



User-centered development of a digitally-delivered dietary intervention for adults with type 2 diabetes: The T2Diet study

Jedha Dening^{*}, Elena S. George, Kylie Ball, Sheikh Mohammed Shariful Islam

Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences, Deakin University, Locked Bag 20000, Geelong, Victoria 3220, Australia

ARTICLE INFO

Keywords:

Type 2 diabetes
Diet
User-centered design
Digital intervention
Web-based
Patient engagement

ABSTRACT

Background: Web-based interventions can help address challenges of accessibility and availability of dietary support for people with type 2 diabetes (T2D). However, concerns regarding adherence and engagement in web-based interventions have been noted. Implementing a user-centered approach to intervention development has been shown to encourage better participant engagement. The overarching aim of this paper was to describe the user-centered approach used in the T2Diet Study to develop a new web-based dietary intervention for adults with T2D, exploring strategies for enhancing adherence and engagement.

Methods: Intervention development was based on a flexible iterative user-centered approach to enable new product development. Twenty-one adults with T2D were engaged in six guided discussion groups across four iterative development phases, alongside reference to evidence and theory throughout the process. The phases of user inquiry progressed from broad discussion on areas to support dietary needs; to design feedback on aspects of site layout; through to further feedback on aesthetics and functionality; then into a two-week field test followed by final user inquiry and participation in user experience polls. A hybrid approach of thematic data analysis was used, incorporating both a data-driven inductive approach and a deductive approach based on a priori identification of themes.

Results: Group discussion across the four phases highlighted factors the participants considered may motivate them to adhere and engage, which predominantly included relevance of resources, clear and simple positive communication, and flexibility for personal tailoring. Participant feedback provided an actionable list of intervention developments and input to inform intervention structure and theoretical framework. The two-week field test highlighted factors participants valued in terms of the user experience, most notably usability and accessibility. Additionally, the field test indicated a positive user experience, with no significant usability issues identified.

Conclusion: This paper provided the first detailed report of a user-centered approach to iterative development in the context of a web-based T2D dietary intervention. The insights will be useful to inform future digitally-delivered dietary interventions for adults with T2D or to inform a similar user-centered approach for other chronic health conditions.

1. Background

Type 2 diabetes (T2D) is a health condition affecting approximately 417 million globally in 2019, with a trajectory to rise to 630 million by 2045 [1]. T2D affects the body's ability to regulate blood glucose levels [2]. Treatment recommendations frequently include a combination of diet, physical activity, and medication if necessary [2]. Dietary modification has been shown to be effective for improving blood glucose control, and can be as effective as commonly available glucose-control

medications [3]. However, due to barriers such as cost, accessibility, and availability of healthcare professionals and programs, there are significant challenges in reaching enough people with T2D with the dietary education and support they may need [2]. Web-based interventions show promise in bridging this gap, providing a flexible alternative to support people with T2D to improve dietary behavior and clinical outcomes [4]. However, systematic reviews of web-based interventions in people with T2D have identified that website usage decreases over time [5,6], which raises concerns about ongoing participant engagement.

^{*} Corresponding author at: Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences, Deakin University, Locked Bag 20000, Geelong, Victoria 3220, Australia.

E-mail address: deningje@deakin.edu.au (J. Dening).

<https://doi.org/10.1016/j.invent.2022.100505>

Received 1 November 2021; Received in revised form 1 February 2022; Accepted 9 February 2022

Available online 12 February 2022

2214-7829/© 2022 The Authors.

Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Abbreviations	
T2D	type 2 diabetes

Qualitative studies in people with T2D in eHealth interventions have identified that ‘losing motivation’ was a critical factor associated with low participation [7], and a key barrier to program usage [8,9]. Losing motivation was caused by discouraging experiences with website aesthetics, navigation and technical difficulties, link errors, website functionality, user-friendliness, communication style, and content relevance [7,9–11]. These issues are related to the user experience, which can be addressed by capturing user feedback and manipulating intervention characteristics, aesthetics, and design [10,12]. A user-centered approach allows researchers and developers to understand the needs and preferences of the people the intervention aims to serve [13]. This approach focuses on engaging end-users in an iterative outcome-focused process, with a shared goal of solving problems, overcoming barriers, and finding solutions [14]. Furthermore, taking a user-centered approach is known to increase the effectiveness of diabetes-related platforms [15], predict higher usage and better adherence [16,17], and lead to improved clinical outcomes in people with T2D [5].

In a previously published systematic review [4], a web-based T2D dietary intervention was defined as an intervention that included dietary components and an assessment of dietary outcomes, as opposed to comprehensive T2D self-management, which can include components related to physical activity, diet, medication, or other factors. To the best of our knowledge, a user-centered approach has been previously used in only one web-based T2D dietary intervention [18]. However, that study lacked detailed reporting of the process and outcomes of the user-centered approach undertaken [4]. Lack of reporting has also been identified in digital T2D comprehensive self-management interventions [19]. The overarching aim of this paper was to describe the iterative user-centered approach used in the T2Diet Study to develop a new web-based dietary intervention for adults with T2D, exploring strategies for enhancing adherence and engagement.

