LISTEN TO YOUR BODY:

Designing For Type 2 Diabetes Management

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Abstract

This study informed the design of several components of a digital application to support education and strategies for the management of type 2 diabetes. This tool allows individuals to track food intake, activities, and blood glucose readings, creating visual representations of the relationship among individual's actions, choices, and their body's response.

The study helped identify the needs of those with diabetes and their healthcare providers through expert interviews. Scenarios and Requirements were used to generate key components for a prototype digital application. A usability study was conducted with healthcare providers to evaluate content and design, with results informing recommendations for the next iteration to be tested with those living with diabetes.

This study revealed the value of designing for information need. Further studies could include user testing with individuals with type 2 diabetes to collect their perceptions and needs in the context of using a digital interface and self-care strategies.

Dedication

To my mother, Ann Snow, who encourages intellect, rational thinking, and quality of craft.

To my father, Jack Snow, who encouraged creativity, irrational thinking, and curiosity. A sign that says "do not enter" always conceals something worth seeing.

To my children Madeline and Thomas. May this thesis serve as a symbol to you both that no matter the circumstance of your life, you can do or be anything you strive for.

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Introduction

This study was inspired by the results of a 2012 report that revealed Canadians place a high level of significance on the Nutrition Facts label yet many could not easily understand the content or identify how the content relates to their health (The Strategic Council 2012, 6). Inability to understand food labels is especially problematic for those who have medical conditions that are heavily influenced by what they eat and specifically, those living with type 2 diabetes.

Individuals with type 2 diabetes make multiple decisions daily in relationship to their self-care strategies. If these decisions do not result in desired outcomes, such as consistent blood glucose levels (BGL), it can be easy for a person to stop trying, which can result in serious damage to kidneys, heart, eyes and nerves.

The goal of this study was to see how information design could support existing strategies and education provided by healthcare providers and assist Canadians living with type 2 diabetes in making more personally relevant choices in relationship to their type 2 diabetes management needs.

The need for a support tool for those with type 2 diabetes and their healthcare providers

Type 2 diabetes occurs when the pancreas can no longer produce enough insulin or when the body cannot use the insulin it produces (CDA 2013). This results in abnormally high levels of glucose in the bloodstream, referred to as hyperglycemia. Because the body is unable to effectively produce/use insulin, it is common for people with diabetes to use Medical Nutrient Therapy (MNT) to help attain and maintain appropriate blood glucose levels (BGL) to slow down or prevent the damaging consequences of hyperglycemia (Wilson et al. 2010, 280). Hyperglycemia can cause: kidney damage, transplants and/or dialysis treatments; heart disease, stroke and heart attack; eye disease, and blindness; and nerve damage and non-traumatic limb amputation (CDA 2011,1). MNT is the use of nutrition interventions (food choices, portion control) provided by a healthcare provider (primarily a registered dietitian), and has been proven to be very effective at meeting treatment goals with “its greatest impact at diagnosis of diabetes” (Wilson et al. 2010, 277).

Originally (prior to 1994 and MNT) nutrition recommendations focused on an “ideal” nutrient prescription that would apply to everyone with diabetes (Wilson et al., 2010, 277). Theoretical calculations of calories, carbohydrates, protein and fat comprised the details of a strict framework for diabetes management,which did not allow for adaptations needed to accommodate a client's circumstances or personal aspirations (Wilson et al., 2010, 277). MNT adopts a more realistic approach to nutrient prescription with a focus on goals an individual is willing and able to work with.

The key goal for MNT for people with type 2 diabetes is to maintain consistent BGLs (Wilson et al. 2010, 275) and, as research has shown, offers similar outcomes to diabetes medication (Wilson et al. 2010, 277). This therapy also includes ongoing education and counseling sessions to address awareness of carbohydrate counting, use of data from BGL monitoring, simplified and individualized meal planning, reduction in energy (calories) and fat intake (for those who would benefit from weight loss), and physical activity and behavioral change strategies (Wilson et al. 2010, 277-281)

The Canadian Diabetes Association (CDA) states that due to the complex nature of diabetes “individuals with diabetes have a right to timely, affordable and ongoing diabetes education and comprehensive treatment services provided with seamless coordination by a diabetes healthcare team and other specialists…” (CDA, Access to Health Services 2014). There is also a need for better and continuous education for healthcare providers (CDA, CDA's Position on Health Professionals 2014).

The CDA also recognizes individuals (herein referred to as "clients") with type 2 diabetes as a key member of the healthcare team, which suggests the need for client education too. However, access to education does not guarantee successful or sustainable diabetes management.

A systematic review examined interventions to improve diabetes care revealed the least-successful interventions were those offering short-term didactic education attempting to improve diabetes knowledge (Glazier et al. 2006, 1677). More successful interventions included culturally sensitive tailoring, one-on-one support, individualized assessments/reassessments, feedback from clients on their diabetes management progress, and frequent contact with healthcare providers over a long duration (Glazier et al. 2006, 1677).

Numerous studies also reveal the rote transfer of knowledge from healthcare provider to clients with type 2 diabetes does not provide enough information for diabetes management. A systematic review conducted by Health Quality Ontario revealed challenges to accessing knowledge including: the relationship between BGL, food and exercise, counting carbohydrates or calories, the connection between BGL and diet, difficulties in communication due to language issues, and low levels of health literacy (Health Quality Ontario 2013, 21). This report recommended health information be provided in a manner more applicable to a client's circumstance (Health Quality Ontario 2013, 26).

A Swedish study revealed misunderstandings were common among participants and while many of them followed instructions provided by healthcare providers, they did not understand why or how they benefited from practices such as BGL tracking, diet and eating habits (Holmstrom and Rosenqvist 2005, 150).

As stated in the introduction, one of the barriers in accessing information can be attributed to the format and representation of information. This is particularly concerning when it comes to Canadians who have been diagnosed with type 2 diabetes as the ability to accurately navigate a nutrition label can underpin success in managing their diet.

A US-based study focused specifically on people with diabetes and the use of the nutrition label revealed confusion with the terms sugar and carbohydrates and how these affect BGL. While the study highlighted that participants had a higher average label use (91%) than the general public (71%), questions were raised about how accurately they were using the label (Kessler and Wunderlich 1999, 553). According to the study, "food labels were checked most frequently (88%) for information about sugars. However, only 59% of label users indicated checking the total carbohydrates on food labels "often" or "sometimes" (Kessler and Wunderlich 1999, 553). This could indicate that some people with diabetes believe their BGLs are in relationship to the sugar in food and not to the total carbohydrates in their food, which, once consumed, are converted into glucose.

Thus the main form of information the general public can access on nutritional content of food in real-time can be challenging for many people to interpret. It is not enough for people to simply have access to nutritional information, but that the information needs to be provided in context to make it understandable and useful to improve their health outlook.

In summary, these studies indicate that individuals with type 2 diabetes have a greater opportunity for beneficial type 2 diabetes management through MNT, provided by healthcare professionals, with long-term and continuous support. In order to deal with known barriers: (1) misunderstandings of knowledge, procedures, and actions; (2) challenges to understanding and applying information and (3) lack of customization of content, a much more user-centric set of resources than is currently found in traditional diabetes education programming is required (Glazier et al. 2006, 1677).

