2021) of Deakin University.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data are available upon reasonable request to the authors.

**Conflicts of Interest:** Eugene Gvozdenko is a director (unpaid position) of Great Australian Pty. Ltd. Great Australian Pty Ltd. provided in-kind technical support for software and had a non-financial interest in the development of a voice-based virtual assistant software for telehealth. Great Australian had no input into the study design, analysis, or interpretation of results, or the decision to publish.

## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| AEP | Accredited Exercise Physiologist |
| APD | Accredited Practicing Dietitian |
| ANZCTR | Australian New Zealand Clinical Trials Registry |
| BGLs | Blood glucose levels |
| DVA | Digital voice assistant |
| ESSA | Exercise and Sport Science Australia |
| PRACTIS | Practical Planning for Implementation and Scale-up |
| RCT | Randomised controlled trial |
| RPE | Rating of perceived exertion |
| SRQR | Standards for Reporting Qualitative Research |
| T2DM | Type 2 diabetes mellitus |

## Appendix A. Interview Questions and Prompts

ADOPTION (The intention, initial decision, or action to try or employ an innovation or evidence-based practice)

1. What made you decide to take part in this project?

2. What do you think is the best way to reach older adults with T2DM to engage in lifestyle programs delivered by an Alexa?
    a. Outside of the research study, how would you have liked to be made aware of the study?
    b. What do you think makes it harder/easier to reach older adults with T2DM to engage in an exercise and dietary program delivered by an Alexa?

COSTS (The cost impact of an implementation effort)

3. For the purposes of this research study, this project is free to use. Had you not been part of this study, is this something you would have paid for if it was offered to you?
    a. **If yes**: how much would you be willing to pay?
    b. **If no**: can you describe the reasons why?

APPROPRIATENESS (The perceived fit, relevance, or compatibility of the innovation or evidence-based practice for a given practice setting)

4. As this is a research study, you may have been aware of this project via an email based on engagement with a previous research study. In the future, we plan to offer the program (or recruit) via social media.
5. How appropriate is this as a way to reach potential participants?
    a. Are there any advantages/disadvantages in using this recruitment method?
    b. What would be a more/another appropriate way?

ACCEPTABILITY (The perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory)

6. In general, how satisfied were you with this project?
    a. For example, in terms of the format of the material and content, usability of the Alexa device, conversational based interactions?
    b. Which aspects did you like the most/least? Can you explain why?
    c. In what ways could the Alexa delivery be improved?

FIDELITY (The degree to which an intervention was implemented as it was prescribed in the original protocol or as it was intended by the program developers)

7. Were you able to complete all exercise and dietary sessions?
    a. **If yes,** what helped you achieve this?
    b. **If no**, what prevented you from doing that?

FEASIBILITY (The extent to which a new treatment, or an innovation, can be successfully used or carried out within a given agency or setting)

8. How realistic is it to expect older adults in general to complete all components of the dietary and exercise program delivered by an Alexa?
    a. Why is that?
    b. How might this be improved/made easier?

APPROPRIATENESS (The perceived fit, relevance, or compatibility of the innovation or evidence-based practice for a given practice setting)

9. In terms of your experiences receiving lifestyle information in a conversational based format, how appropriate was this as a way to support older adults and communicate relevant exercise and dietary information?
    a. **Was appropriate**: what makes this an appropriate way of communicating and reaching older adults?
    b. **Not appropriate**: what makes you say this?

c. **Not appropriate**: what do you think is a better way to communicate this information and reach older adults?
d. Are there any advantages/disadvantages to this project being available or delivered using a conversational based format?

SUSTAINABILITY (The extent to which a newly implemented treatment is maintained or institutionalized within a service setting's ongoing, stable operations.

10. Did you use the Alexa device to adhere to your lifestyle program for the full 12 weeks?
    a. **If yes**, what enabled or encouraged you to maintain usage for this length of time?
    b. **If no**, what prevented or discouraged you from continuing to use it?
11. Do you think you'll continue to use the Alexa device to adhere to your lifestyle program (i.e., beyond the 12 weeks)?
    a. Is there anything we can change to help support older adults to continue using the device?

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