2. Methods

2.1. Study design

A user-centered qualitative descriptive design [20] was the methodological orientation applied in this study. A user-centered approach aims to understand the needs and preferences of users in an outcome-focused process [13,14]. Qualitative description is a design that entails comprehensive yet simple presentation of the facts derived from the perspectives and experiences of the people involved [20,21]. To enable the development of the new web-based dietary intervention, existing website resources previously developed through the nutrition business of one of the researchers (JD) were provided. These included resources such as evidence-based eating guidelines, information about T2D, recipes, food preparation tips, menu planning examples, and cooking demonstrations.

2.2. Participants and recruitment

Twenty-one adults with T2D participated across four phases of group discussion and iterative development (Fig. 1), between January and October 2020. The total sample size was estimated at 20–30, based upon the number of participants recruited in previous user-centered T2D studies [19,22,23]. A purposive criterion sampling strategy [24] was used to include adults (≥18 years) with T2D, access to a computer and the internet, an active email address, able to read and understand English, located in Australia, and able to provide informed consent. The exclusion criteria included people with type 1 diabetes, prediabetes, or gestational diabetes. Participants were recruited online using an available email list of adults with T2D (voluntary subscribers from one of the researcher’s websites); and using social media (Facebook and Twitter). Interested participants were referred to a webpage that provided a plain language statement and an online consent form. Immediately following, they were directed to another online form to complete a baseline/eligibility questionnaire. Eligible participants were invited by email to attend the group discussions. Groups of participants were recruited consecutively for each phase based on the eligible participants available prior to each phase commencement.

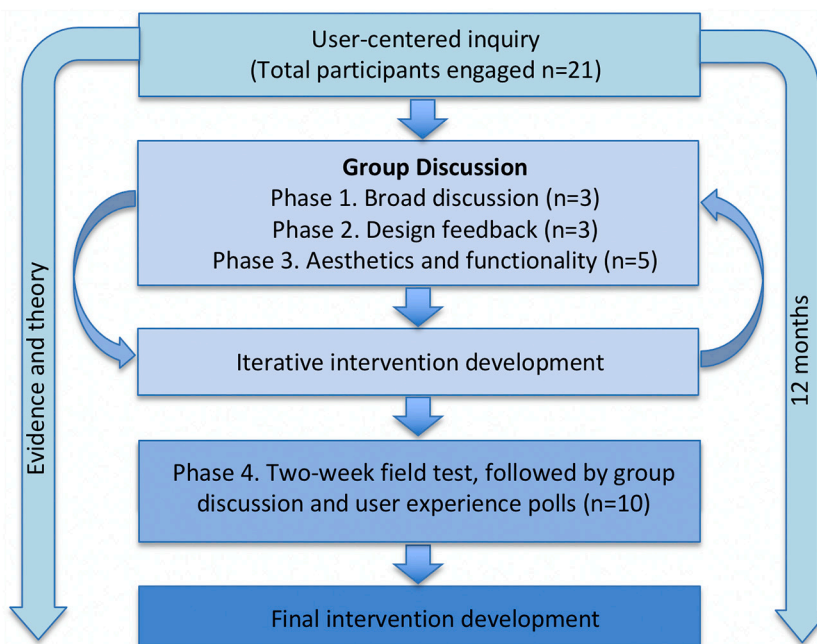


Fig. 1. Study flow diagram.

2.3. Data collection process

A user-centered process described in new product development was used [25,26], whereby each group discussion was kept variable and findings from each discussion, alongside evidence and theory, informed iterative development (Fig. 1). Participants were engaged in four phases of group discussion, which included: 1) broad discussion; 2) design feedback; 3) aesthetics and functionality; and 4) a two-week field test followed by final user inquiry and participation in user experience polls. Group discussions were guided by semi-structured topic guides and activities (Appendix 1), which were informed by the literature [7,8,10,19,22,27–31]. All groups were held online via Zoom web conferencing software. Each group discussion was conducted by the same experienced facilitator (JD) for approximately 60 minutes in duration. The group discussions were audio-recorded with permission, transcribed verbatim, edited for accuracy, and anonymized before data analysis commenced.

2.4. Phases of data collection

2.4.1. Phase 1 broad discussion

A group of participants ($n = 3$) were engaged in discussion about website features that would encourage usage, existing and potential resources, general setup and aesthetics, barriers and facilitators, and additional areas to support dietary needs.

2.4.2. Phase 2 design feedback

Iterations were presented to a new group of participants ($n = 3$). During the group discussion, participants pilot-tested various page layouts, navigation, aesthetics, where they compared and contrasted options, and talked about the advantages and disadvantages, likes and dislikes [25,28].

2.4.3. Phase 3 aesthetics and functionality

A new group of participants ($n = 5$) were engaged to respond to the applied iterations. Two days before the group discussion, participants were provided with login access to browse available resources at their leisure. During the group discussion, participants were asked to give feedback on initial impressions, navigation, look and layout, aspects that stood out as useful or unhelpful, and recommendations for improvement [25].

2.4.4. Phase 4 two-week field test, final user inquiry and user experience polls

A new group of participants ($n = 10$) were asked to engage in a two-week field test of the web-based intervention in a real-world setting [27]. Previous work identified that ten participants were required to identify up to 80% of usability problems [32]. Following the field test, participants were invited to attend one of three small groups for the final discussion phase. The Honeycomb Model [30,31] was used to engage participants in user experience polls and guide the group discussion. The Honeycomb Model is a frequently used tool in real-world contexts to inform development by understanding the users' experience across seven domains—valuable, usefulness, usable, desirable, accessible, findable, and credible [30,31]. Different forms of the model have been used previously in digital health interventions [33,34]. There is no one defined method for using the tool. The model allows for the development of study-specific questions to collect participant's responses for the seven domains (Appendix 1).