While there are several diabetes specific digital applications[1] (digital apps) available they emulate traditional diabetes education programming resources (e.g. logging of information in a diary) and thus replicate the barriers summarized above. For example, many of the digital apps offer clients the ability to collect data such as the tracking of BGLs or food consumption but do not address issues of understanding or aid in the application of the information collected to individual circumstance. In instances where data is presented in relationship to an individual's goal (e.g. the BGL reading plotted onto a chart in relationship to a clients BGL goal) it is presented in a silo without relation to other tracked information. For example: *nexJ*[2], *Glucose Buddy*[3] and *My Fitness Pal*[4].

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1 A digital application (digital app) is a software program typically developed for mobile devices such as smart phones and tab lets. Examples include banking apps that allow you to pay bill or transfer funds on your cell phone or music apps that allow you purchase and play music.

2 *nexJ* is a digital app used by Health Coaches at the Black Creek Community Health Centre to support those with type 2 diabetes. Clients can track lifestyle factors such as mood, blood pressure, BGLs, food choices (though photos), exercise etc. This digital app also allows for a Health Coach to have remote contact with their clients.

3 *Glucose Buddy* is a digital app that focuses on logging and tracking of blood glucose, food, exercise and medication.

4 *My Fitness Pal* is a digital app that focuses on logging and tracking of food and exercise. Note: not diabetes-centric.

Given the complex nature of the aforementioned concerns and needs, this study set out to explore how information design in the form of a digital app could support existing strategies and education to assist Canadians living with type 2 diabetes in making more personally relevant choices in relationship to their individual type 2 diabetes management needs.

This study looked to methods from information design and interactive design to develop a tool to customize content specific to diabetes management that could lead to increased understanding and the potential to improve health outcomes.

Information design

Information design, as defined by the idX group[5] is, "the defining, planning, and shaping of the contents of a message and the environments in which it is presented, with the intention to satisfy the information needs of the intended recipients" (IIID 2007-08, 7). IDX's definition of information design is embodied in each phase of this study with the purpose of creating a holistic approach to diabetes management and the design of a support tool where information need and the form that presents that information work together to support the end user.

In the essay *I Strive To Understand What It Is Like Not To Understand,* Richard Saul Wurman highlights notions of understanding that are particularly salient to this study. First, understanding validates information: "We are what we understand. We remember what we are interested in. This is the definition of learning" (Wurman 2012, 40). This is an important matter of concern in terms of how to approach the representation of content so it is in service of individual needs and goals. Second, "understanding precedes action" (Wurman 2012, 41). In order for an individual to make behaviour change (a key aspect of diabetes management) she/he needs an understanding of why a behaviour needs to be changed and have an interest in or motivation to sustain a change. If information can be organized in a way that facilitates understanding, it is more likely to support those who are seeking to make change. This cannot happen in isolation and must occur in the context of a wider system.

While the intent of this study is to design a visual and interactive solution to support diabetes management, it is important to approach the design with a "much broader understanding of systems and system behaviour than we find in visual systems. Instead of thinking of systems only as things we make, we need to think of them as things that are affected by what we make. In other words, we need to consider design as an element or force that produces some kind of change within other systems" (Davis 2012).

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5 The idX group began in 2002 at the Infodesign ED 2002 conference at Reading University, GB. The goal of the group was the development of International Core Competencies and curriculum in Information Design. This is the definition the group agreed to as they developed these core competencies.

In order to prevent challenges in understanding and in an effort to support the information needs of individuals with type 2 diabetes, the planning and customization of user-centric content must be included within the development of the a digital app prototype.

Interactive design

Jakob Nielsen's *10 Usability Heuristics for User Interface Design* is comprised of ten general principles for interactive design when conducting heuristic evaluation (Nielsen 1995):

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

Of the ten principles, six were particularly salient to this study as they relate to ease-of-use and are based on the human interaction aspect of the interface design[6]:

1. Visibility of system status

Visibility of system status infers controls for functions should be clearly visible so it is easier for a person to know what to do next (Preece et al., 2011, 26), what options are available to them and where they are in the system (Benyon, Turner and Turner 2005, 65). Humans engage in the physical world where an action always has the consequence of a reaction. Thus, in order for an individual to know their actions are “working” a system must provide "feedback." Feedback (an indication that the system is responding to an action, for example, a progress bar that displays a numerical percentage of how far along a program is in loading a file) contributes to visibility in a system (Preece et al., 2011, 26) by helping an individual feel in control (Benyon et al., 2005, 65). Inclusion of this principle encourages a positive experience and promotes the sustainable use of a digital app.

2. Match between system and the real world

This principle encourages a more human-centered over a machine-centered approach to the interface (Nielsen 1995). Thus, it is important to intentionally use relevant wording, labels, and content to reinforce the diabetes management education provided by the healthcare provider that matches the understanding of the individual.

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6 The remaining four principles (shown in gray in the list on page 4: Error prevention; Flexibility and efficiency of use; Help users recognize, diagnose, and recover from errors; Help and documentation) would become more important in future iterations of the digital app.

3. User control and freedom

People often chose the wrong function or change their mind about an action they are in the middle of; to stop, redo or remove an action should be simple (Nielsen 1995). Given the many decisions an individual has to make daily to support their diabetes management user control and freedom is essential to efficient use of a digital app and positive user experience.

4. Consistency and standards

Consistency and standards lead to interfaces that are easier to learn and use (Benyon et al., 2005, 65) as similar treatments (e.g. same type size, colour, and feedback of a "Save" button across a digital app) are used for similar functions (Preece et al., 2011, 28). Using consistency and standards could lead to pattern recognition making the interface seem simple and memorable. This is important for a system that needs to support sustainable use by building confidence, and increasing understanding.

6. Recognition rather than recall

It is easier for a person to recognize something than it is to recall something (Benyon et al., 2005, 65). Thus, recognition rather than recall is used to guide the design of an interface and using easy to identify visual representations so that a user does not need to rely on the memorization of a series of abstract symbols in order to navigate an interface. This should also ensure the primary functions are easy to identify in terms of what the function is or does.

8. Aesthetic and minimalist design

Aesthetic and minimalist design supports a system that keeps the priority functions as the focal point (Nielsen 1995). Extraneous information can lead to confusion or slow down actions (Nielsen 1993, 121), both of which are undesirable in the context of any digital app, but especially given the circumstances of those with type 2 diabetes who already face challenges in understanding.

Methods

Expert interviews were used to inform the design of digital app components that were then evaluated with a usability study. This study is comprised of three phases:

1. Expert interviews
2. Prototype design
3. Usability study

Expert interviews

Semi-structured interviews

Semi-structured expert interviews were used to gather information about strategies, support, barriers, eating and lifestyle choices, tools currently in use (including nutrition fact labels), services (including technology), and programs from healthcare providers. This was done in order to document existing practices and approaches to diabetes management as well as to reveal information gaps and needs.

Interviewees were asked a series of questions (see Appendix A) but given the semi-structured approach to the interviews, questions were not necessarily asked in the same order and some responses led to different sub-questions that did not manifest in other interviews.

Interviews were audio recorded and transcribed by an outside transcriptionist and then double-checked for accuracy by the researcher.

Ethics

This study was reviewed and approved by the Office of Research Ethics at York University (see Appendix B). Expert interview participants were recruited via email (see Appendix C). They included a variety of healthcare professionals who work as part of a diabetes healthcare team. Purposive sampling was used to select participants. Healthcare providers who worked with individuals with type 2 diabetes were approached for two main reasons:

1. Health care providers are the primary source by which an individual learns how to manage their type 2 diabetes.
2. Health care providers could specify the challenges they face in order to discern if information design via a digital app could support them in treating the diverse range of individuals they work with.

Emails were sent to diabetes and endocrine clinics and to dietitians from the *Find a Dietitian* feature on the *Dietitians of Canada* website around the city of Toronto.

Before the interviews were conducted, each participant reviewed the contents of the consent form (*see Appendix D*) and were given an opportunity to ask questions before signing the consent form.

Data analysis

Collected data was systematically organized into relevant concepts based on coding procedures originating from grounded theory (Strauss and Corbin 1990). Open coding—specifically sentence-by-sentence coding—was used to distill the main concepts revealed in the interview process.

Concepts were identified and organized into categories, properties, and qualities related to diabetes management to help establish core components of the digital app.

The results from the data analysis of the expert interviews were used to generate "Requirements" to inform the components needed for the digital app prototype.

Requirements

A Requirement is a statement that specifies what a product should do or how it should perform (Preece et al., 2011). Requirements for this study were prioritized according to the MoSCoW rules. The MoSCoW rules act as a framework (*www.dsdm.org*) to define the most important requirements in order to produce usable and useful systems (Benyon et al., 2005, 214).

To help determine which requirements would be included in the prototype, each was prioritized using the MoSCoW rules:

Must have
Fundamental without which the system would be unworkable — the minimum usable subset.

Should have
Would be essential if more time were available, but the system would be still be usable and useful without them.

Could have
Lesser importance, could easily be left out of the current iteration.

Want to have but won't have this time around
Could wait until a later development.
(Benyon et al., 2005, 214)

In addition to prioritizing, each Requirement was further identified as functional or non-functional. Functional refers to something the system (the digital app) *must do* (Benyon et al.,2005, 211-212)—for example: record food items consumed with a date and time stamp. Non-functional is a *quality a system must have* (Benyon et al.,2005, 211-212)—for example, simplicity: adding food items needs to be simple and efficient.

Prototype design

In the prototype design phase the Requirements were used to guide the development of scenarios and conceptual diagram, and establish the wireframes that will serve as a blueprint for the high-fidelity prototype design.

Scenarios for wireframing

Scenarios are “stories about people undertaking activities in contexts using technologies” (Benyon et al, 2005, 192) and are used to help keep the focus of the design on the human-centered aspects of interactive design.

The scenarios were generated to reflect real-world activities that the digital app would be expected to support (Benyon et al, 2005, 192). The conceptual diagram (*see Figure 1, page 22)* provides an overview of the system emphasizing structure and organization of content (Benyon et al, 2005, 290) and maps how the user could move through the digital app. The wireframes, developed in tandem with the conceptual diagram, are a physical representation of the key components needed to accomplish a given task (Benyon et al, 2005, 602).

High-fidelity prototype

A high-fidelity prototype (*see pages 28-46*) is a software model that runs a set of key functions on a mobile device; it is similar to the look and the behaviour of what the final digital app is expected to be/do (Benyon et al, 2005, 254). High-fidelity prototypes allow for detailed evaluation of the core elements (the Requirements, *see pages 13-21*) of an interactive design and the interface (in relation to the six heuristic principles as described in the literature review). It also helps to evaluate how a user interacts with the components, the data interaction (user input, mathematical calculation and source data), and the over-all functionality.

Usability study

A usability study using a high-fidelity prototype was conducted to identify issues with content, functionality, and the interface design to improve capabilities of the digital app.

DECIDE framework

A DECIDE framework (*see Appendix E)* was used to design the usability protocol and to document the intent of the usability study. DECIDE is an acronym for the six elements used in planning and in designing the test (Preece, Rogers and Sharp 2002, 456). This framework was useful in helping:

Determine the purpose of the digital app.
Explore questions about the components of the digital app.
Choose the data collection/materials.
Identify practical issues that may surface during the course of the study.
Decisions made on ethical issues.
Evaluate/interpret/present data.

Questionnaire

This framework lead to the creation of a questionnaire that was administered to participants at the beginning of the usability study to establish their clinical roles, priorities in diabetes management, expertise in web/mobile use, and to reveal the current methods of data collection for diabetes management (*see Appendix F).*

Task-based scenarios

Task-based scenarios are a way of creating a possible series of events a client could encounter when using a digital app. When designing task-based scenarios, it is important to consider the context (e.g. home, work, recreation, etc.) and the scope of the client's activity (eating, exercising, resting, etc.) In this way, the researcher can test activities to be supported by the digital app in order to evaluate it's capabilities and make further improvements. A protocol script was then generated to organize the task-based scenarios and document clear guidelines on a talk-aloud protocol (participants vocalize her/his thoughts as they work through the tasks). Post-task questions (an opportunity for participants to provide additional feedback on the tasks/ prototype once the scenarios are completed) were asked to ensure consistency between participants during the usability study (*see Appendix G)*.

Ethics

Participants for the usability study were recruited via posters (*see Appendix H*) posted through the Black Creek Community Health Centre and sent to those who participated in the expert interview phase. Before the sessions began each participant reviewed the contents of the consent form (*see Appendix I*) and were given an opportunity for questions before signing the form.

Results

Expert interviews

Participants

Five participants were interviewed: two participants were interviewed face-to-face and three were interviewed over the phone. One participant withdrew when she/he learned she/he was not permitted to participate in interviews without consent from her employer. Recordings from this interviewee and documentation were securely deleted. This left four participants: one dietitian (Dietitian) from a diabetes clinic in Hamilton, Ontario; two health coaches (Health Coach 1, Health Coach 2) from a Community Health Centre in North York, Ontario; and one nurse practitioner (Nurse Practitioner) from a diabetes clinic in Toronto, Ontario.

While each interview had its own nuances, similar concepts emerged in relation to the needs faced by each practitioner and the individuals with whom they worked. The following is a summary of key results from each interview.

Dietitian

The Dietitian interviewed focused her answers on educational tactics with a particular sensitive to the realties of day-to-day living with an individual with type 2 diabetes.

The Dietitian indicated that time-management was a predominant barrier in diabetes management:

> [Clients need] time to manage it…to do the testing, time to take the medications, time to attend appointments.

The Dietitian spends a lot of time educating the individuals they work with on nutrition fact label reading (both individual and group sessions):

> …We'll look at labels and we'll compare …focusing on the serving size, focusing on the carbohydrate section…and comparing the serving size you are actually eating.

The Dietitian specified the benefits that digital apps provided to both healthcare professionals and the individuals they worked with. For example:

> [Digital apps] have made our job a little bit easier…[clients] like it too because they don't have to carry a book and a paper around.

Thus, in order to support the challenges identified by the Dietitian, a digital app would include components that support time-management such as scheduling specific to diabetes management (e.g. a reminder to take a BGL reading). Given that the Dietitian spends a lot of her time deciphering information collected by the client a report feature could help save time and offer a tool to support greater understanding. The Dietitian also inferred a much more simplified listing could help clients to focus on nutrients that relate specifically to diabetes management. Relational serving size to food item (e.g. the plate method. A carb or protein is to be a quarter of the plate and a vegetable is to be half of the plate) could also help to support the methods used by the Dietitian and her clinic.

Health Coach 1

Health Coach 1 spoke primarily about how she/he uses one-on-one support to foster awareness (cause/effect of choices and actions) and provides customized approaches to encourage self-sustaining diabetes management. When asked about prescription or use of a general tactic (e.g. plate method) she/he would often qualify her answer around the intent of her client. For example:

> …I think it depends on what the client's eating and what the client's goals are.