2.5. Data analysis

Data analysis was conducted manually by one member of the research team (JD), then discussed and confirmed by a second member of the research team (SMSI). A hybrid approach of thematic data analysis was used, incorporating both a data-driven inductive approach and

a deductive approach based on a priori identification of themes [35–37]. Derived from the literature [7,8,10], the deductive themes consisted of four broad parameters: 1) aesthetics and navigation; 2) functionality; 3) content relevance; and 4) communication and presentation. Following each group, the data were first coded into these themes to derive an actionable list of suggestions to apply to intervention development. Repetitive themes or singular comments about features related to these themes were considered equally important [35]. Secondly, this hybrid approach allowed the emergence of codes and themes directly from the data through inductive analysis [38], which was used to broaden understanding of the users' perspective, and identify strategies for enhancing adherence and engagement. Codes and themes were revised as necessary until a saturation point was reached where no further changes seemed necessary [37–39]. In addition, the poll data collected during the group discussions were rated on a scale from 0 (worst experience) to 8 (best experience), and summarized using a visual evaluation tool known as the User Experience Radar [40].

2.6. Research team

All forms of qualitative research position the researchers central to the data collection and analysis process [29]. Our multi-disciplinary research team provided a broad set of skills, beliefs and perspectives to the process of planning, implementation, and analysis of the research.

3. Results

Twenty-one participants engaged in six guided group discussions conducted over four phases of iterative inquiry and intervention development. Demographic characteristics for the overall sample are presented in Table 1.

3.1. Barriers and facilitators to adherence and engagement

In response to engagement with intervention resources across the four phases of inquiry, three predominant themes emerged, providing insight into factors that could facilitate or detract from adherence and engagement. These themes are described below.

3.1.1. Potential barriers to engagement

Regardless of whether participants were newly diagnosed with T2D or had T2D for a decade or more, participants expressed a desire to acquire more knowledge that could help them improve self-care. Participants frequently reported the barriers they experienced in terms of access to information. Being the internet is a widely used information resource, they shared that relevant information can be difficult to find.

"I find that when you do the search for a particular thing, quite often you just can't find the information because it comes up with everything else that's not relevant." P2, Group 3.

This issue was highlighted as particularly pertinent to those with newly diagnosed T2D who felt their "world was turned upside down and everything's gonna change." However, it was also noted as an ongoing frustration for those with longer-term T2D. Thus, participants indicated the value of having access to relevant web-based resources they could trust and access on-demand when they needed to.

"You're not relying on the internet and social media, word of mouth from well-meaning friends, all that sort of thing. It was something that I can put my trust in." P3, Group 4.1.

Another significant barrier described by participants was the way they felt information is frequently communicated to them. Participants mentioned repetitively throughout groups that they felt much of the information received was provided to them in a negative tone or not given to them in a way they can easily understand. Participants used a

Table 1
Demographic characteristics of participants.

Demographic category	Demographic details	n%
Gender	Female	77%
	Male	23%
	Other	0%
Age	Mean 60.7 years (range 41–75 years)	
	Duration of diabetes	
Duration of diabetes	<1 year	23%
	1–3 years	19.2%
	4–6 years	15.4%
	7–10 years	11.5%
	11–15 years	27%
	>15 years	3.9%
Relationship status	Married/living with a partner	69.2%
	Never married	15.4%
	Separated, divorced, widowed	11.5%
	Prefer not to answer	3.9%
Most recent self-reported hemoglobin A1c result	<6.0%	11.5%
	6.1–8.0%	42.4%
	>8.0%	11.5%
	Unknown/can't recall	34.6%
Current diabetes management	Diet only	11.5%
	Diet + diabetes medication	73%
	Diet + diabetes medication + insulin	15.5%
	Education level	
Education level	Master's degree or higher	15.4%
	Bachelor's degree	15.4%
	TAFE/university course below Bachelor's degree	15.4%
	National certificate, trade certificate	34.6%
	Completed high school	19.2%
	None	0%
Employment status	Employed full-time	46%
	Employed part-time	15.4%
	Not working	4%
	Retired	34.6%
	Prefer not to answer	0%
Level of comfort with computer/internet usage	Very uncomfortable	0%
	Somewhat uncomfortable	0%
	Neutral	7.7%
	Somewhat comfortable	26.9%
	Very comfortable	65.4%
Frequency of internet usage	More than once per day	80.8%
	Once per day	19.2%
	Once per week	0%
	Less than once per week	0%

variety of concrete terms to describe their experiences, including “being told,” “getting the lecture,” “waffle,” “blah, blah, blah,” “rubbish,” “mumbo jumbo,” “full of scientific terms,” “all the dribbly drab,” “wishy-washy,” “BS,” and “in double Dutchness.”

“Some of them just waffle, some of them are not laymen terms and, uh, they get too involved in the medical side of it, and they lose someone that's not, you know, a medical person. It's so involved you just, honestly, you need a degree, well, a medical degree to understand it all.” P5, Group 3.

There was an underlying desire to have information presented in simple terms they could understand. In addition, information that was short and to the point was seen as highly valuable. Otherwise, they indicated they most likely felt overwhelmed and would disengage very quickly.