Health Coach 1 often uses the internet with her/his clients to look up a variety of information. For example:

> I have a lot of clients who like the *Fibre One* bar. So we go to the website,we look at them, and I print them [nutrition facts label] and use a highlighter and explain [the content of the label]…by-step process.

Thus, in order to support approaches similar to Health Coach 1, a digital app that could support customization and be designed to accommodate modifications in order for information to be made relevant to individual circumstances (i.e. choosing what features/content are displayed).

Health Coach 2

Health Coach 2 framed many of her/his answers around the challenges of low socio-economic groups and language and cultural mismatches.

Health Coach 2's comments revealed that some healthcare providers find barriers within the programing they provide. Health Coach 2 tries to educate her/himself on culturally specific food practices to overcome barriers, for example:

> It's always a learning experience…I've learned so much about different cuisines...

Cultural challenges could be addressed by a digital app that includes a more culturally-sensitive food database that has the ability to present information through educational components such as videos or recipes.

Demonstrations of food preparation techniques that honour non-North American approaches could help healthcare providers gain insight into the cultural nuances of an client's food preparation, potentially helping them offer more relevant support and advice.

Nurse Practitioner

The Nurse Practitioner focuses her/his diabetes management support specifically around the interest and the goals of the individual.

The Nurse Practitioner spends most of her/his time supporting individuals in defining their own goals and guiding them to take ownership of how and what they chose to focus on in their diabetes management.

> So how did you do with your goals? And if they say, "Well, I didn't meet my goal," then that's okay, let's maybe set some new ones, that maybe aren't quite so difficult to get to and we'll go from there.

> We don't expect you to be perfect…it is challenging…And often times just the fact that they know that we're in support of them even when they have fallen off the track or they just can't be on the bandwagon at all that we are still going to support them.

Thus, in order to support approaches used by the Nurse Practitioner, a digital app should include the option to offer customizable displays and personalized presets that encourage a client, with the help of their healthcare provider, to determine the goals they wish to set for themselves or focus on where they want to pay attention in terms of their diabetes management.

Requirements

Five Requirements were deemed to be essential to the design of the digital app. Corresponding design implications were compiled from the data collected in the expert interviews. Appendix J-N shows the concepts that emerged from the analysis and their individual MoSCoW categorization.

Requirement 1: Customization

This first Requirement is customization. As supported by the findings in the literature review and the expert interviews, customization (making information relevant to a client's circumstance) is key to more sustainable diabetes management. Findings from the expert interviews revealed shortfalls within two ares of diabetes management that can be addressed through customization of the digital app:

a) Use of tools in diabetes management support
b) Use of sustainable and non-sustainable tactics

1 a) Use of tools in diabetes management support

The interviews revealed that Healthcare providers interact with clients via classes/programs/individual sessions, and use print materials and digital materials. All participants use one-on-one counseling sessions and indicated the value of an individualized approach to diabetes management support. The Dietitian engages in group sessions, Health Coach 1 indicated that the Dietitians in her clinic offer seminars for shopping on a budget or carb-counting strategies in order to address the specific needs of the communities they worked with.

Printed materials often include general information on diabetes and nutrition facts or basic log sheets/booklets that can be used to document food choices and BGLs. All participants mention that they use *Canada's Food Guide* in their respective health clinics, but both health coaches are reluctant to encourage it's use because they find the content is often not relevant to many of their clients. Health Coach 2 indicated that many of the individuals do not recognize or won't eat the foods described in the guide because they are not typical of their culture.

The digital materials used by clients are primarily digital apps for the documentation of information such as foods consumed and BGLs. In addition, Health Coach 1 uses the internet to search for nutritional information on food content, recipes or local sales flyers for grocery stores. Health Coach 2 uses Google maps to look up local walking trails and events that the individuals can take part in to increase their activity levels. Both health coaches also indicated that it is challenging and time consuming to find information on nutrition or culturally specific food practices, either in print or digitally (e.g. searching the internet).

The Dietitian mentioned that the digital app used by her/his clients, *My Fitness Pal*, does not log information in a way that can make it easy for an individual to understand how their choices are affecting their diabetes management. Thus much time is spent printing pages from *My Fitness Pal*, and manually adding information to help make the information collected relevant to an individual's circumstance.

The interviews revealed that participants are engaged in many individualized approaches to offer support and education through their programs. However, many of the tools used offered generalized content or only provided a way to document information.

Requirement 1: Customization

1 a) Use of tools in diabetes management support

GAP REVEALED

The print and digital materials used by participants offered limited customization (e.g. general CDA nutrition facts sheets with a few language options) or no customization (e.g. *My Fitness Pal* had no ability to modify the journal set up which the Dietitian found challenging. The food items could not be time-stamped and there was no way to log BGLs.)

DESIGN IMPLICATION

The Dietitian and both health coaches mentioned a lot of time is being spent deciphering information the client has collected. A report feature, for example, that could display multiple information sets could make it easy for an individual to understand how their choices effect their diabetes management.

1 b) Sustainable and non-sustainable tactics

Examples of tactics (a plan or an action to help an individual to maintain their goal of consistent BGLs) revealed in the interviews can be described as: self-sustainable (an action that can be successfully taken up and maintained by an individual for diabetes management) and non-sustainable (a suggested action that is rejected by an individual).

Examples of self-sustainable tactics were those created between the healthcare provider and client and took into consideration the client's circumstance. For example, Health Coach 1 stated:

> The doctor tells them to go eat healthy food—How are they going to do that if they don't have enough money to feed their kids? To wear clothes?…I want them to know that it's still possible to move forward—what can we do right now? So I teach individuals how to buy food on a lower budget, how to find and use local farmers' markets…[how to] exercise on their own at home…

Heath Coach 2, after many one-on-one sessions with an individual, was able to devise a tactic using Google Maps to create a customized activity plan.

> Google Maps shows you where all the bike trails are, where all the sidewalks are. You can use technology to find the exact distance it takes to walk around your neighbourhood. There's one client that I've shown this to and we found out that she has access to the beach in her neighbourhood. There was a walk that she wasn't aware of and now she's walking a trail down to the beach.

Tactics that were identified as non-sustainable, were too generic and not grounded in an individuals circumstance. For example, both health coaches spoke about the use of mainstream food suggestions :

> A lot of people are from different cultures, and the foods they eat don't match *Canada's Food Guide*. When they see a dietitian and that dietitian presents them with *Canada's Food Guide* it's not useful. (Health Coach 1)

> I would suggest eating a certain food item and they would agree to try it out … At the next session I would ask, 'How did you feel pre and post the particular meal?' They say, 'Felt great.' 'Are you keeping up with it?' They say, 'No, it doesn't fit my lifestyle…' or 'I can't imagine myself doing this for a very long time… (Health Coach 2)

The examples above coincide with results from Glazier, et al's (2006) systematic review were they found that tactics generated over multiple one-on-one sessions—once a healthcare provider could get a better understanding of the individual's circumstances—were the ones that seemed to be more easily adopted by individuals. The least successful interventions were those comprised of generalized approaches that did not reflect the circumstances of the individual, and thus were rejected by the individual.

Requirement 1: Customization

1 b) Sustainable and non-sustainable tactics

GAP REVEALED

Tactics that are relevant to an individual circumstances have a greater chance of being sustainable over generalized tactics that are not relevant.

DESIGN IMPLICATION

The digital app components could include information and be designed to accommodate modifications or augmentation in order for information to be made relevant to individual circumstances. For example a digital app would offer a variety of tracking options so that a client (ideally in conjunction with their healthcare provider) could decide what features he/she wished to use. e.g.: those starting out may wish to track only BGLs. Thus a digital app that can offer customizable displays and personalized presets should be considered.