3.1.2. Situational food environments as an influencer of adherence

The situations participants commonly find themselves in were described many times—workplaces, traveling, restaurants, cafes, fast food outlets, family, and social occasions. These are all situational food environments where they find adherence to healthy eating more challenging. Overall, participants communicated that resources to support better dietary choices and decisions in various contexts could support them to maintain consistency in their eating plan.

“To have ideas, like where you can eat, what you can eat when you go out, and what you shouldn't eat. I do a bit of traveling, so it's just sort of like, what do you get? And you just end up at McDonald's or somewhere. But having a couple of options that you know, like there's something here that can be one of those options, then you're gonna go for that and give it a go and eat better.” P1, Group 1.

3.1.3. Content relevance as an engagement enhancer

As noted above, content relevance was viewed as highly important and was the topic of much discussion throughout groups. When provided with relevant information, there was indication of enhanced engagement.

“It's just made me start looking, not just from the sugar content, the carb content in things as well. Before, I just looked at the sugar and if it was high or low, and I was just kind of buying stuff on that.” P4, Group 4.1.

The concept of convenience was highlighted, as participants frequently need to meet the challenge of maintaining a healthy eating plan amidst juggling life commitments, which often induce significant time burdens upon them. Thus, they emphasized a need for resources they could use practically. Recipes were continually viewed as a favorable resource, as participants noted that having new ideas could prevent falling into a “rut routine” or “get sick of the same old stuff.”

Discussion around personalization and preferences arose. Participants realized their eating preferences differed from one another. Thus, in general, they preferred to personalize their eating plan within the intervention guidelines rather than having everything planned explicitly for them. It also became apparent that perceived usefulness was anchored in providing enough flexibility in the guidelines to be realistic enough to be followed.

“I'd just like to say, um, I like the very opening where you say look, um, just keep an eye on the carbs but don't get sort of hung up on the details, you know, you can eat until you're full, things like that. Very often, you get very strict regimes, you know, where people really almost tell you off, and then go on to a very excessive sort of diet proposal, when I suppose, I switch off because, I think to myself well, that's a bit too abnormal.” P2, Group 4.1.

3.2. Intervention development

Participant feedback provided an actionable list of intervention developments (Appendix 2, Table 1). Content relevance was the predominant focus and included editing or adding new resources to support the users in various contexts. Modifications related to aesthetics and functionality included rearranging or renaming navigation labels, increased use of imagery, and reorganizing or cross-checking resources. Feedback obtained from participants about communication and presentation contributed to the theoretical framework that informed the creation of weekly structured behavior change modules. The theoretical framework consisted of three aspects: 1) self-efficacy theory [41]—a key determinant of self-management behavior in T2D [42–45]; 2) positive message framing—framing messages to emphasize benefits [46,47]; and 3) persuasive technology principles—such as dialogue support to prompt behavioral actions [12,48]. The weekly modules were presented with short videos, summaries, recipe suggestions, and action steps (Fig. 2). These formats were confirmed via the literature to address literacy levels and improve engagement and outcomes in T2D [10,46,49,50].


3.3. Feedback from the two-week field test and user experience polls

The results of the user experience polls are outlined in Fig. 3. The highest mean scores were seen for ‘usable’—signifying ease of use; and ‘accessible’—representing appropriate communication and suitable

Week 2 Modules

T2Diet guidelines recap
Benefits of fibre
Understanding T2D
Healthy blood sugar
Recipe suggestions
Action steps

Week 2: Benefits of Fibre (Video - 4:05 minutes)



Types of Fibre

The main types of fibre are:

- Soluble fibre: creates gel-like substances to slow and support digestion
- Insoluble fibre: forms bulk to help improve digestion and remove waste
- Resistant starch: feeds beneficial gut bacteria

All types of fibre are important and can be found in many nutrient dense plant foods including vegetables, fruits, beans and legumes, nuts and seeds.

Daily Fibre Recommendations

Women: at least 25 grams per day

Men: at least 30 grams per day

Do your best to include fibre-rich foods in your menu each day.

Fig. 2. Example presentation of the weekly structured behavior change modules.

delivery methods. In response to the two-week intervention field test, the group discussions highlighted factors of the user experience that participants considered important (Appendix 2, Table 2). Participants indicated they largely enjoyed their experience and benefited from engaging with the intervention. The self-reported benefits included improved food shopping and eating behavior, and increased motivation toward positive health behavior.

“My first shop, once I got my first emails, I went to the fruit and veggie area, which was really good. It just made me more aware.” P1, Group 4.2.

Participants confirmed that the presentation format of the weekly modules was suitable, which appeared to promote a positive user experience.