Requirement 2: Tracking of BGL, food, and activity

The second Requirement, tracking, focuses on the need for individuals to accurately track their actions (food intake and activities) in order to see how those actions affect their BGLs over time.

2 a) Tracking to support awareness of cause/effect

Health Coach 1, when working with new clients, starts out using tracking primarily for observation. She/he believes that observation encourages clients to become aware of changes that occur in their BGLs when they make certain food choices or engage in different activities:

> Make sure that they're tracking, whether it's tracking on a calendar, tracking on a cell phone or even just having like a little booklet… so they can see the changes in the blood glucose, even if they're not making any changes [to their food intake or activity level].

Health Coach 1 stated that this awareness helps her clients to see the effect food intake choices or activity has on their BGLs. This awareness could contribute to clients making more informed choices for their diabetes management:

> …I ate this today. OK, maybe I won't eat this tomorrow…

Tracking, customized to diabetes management needs, would allow the healthcare provider to become aware of what actions the client currently engages in (food intake and activity) and how his/her body is responding to those behaviours (BGLs). The client becomes aware of what and how their body responds to their choices with the guidance of their healthcare provider and the visual displays of the information in the digital app.

Requirement 2: Tracking of BGL, food and activity

2 a) Tracking to support awareness of cause/effect

GAP REVEALED

Observations of cause/effect on BGLs, food intake and activity can be used as an educational tactic. Thus greater awareness of actions in relationship to decisions and choices related to diabetes management is needed.

DESIGN IMPLICATION

Tracking glucose levels, food and activity are the key activities associated with maintaining consistent BGLs. In order for a client to see the relationship of these actions and choices a reporting feature that visualizes the relationship between the different tracking options could support the efforts of the healthcare provider to create awareness of choices as well as offer the potential to reduce time deciphering a clients documentation of information.

2 b) Time-specific tracking

The Dietitian mentioned that many of the existing digital apps (e.g. *My Fitness Pal*) do not log information in a way that could make it easy for an individual to understand how their choices are affecting their diabetes management:

> With *My Fitness Pal*, the snacks are kind of confusing because the snacks are all lumped at the bottom. The meals that are spread out and then you got the snacks all together, so you end up asking the patient well, when did you have this snack? Was this in the morning or the afternoon…or the evening?…
>
> [Another] downfall with the *My Fitness Pal* and [there are] some other diabetes apps out there too where we end up having to take the blood sugar information and write it down beside the food. We're looking for patterns…

Typically pre-existing digital apps offer a journal space to log breakfast, lunch, dinner and snack but have no way to add what time those meals were eaten or the ability to add other types of information to the tracker such as BGLs. Often clients working with the Dietitian cannot recall details about when a meal was eaten in relationship to when the BGL was taken. This makes it challenging to see the cause/effect of food choices.

Requirement 2: Tracking of BGL, food and activity

2 b) Time-specific tracking

GAP REVEALED

Some digital apps are not optimized to collect the kinds of details needed for diabetes management making it challenging for individuals to observe the effects of their actions.

DESIGN IMPLICATION

In order to address the need for clearly documented diabetes management information, a time-specific tracking option is recommended. For example each food item added to the tracker could automatically preset for the time of day (for example at 7:00 am the preset would be "breakfast" and the preset for 10:30am would be "morning snack") while still being modifiable so if an item was forgotten it could be added at a later time and still be time stamped as accurately as memory allows.

Requirement 3: Diabetic-focused nutrition facts

The third Requirement supports the need for simplification. According to the observations of the dietitian interviewed, access to too much, too complex or too many options in regards to information can be overwhelming for many clients.

Health Coach 2 does not use the nutrition facts label as she/he believes it is not an effective way to help people make decisions. She/he also found the label confusing and misleading:

> I don't like how it says carbs and then it says sugar, so sometimes it can be very misleading.

Health Coach 1 likes having access to nutrition information so she/he can understand the content of foods she/he is unfamiliar with. However, she/he recognizes that it is challenging for clients she/he worked with to use the nutrition label .

> …it can be a useful tool—it's just how it's presented…

Both the literature review and the expert interviews revealed many people believe nutrition information is valuable but in order for it to be useful it needs to be in context to individual needs and goals so it can be used to benefit their decision making process.

According to the interviews and confirmed in the literature review, there are three generalized nutrition fact groupings that are most relevant to diabetes management:

1. Carbohydrates: "Carbohydrates are key to consistent BGLs" (Dietitian, Nurse Practitioner, and supported by MNT treatment practices)
2. Calories: "5-10% weight loss would help improve some of these patients' blood sugar levels" (Dietitian, Nurse Practitioner)
3. Fat + Sodium: "Most people with diabetes have the same cardiovascular risks as those with cardiovascular disease" (Dietitian, Nurse Practitioner, and supported by MNT treatment practices)

Requirement 3: Diabetic-focused nutrition facts

GAP REVEALED

Too much information, information that is too complex or having too many options is confusing for some individual.

DESIGN IMPLICATION

Instead of information dense representations similar to the Nutrition Facts label, a much more simplified listing could help clients focus on nutrients that relate specifically to diabetes management:

1. Carbohydrates
2. Calories
3. Fat
4. Sodium

Requirement 4: Relational serving size to food items

The fourth Requirement stems from the need to support realistic approaches to portion awareness and application. Serving size and portions that are easy to extract from a food item or relate to the whole item may help individuals make appropriate choices for their individual needs. The dietitian stated,

> …The serving that's indicated on the label is very different from what they're actually eating, so a can of soup, for instance…541ml, and on the label it says 240ml per serving. You need a calculator to determine the carbohydrates in the whole can… So they may just eyeball it.

This could potentially mean that more accurate tracking, supported by better serving size and portion options could facilitate greater accuracy in knowing the effect a food item has on an individual's BGL.

Participants spoke about a more visual way of determining portions. Rather than having to weigh or measure food they encourage the plate method (half the plate is vegetables, a quarter is meat [protein] and a quarter is carbohydrates) and using relationships between food portion sizes and the human body (a serving of a carb is the size of your fist, a serving of meat is the size and thickness of the palm, a serving of vegetables is two handfuls).

The Dietitian offered insight into the use of the plate method in their clinic:

> Some people, whether it's a language barrier, [or] just even literacy level, find it complicated with the labels…So for some of those folks we may use more general principles… limiting the starch to about the size of your fist, two hands full of vegetables, protein the size of the palm of your hand and thickness. So we use different strategies for different people.

Both health coaches used the *nexJ* digital app photography feature to have their clients photograph their meals. Health Coach 1 stated that having clients photograph meals gave them a moment at each meal to consider what and how much they were eating. Some clients expressed greater accountability for their food choices when they thought that someone else was going to see what they were eating:

> Oh no, someone's looking at my food…but really there's no one watching them. It's more them watching themselves…

Health Coach 1 also found that the photography feature allows his/her clients to label an image with their perception of portions (e.g. 'this was a small portion size') that could be discussed and analyzed next time they meet in order to support reasonable portion control.

Educating individuals on multiple ways to determine serving sizes and reinforcing this by offering options for tracking food could encourage sustainable use of the digital app. For example, when dining out a person can not realistically measure a food item, but they can determine it's portion in relation to the plate it is served on or take an image of it for observation with their health care provider at a later time.

Requirement 4: Relational serving size of food items

GAP REVEALED

1. Language and literacy/numeracy issues make nutrition fact label reading challenging.
2. Serving sizes displayed on nutrition fact labels are not easily translatable when attempting to determine a realistic percentage/portion of a food item.
3. Existing use of plate method and portion in relation to individual's body is a common tactic used in diabetes education, yet none of the digital apps mentioned by the healthcare providers offered a plate method tracking option.

DESIGN IMPLICATION

In addition to serving size adjustments and traditional units of measurement an additional feature that is relational to the individual's body and plate. An option to photograph food could be included in the tracking feature of the digital app.

Requirement 5: Acknowledging cultural differences

The fifth Requirement focuses on acknowledging cultural differences when providing information. It can be challenging to understand the nuances of a culture outside of one's own, but unless effort is made, the consequences can result in ineffective diabetes management (whether intended or not). Ellen Langer's *The Power of Mindful Learning*, refers to this as context confusion. People typically assume others have the same motives and intentions (Langer, 1997, 40). Context confusion often happens with a less-dominant group(s)—in the context of this study, those with a different culture then the dominant group(s)— when the dominant group(s) are the ones determining a program or the contents of a support tool. To the less-dominant groups' detriment, the tools tend to be coupled with criteria that are irrelevant to their individual intentions and goals (Langer, 1997, 40).

Health Coach 2 most conscientiously recognized context confusion in the Centre they worked in:

> You have to learn about other people's cuisines because the stuff that you see in the Canadian Food Guide—nobody eats that. I learned so much about Guyanese food and Jamaican food where, you know, it's a totally different...I think diabetes educators need to be educated on what the typical cuisines for these kinds of populations are, because they're basing their knowledge on whatever the Food Guide is recommending.
> (Health Coach 2)

As stated in the literature review information that is relevant to clients circumstance is key to diabetes management. The expert interviews revealed that cultural differences cause barriers to success. Some healthcare providers are unfamiliar with foods from other cultures and the educational materials they use do not include foods from cultures outside of North America.

Requirement 5: Acknowledging cultural differences

GAP REVEALED

A barrier to accessing relevant information is cultural difference. Many healthcare providers and the materials they use or have available to them (e.g. Canada's food guide) are North-American centric.

DESIGN IMPLICATION

A more culturally-sensitive food database could make the digital app more inclusive of a variety of cultural food choices. Educational components such as videos or recipes could, for example, demonstrate a variety of food preparation techniques that honour non-North American approaches. This could help healthcare providers gain insight into the cultural nuances of a client's food preparation, potentially helping them offer more relevant support and advice. For clients, apart from providing the option to select from pre-populated foods from their own culture, a more varied selection of foods could be used to introduce new food and food preparation techniques.

In summary, the following five Requirements:

1. Customization
2. Tracking of BGL, food, and activity
3. Diabetic-focused nutrition facts
4. Relational serving size to food items
5. Acknowledging cultural differences

represent the needs revealed from the expert interviews, supported by the literature review and provide the basis for the design of a digital app for diabetes management.

Prototype design

Scenario-based design for wireframing

Based on the data collected in the expert interviews and the generation of Requirements, Scenarios, were developed to address every day activities of clients with type 2 diabetes. The Scenarios were used to inform a series of wireframes that formed the basis for the content of a digital app prototype.

While this approach begins free of design constraints, in order to move into something more concrete, these Scenarios aided in the design of 'what if' aspects of activities (Benyon, Turner and Turner 2005, 205). For example, what if a client forgot to log an activity or measure a food item. In this study, scenarios and wireframes were developed iteratively along with a conceptual diagram. The conceptual diagram established the overall structure and organization, mapping the potential "pathways"a user could pursue (See *Figure 1*).

Three tasks were developed: (1) Add a meal to food tracker, (2) Add a glucose level to the glucose tracker, (3) Add an activity to the activity tracker.