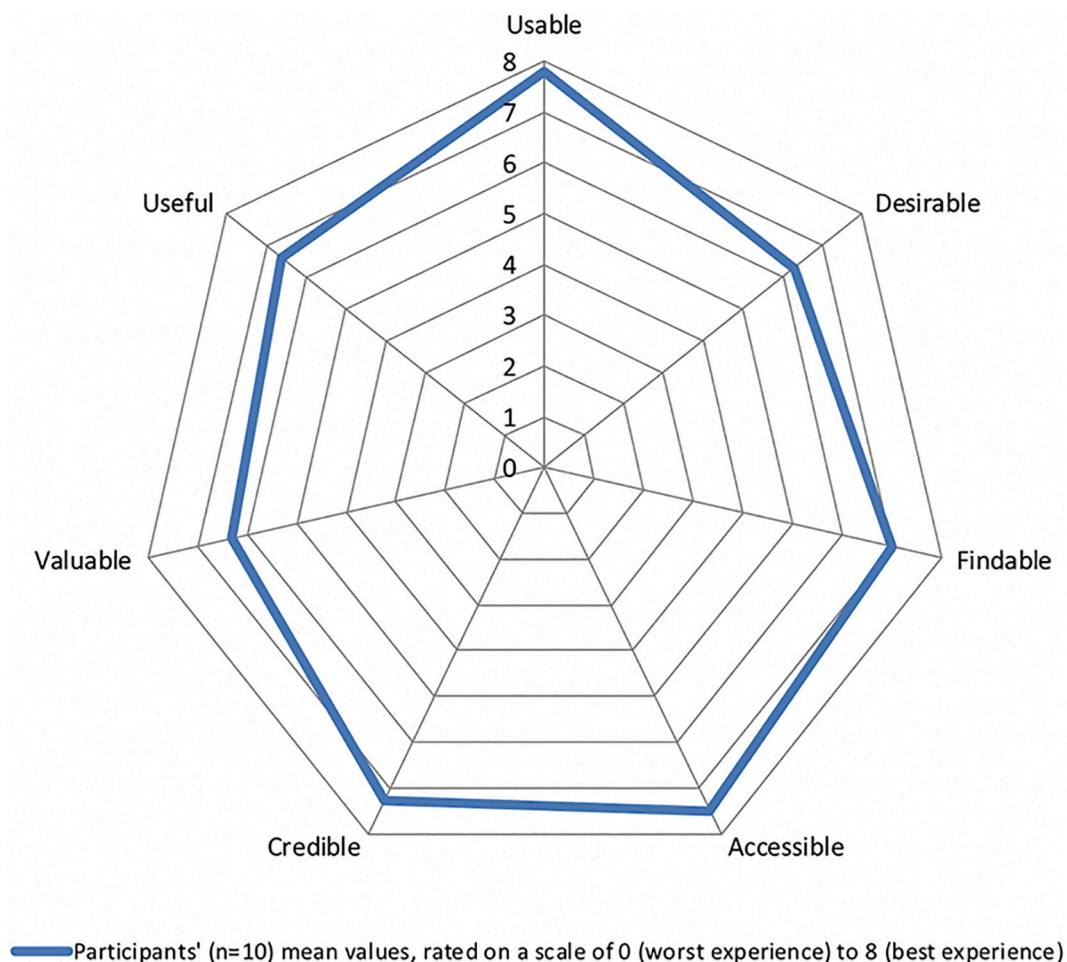


Fig. 3. The User Experience Radar [40] displaying results from the user experience polls.

“It was incredibly helpful the way it was so logically presented each week, you know to follow the, the tabs and what’s coming up.” P1, Group 4.1.

No significant usability issues were identified by participants in terms of navigation, technical difficulties, and link errors. Noted by one participant were minor errors in a few of the recipe instructions. Interestingly, they indicated these minor discrepancies had the potential to reduce their sense of credibility of an intervention. This indicated careful revision of all resources was required. In addition, email delivery was noted as problematic by one participant, as the notifications did not reach their inbox but went to the spam folder.

4. Discussion

The purpose of this paper was to describe the user-centered approach undertaken in the T2Diet Study to develop a new web-based dietary intervention for adults with T2D. To the best of our knowledge, this is the first paper to do so in the context of a web-based T2D dietary intervention. Intervention development involved four iterative phases, collecting primary data from users alongside reference to evidence and theory. This combination generated a variety of valuable outcomes: an actionable list of suggestions to apply to intervention development; feedback to guide the theoretical framework and structure for the intervention; multiple opportunities to evaluate iterations and incorporate user feedback; valuable insights into the user experience across the seven domains; and valuable observations that indicated the intervention is likely to be relevant and appealing to our target group.

Importantly, the results of our user inquiry met our objective of identifying factors that may facilitate better adherence and engagement in our target users. The main factors noted by participants included providing relevant information that is easy to understand and positively communicated, providing practical resources that can support them in various situational contexts, and flexibility in the guidelines to tailor to personal preferences. In addition, participants noted the value of having resources they could trust that were easy to access when required.

Similar to our approach, the web-based comprehensive T2D health interventions developed by Dack et al. [19] and Yu et al. [22] were evidence and theory-based, used small focus groups to capture rich data from users, and used an iterative development approach. Across the two studies, there were similarities to our findings in terms of potential barriers and facilitators of engagement. In particular, patient-centered positive communication style, access to information, and relevance of content were noted. International diabetes guidelines express the importance of patient-centered communication in any setting, along with facilitating access in terms of literacy [2,51]. In contrast to our approach, neither Dack et al. [19] or Yu et al.’s [22] previous interventions developed structured modules, which have been suggested to facilitate improved T2D self-management [2]. The results of the above-mentioned interventions varied. Dack and colleagues’ [19] intervention was effective for reducing the clinical outcome hemoglobin A1c but not diabetes distress. Yu and colleagues [22] found no effect on self-efficacy, diabetes distress, or clinical outcomes. Interestingly, Yu et al. [22] interviewed participants post-intervention, who noted a lack of practical resources. This highlights one of the most valuable insights from our user inquiry—that inclusion of practical context-based

resources may be one particularly effective strategy to facilitate greater adherence and engagement to web-based interventions—as practicality was frequently noted by our participants.