Conceptual diagram

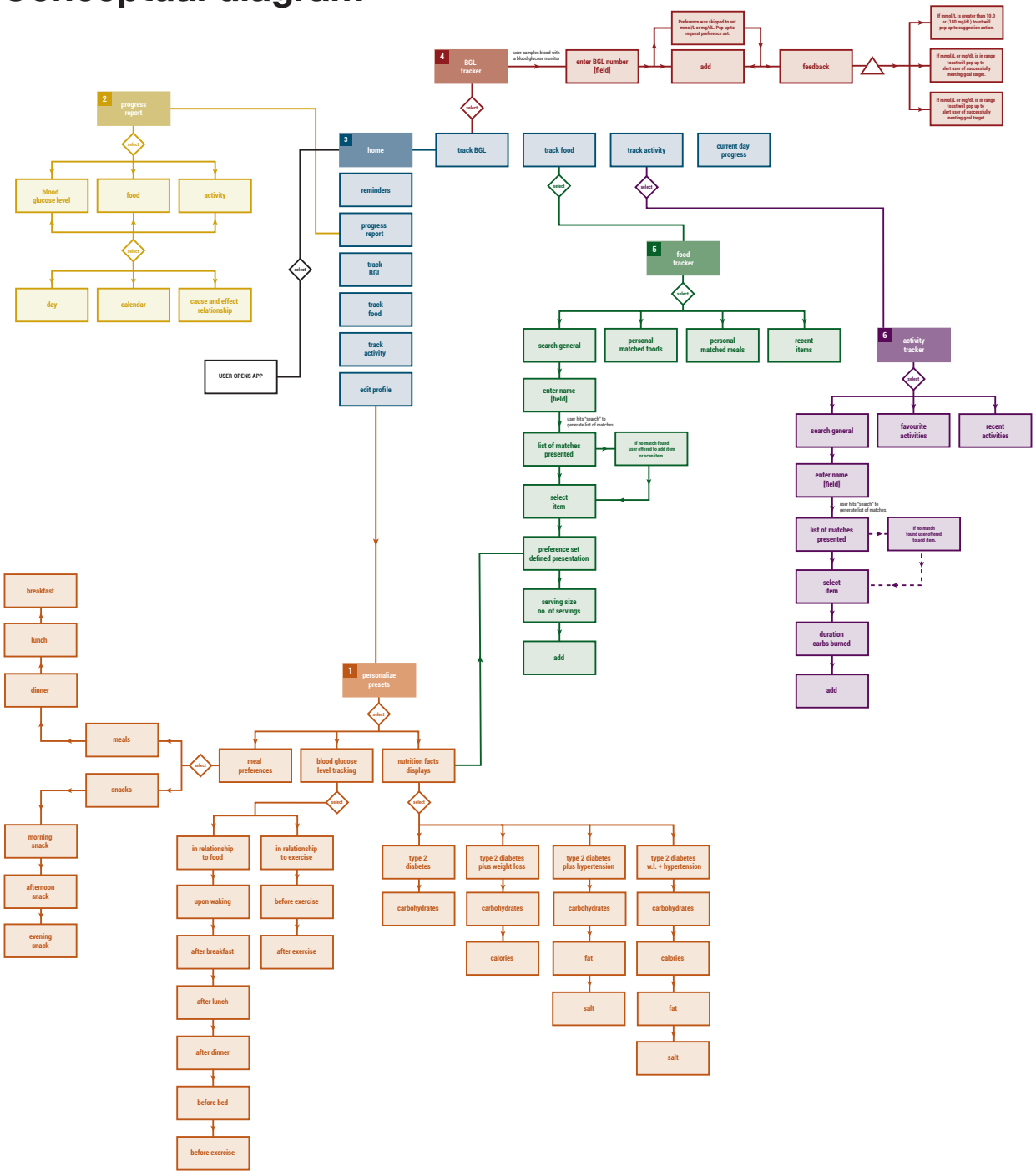


Figure 1. Conceptual diagram

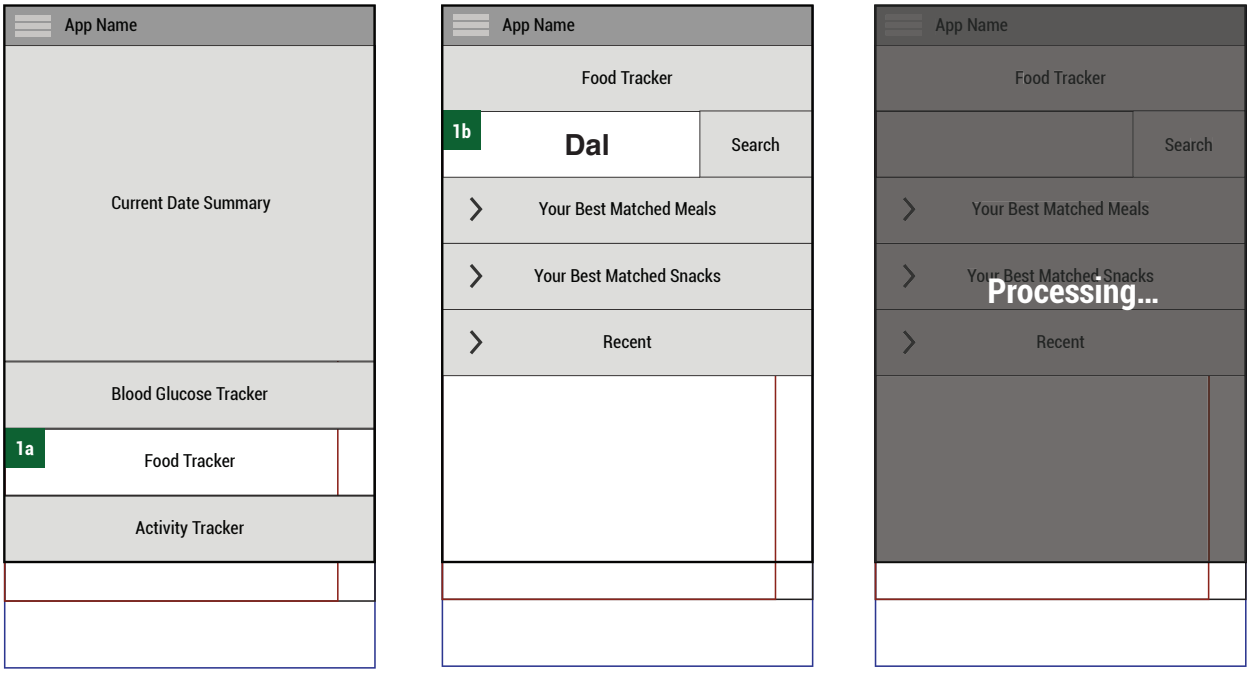
The conceptual diagram emphases the layout of the systems structure and organization of content. While not everything contained in the conceptual model was included or developed for the high-fidelity prototype it was important to conceptualize the bigger picture to understand the context in which the components were developed existed and interacted in the larger system of the information architecture. This conceptual diagram was based on Jesse James Garrett's *A visual vocabulary for describing information architecture and interaction design* (http://www.jjg.net/ia/visvocab/).

Scenario 1 task: Add a meal to the food tracker

Scenario 1 satisfies the Requirements of Time-specific tracking of BGL, food, and activity, Diabetic-focused nutrition facts, Relational serving size to food items, and Acknowledging cultural differences (See *Figures 2,3*).

On her way home from work Sarah decides to have dal and roti for dinner as she had some left over from the previous night's meal. She goes home heats up her meal and sits down to watch some TV with her family. Half an hour later she realizes that she forgot to add her meal to her food tracker. She also forgot to measure/weigh her food but she is pretty sure she had a serving about the size of her first of the dal, based on the size of the bowl she used. All the roti were made approximately the same size so she could just use the serving size from the previous night.

Both items are added to the tracker and Sarah sees she is slightly over her meal target of 45–65g of carbs. The app detects this and prompts her to test her blood BGLs in an hour to see how her body responds to the meal she just ate.

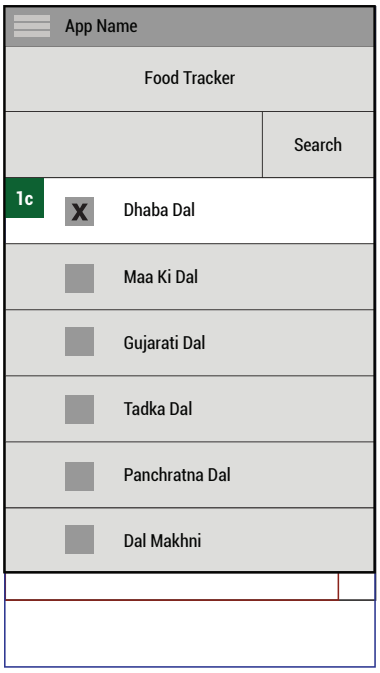


Sarah selects the Food Tracker button from the home page (1a).

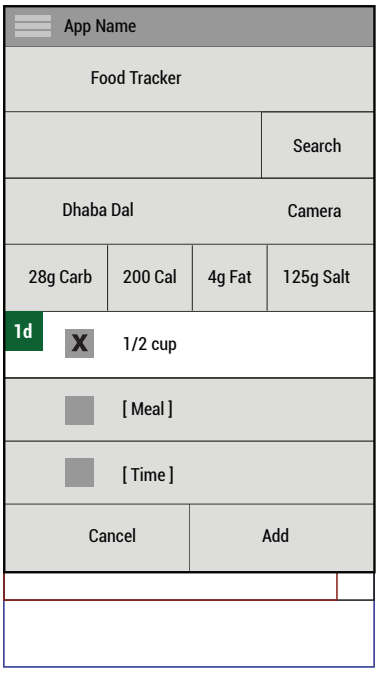
Sarah types 'dal' into the search bar (1b).

She waits a second or two for the system to find matches.

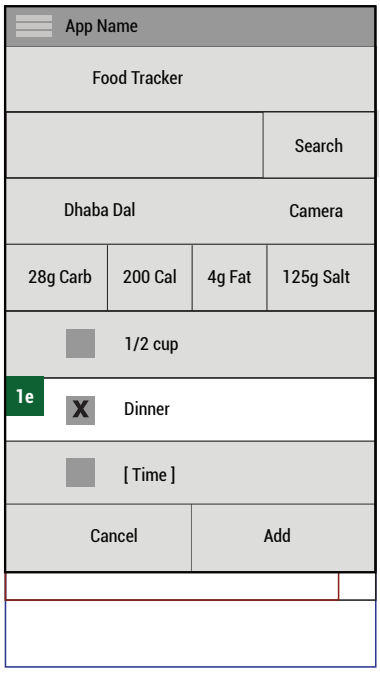
Figure 2. Scenario 1 task: Add a meal to the food tracker
Wireframes include the layout, content and implied functionality that would be required for "Sarah" to add her meal to the food tracker as described in Scenario 1.