As suggested in Section 1 Background, only one previous study had implemented a user-centered approach in the context of web-based T2D dietary interventions [4]. The Malaysian Dietary Intervention for People with Type 2 Diabetes: An e-Approach (myDIDEA) [18,23] engaged a user-panel of T2D participants to pilot test the intervention website. After receiving feedback from users, the authors implemented changes to the intervention. This may have contributed to the low drop-out rate seen in the study intervention group, compared to higher drop-out rates in other web-based T2D dietary intervention groups [4]. However, the authors [23] failed to report how the user-centered approach influenced their intervention and how any changes or user feedback may have influenced study results. Understanding these factors is important to advance the field. The effect of employing a user-centered approach cannot be thoroughly evaluated until post-intervention. Therefore, reporting evaluations and reflections related to intervention outcomes will provide important insights for future researchers [52] and could generate useful reviews as the body of evidence in this space increases.

4.1. Strengths and limitations

Strengths of our approach included the involvement of users combined with an evidence- and theory-based approach throughout the iterative development process; and engagement of a heterogeneous sample of participants in terms of various ages, duration of diabetes, education, and employment status. Our user-centered inquiry was conducted online, which could be viewed as a strength in the sense that participants involved may have been more motivated to participate in this form of digitally-delivered intervention. However, it could also be a limitation as we may have missed capturing feedback from participants in the community who were less comfortable with computer/internet usage. While this study involved a larger proportion of females, males were involved across all phases of group discussion. Future research could look to acquire feedback from a more even split of genders. In addition, our sample may not be generalizable to the entire T2DM population. Future researchers could conduct a similar process independently in different samples, countries, or contexts. While there is no standardized method for implementing a user-centered approach [15], we did not include more complex usability testing methods such as participant observation or think-out-loud exercises, which frequently involve face-to-face engagement. However, based on previous literature we did have an adequate sample size, which was sufficient to identify potential usability problems [32]. Another limitation is the necessity, due to funding and pragmatic reasons, of restriction to a sample that already had internet access and were English-speaking, which may have missed particularly vulnerable participants (e.g., very low income, different cultural/ethnic groups). Future research should look to investigate and address the contexts of these users.

5. Conclusion

This paper described the iterative user-centered approach to develop a new web-based dietary intervention for adults with T2D. Primary feedback from users indicated key strategies to improve adherence and engagement in this target group were providing relevant trustworthy resources that were easy to access and positively communicated, practical resources to support users' across various contexts, and flexibility to tailor intervention guidelines to personal preferences. Insights derived will be helpful to other researchers and developers to inform future digitally-delivered dietary interventions for adults with T2D, or to inform a similar user-centered approach for other chronic health conditions.

Ethics

Ethics approval was obtained from Deakin University Human Ethics Advisory Group Health (#HEAG-H 166_2019).

Informed consent

All participants provided informed consent prior to participation in the study.

Data availability statement

Upon reasonable request, an ethically compliant, deidentified dataset may be made available subject to appropriate ethical approvals.

Funding

This work was supported by allocated annual PhD student funds from Deakin University Institute for Physical Activity and Nutrition. The funding body had no role in the study design, collection, analysis or interpretation.

CRediT authorship contribution statement

JD designed the study and wrote the manuscript. JD and SMSI collaborated on data analysis and interpretation. SMSI, ESG, KB made critical contributions to the study design and provided critical input and revisions to the manuscript. All authors approved the final manuscript.

Declaration of competing interest

JD is co-owner of Diabetes Meal Plans, a web-based nutrition support service for people with type 2 diabetes and prediabetes, who licensed the web-platform for this study.

Acknowledgements

The authors would like to thank all the participants for their time and involvement.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.invent.2022.100505>.

References

- 1 Saeedi, P., Petersohn, I., Salpea, P., et al., 2019. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the international diabetes federation diabetes atlas, 9(th) edition. *Diabetes Res. Clin. Pract.* 157, 107843 <https://doi.org/10.1016/j.diabres.2019.107843>.
- 2 American Diabetes Association, 2021. Standards of medical care in diabetes—2021. *Diabetes Care* 44, S1–S232. <https://doi.org/10.2337/dc21-in01>.
- 3 Evert, A.B., Dennison, M., Gardner, C.D., et al., 2019. Nutrition therapy for adults with diabetes or prediabetes: a consensus report. *Diabetes Care* 42 (5), 731–754. <https://doi.org/10.2337/dci19-0014>.
- 4 Denning, J., Islam, S.M.S., George, E., et al., 2020. Web-based interventions for dietary behavior in adults with type 2 diabetes: systematic review of randomized controlled trials. *J. Med. Internet Res.* 22 (8), e16437 <https://doi.org/10.2196/16437>.
- 5 Cottarez, A.P., Durant, N., Agne, A.A., et al., 2014. Internet interventions to support lifestyle modification for diabetes management: a systematic review of the evidence. *J. Diabetes Complicat.* 28 (2), 243–251. <https://doi.org/10.1016/j.jdiacomp.2013.07.003>.
- 6 Pal, K., Eastwood, S.V., Michie, S., et al., 2014. Computer-based interventions to improve self-management in adults with type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care* 37 (6), 1759–1766. <https://doi.org/10.2337/dc13-1386>.
- 7 Lie, S., Karlsen, B., Oord, E., et al., 2017. Dropout from an eHealth intervention for adults with type 2 diabetes: a qualitative study. *J. Med. Internet Res.* 19 (5), e187 <https://doi.org/10.2196/jmir.7479>.
- 8 Booth, A.O., Lowis, C., Dean, M., et al., 2012. Diet and physical activity in the self-management of type 2 diabetes: barriers and facilitators identified by patients and

- health professionals. *Prim. Health Care Res. Dev.* 14 (03), 293–306. <https://doi.org/10.1017/s1463423612000412>.
- 9 Park, S., Burford, S., Nolan, C., et al., 2016. The role of digital engagement in the self-management of Type 2 diabetes. *Health Commun.* 31 (12), 1557–1565. <https://doi.org/10.1080/10410236.2015.1089468>.
- 10 Pal, K., Dack, C., Ross, J., et al., 2018. Digital health interventions for adults with type 2 diabetes: qualitative study of patient perspectives on diabetes self-management education and support. *J. Med. Internet Res.* 2 (20), e40 <https://doi.org/10.2196/jmir.8439>.
- 11 Karekla, M., Kasinopoulos, O., Neto, D.D., et al., 2019. Best practices and recommendations for digital interventions to improve engagement and adherence in chronic illness sufferers. *Eur. Psychol.* 24 (1), 49–67. <https://doi.org/10.1027/1016-9040/a000349>.
- 12 Kelders, S.M., Kok, R.N., Ossebaard, H.C., et al., 2012. Persuasive system design does matter: a systematic review of adherence to web-based interventions. *J. Med. Internet Res.* 14 (6), e152 <https://doi.org/10.2196/jmir.2104>.
- 13 IDEO, 2015. *The Field Guide to Human-Centered Design*.
- 14 Slattery, P., Saeri, A.K., Bragge, P., 2020. Research co-design in health: a rapid overview of reviews. *Health Res. Policy Syst.* 18 (1), 17. <https://doi.org/10.1186/s12961-020-0528-9>.
- 15 LeRouge, C., Wickramasinghe, N., 2013. A review of user-centered design for diabetes-related consumer health informatics technologies. *J. Diabetes Sci. Technol.* 7 (4) <https://doi.org/10.1177/193229681300700429>.
- 16 Miller, C.K., 2019. Adaptive intervention designs to promote behavioral change in adults: what is the evidence? *Curr. Diab. Rep.* 19 (2), 7. <https://doi.org/10.1007/s11892-019-1127-4>.
- 17 Young, C., Campolongo, S., Ponsonby, S., et al., 2019. Supporting engagement, adherence, and behavior change in online dietary interventions. *J. Nutr. Educ. Behav.* 51 (6), 719–739. <https://doi.org/10.1016/j.jneb.2019.03.006>.
- 18 Ramadas, A., Chan, C.K.Y., Oldenburg, B., et al., 2018. Randomised-controlled trial of a web-based dietary intervention for patients with type 2 diabetes: changes in health cognitions and glycaemic control. *BMC Public Health* 18 (1), 716. <https://doi.org/10.1186/s12889-018-5640-1>.
- 19 Dack, C., Ross, J., Stevenson, F., et al., 2019. A digital self-management intervention for adults with type 2 diabetes: combining theory, data and participatory design to develop HeLP-diabetes. *Internet Interv.* <https://doi.org/10.1016/j.invent.2019.100241>.
- 20 Sandelowski, M., 2000. Whatever happened to qualitative description? *Res. Nurs. Health* 334–340. [https://doi.org/10.1002/1098-240x\(200008\)23](https://doi.org/10.1002/1098-240x(200008)23).
- 21 Bradshaw, C., Atkinson, S., Doody, O., 2017. Employing a qualitative description approach in health care research. *Glob. Qual. Nurs. Res.* 4, 1–8. [10.1177/2F2333393617742282](https://doi.org/10.1177/2F2333393617742282).
- 22 Yu, C.H., Parsons, J.A., Hall, S., et al., 2014. User-centered design of a web-based self-management site for individuals with type 2 diabetes - providing a sense of control and community. *BMC Med. Inform. Decis. Mak.* 14, 60. <https://doi.org/10.1186/1472-6947-14-60>.
- 23 Ramadas, A., Chan, C.K., Oldenburg, B., et al., 2015. A web-based dietary intervention for people with type 2 diabetes: development, implementation, and evaluation. *Int. J. Behav. Med.* 22 (3), 365–373. <https://doi.org/10.1007/s12529-014-9445-z>.
- 24 Suri, H., 2011. Purposeful sampling in qualitative research synthesis. *Qual. Res. J.* 11 (2), 63–75. <https://doi.org/10.3316/QRJ1102063>.
- 25 McDonagh-Philp, D., Bruseberg, A., 2000. Using focus groups to support new product development. *Inst. Eng. Designers J.* September.
- 26 Krueger, R.A., Casey, M.A., 2000. *Focus Groups: A Practical Guide for Applied Research*, 3rd ed. Sage Publications, United States of America.
- 27 Riiser, K., Londal, K., Ommundsen, Y., et al., 2013. Development and usability testing of an internet intervention to increase physical activity in overweight adolescents. *JMIR Res. Protoc.* 2 (1), e7 <https://doi.org/10.2196/resprot.2410>.
- 28 Krueger, R., 2002. *Designing and Conducting Focus Group Interviews*. University of Minnesota.
- 29 Merriam, S., Tisdell, E., 2016. *Qualitative Research: A Guide to Design and Implementation*, 4th ed. Jossey-Bass, John Wiley & Sons, Inc, San Francisco.
- 30 Morville, P., 2016. User experience honeycomb [cited 2019 Aug 29]; Available from: <https://interwined.org/user-experience-honeycomb/>.
- 31 University of Waterloo, 2021. User experience design for learning (UXDL) [cited 2021 April 28]; Available from: <https://cms.cel.uwaterloo.ca/honeycomb/index.aspx>.
- 32 Kushniruk, A.W., Patel, V.L., 2004. Cognitive and usability engineering methods for the evaluation of clinical information systems. *J. Biomed. Inform.* 37 (1), 56–76. <https://doi.org/10.1016/j.jbi.2004.01.003>.
- 33 Mansson, L., Wiklund, M., Ohberg, F., et al., 2020. Co-creation with older adults to improve user-experience of a smartphone self-test application to assess balance function. *Int. J. Environ. Res. Public Health* 17 (11). <https://doi.org/10.3390/ijerph17113768>.
- 34 Orr, M., Isaacs, J., Godbout, R., et al., 2019. A usability study of an internet-delivered behavioural intervention tailored for children with residual insomnia symptoms after obstructive sleep apnea treatment. *Internet Interv.* 18, 100265 <https://doi.org/10.1016/j.invent.2019.100265>.
- 35 Fereday, J., Muir-Cochrane, E., 2006. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Int J Qual Methods* 5, 1. <https://doi.org/10.1177/160940690600500107>.
- 36 Azungah, T., 2018. Qualitative research: deductive and inductive approaches to data analysis. *Qual. Res. J.* 18 (4), 383–400. <https://doi.org/10.1108/grj-d-18-00035>.
- 37 Braun, V., Clarke, V., 2019. To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qual. Res. Sport Exerc. Health* 13 (2), 201–216. <https://doi.org/10.1080/2159676x.2019.1704846>.
- 38 Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3 (2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>.
- 39 Green, J., Willis, K., Hughes, E., et al., 2007. Generating best evidence from qualitative research: the role of data analysis. *Aust. N. Z. J. Public Health* 31 (6), 545–550. <https://doi.org/10.1111/j.1753-6405.2007.00141.x>.
- 40 Kikin-Gil, E., 2010. The UX Radar: measuring the user experience [cited 2019 Aug 29]; Available from: <https://www.tilttool.com/?p=23>.
- 41 Bandura, A., 1997. *Self-efficacy: The exercise of control*, 9th ed. W.H Freeman and Company, New York.
- 42 Indelicato, L., Dauriz, M., Santi, L., et al., 2017. Psychological distress, self-efficacy and glycaemic control in type 2 diabetes. *Nutr. Metab. Cardiovasc. Dis.* 27 (4), 300–306. <https://doi.org/10.1016/j.numecd.2017.01.006>.
- 43 Brown, S.A., Garcia, A.A., Brown, A., et al., 2016. Biobehavioral determinants of glycaemic control in type 2 diabetes: a systematic review and meta-analysis. *Patient Educ. Couns.* 99 (10), 1558–1567. <https://doi.org/10.1016/j.pec.2016.03.020>.
- 44 Strychar, I., Elisha, B., Schmitz, N., 2012. Type 2 diabetes self-management: role of diet self-efficacy. *Can. J. Diabetes* 36 (6), 337–344. <https://doi.org/10.1016/j.cjcd.2012.10.005>.
- 45 Ouyang, C.M., Dwyer, J.T., Jacques, P.F., et al., 2015. Determinants of dietary self-care behaviours among taiwanese patients with type 2 diabetes. *Asia Pac. J. Clin. Nutr.* 24 (3), 430–437. <https://doi.org/10.6133/apjcn.2015.24.3.02>.
- 46 Paragas Jr., E.D., Barcelo, T.I., 2019. Effects of message-framed informational videos on diabetes management knowledge and self-efficacy. *Int. J. Nurs. Pract.* 25 (4), e12737 <https://doi.org/10.1111/ijn.12737>.
- 47 Gans, K.M., Risica, P.M., Dulin-Keita, A., et al., 2015. Innovative video tailoring for dietary change: final results of the good for you! Cluster randomized trial. *Int. J. Behav. Nutr. Phys. Act.* 12, 130. <https://doi.org/10.1186/s12966-015-0282-5>.
- 48 Oinas-Kukkonen, H., Harjuma, M., 2009. Persuasive systems design: key issues, process model, and system features. *Commun. Assoc. Inf. Syst.* 24. <https://doi.org/10.17705/1cais.02428>.
- 49 Abu Abed, M., Himmel, W., Vormfelde, S., et al., 2014. Video-assisted patient education to modify behavior: a systematic review. *Patient Educ. Couns.* 97 (1), 16–22. <https://doi.org/10.1016/j.pec.2014.06.015>.
- 50 Desroches, S., Lapointe, A., Ratté, S., et al., 2013. Interventions to enhance adherence to dietary advice for preventing and managing chronic diseases in adults. *Cochrane Database Syst. Rev.* <https://doi.org/10.1002/14651858.CD008722.pub2>.
- 51 The Royal Australian College of General Practitioners, 2020. *Management of Type 2 Diabetes: A Handbook for General Practice*.
- 52 Doherty, K., Doherty, G., 2019. Engagement in HCI. *ACM Comput. Surv.* 51 (5), 1–39. <https://doi.org/10.1145/3234149>.