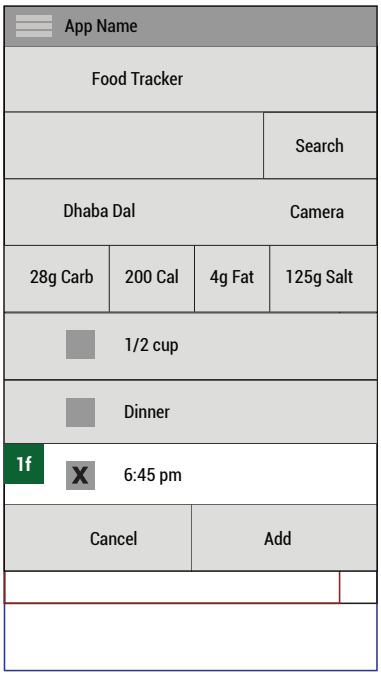
Sarah selects the 'dal' option that matches her meal (1c).



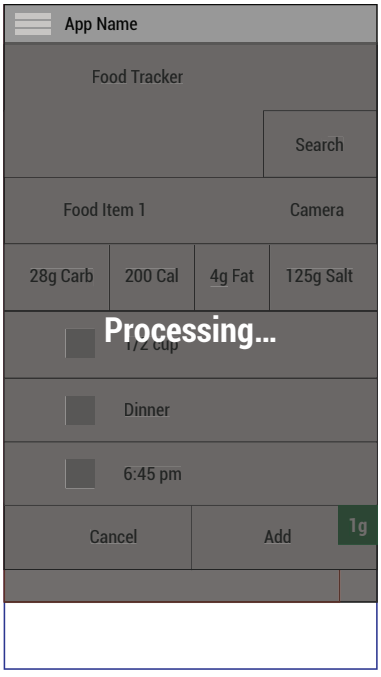
Sarah selects the physical portion option because it is the best match to her memory (1d).



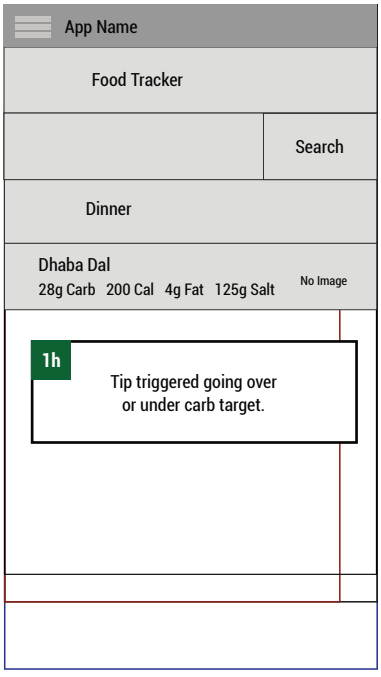
Sarah selects 'dinner' for her meal type (1e).



Sarah changes the time to match the timing of her meal (1f).



She adds dal and waits second or two for the system to add it a the diary (1g).



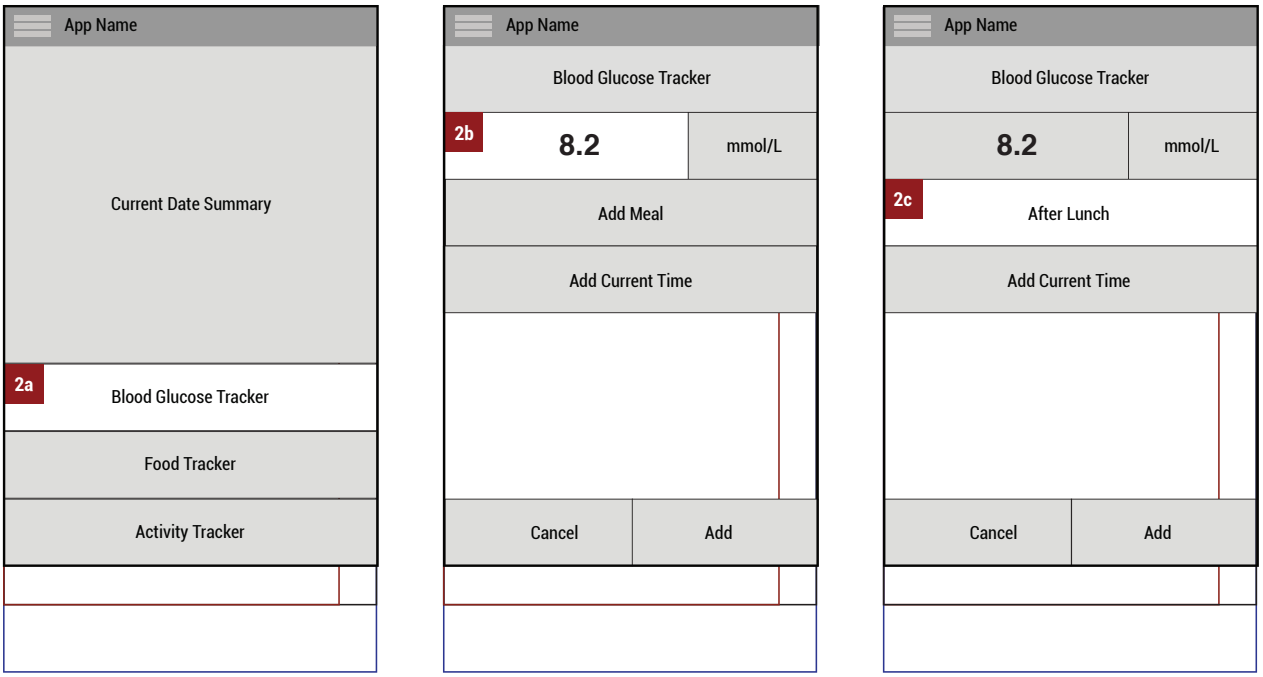
Sarah is 5 grams over her target. A pop-up (1h) is triggered to ask if she wants to check her BGLs in an hour.

Figure 3. Scenario 1 task: Add a meal to the food tracker
Wireframes include the layout, content and implied functionality that would be required for "Sarah" to add her meal to the food tracker as described in Scenario 1.

Scenario 2 task: Add a glucose level to the glucose tracker

Scenario 2 satisfies the Requirements of Time-specific tracking of BGL, food, and activity, Diabetic focused nutrition facts, Relational serving size to food items, and Acknowledging cultural differences (See *Figure 4*).

Sarah has eaten lunch at a local Ethiopian restaurant with friends. She is unsure of what was in her meal as one of her friends, more familiar with Ethiopian cuisine placed the order. Because the meals are served on a communal plate that all diners share, she failed to really notice what she had eaten or how much. Now that she is back home she is curious to see how her meal affected her BGLs. As it has been about two hours since she ate she decides to test her blood and enter the mmol/L number from her meter into the digital app.

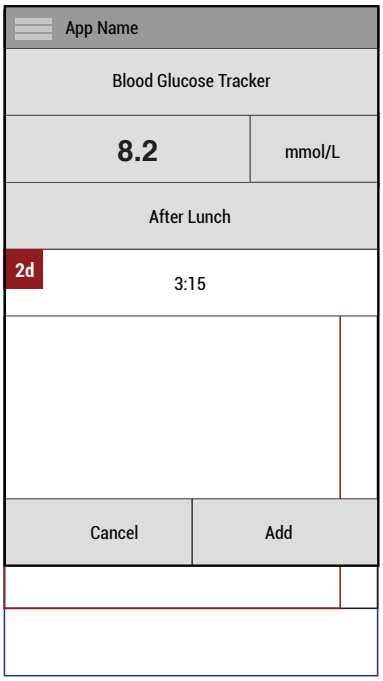


Sarah selects the Glucose Level Tracker button from the home-screen (2a).

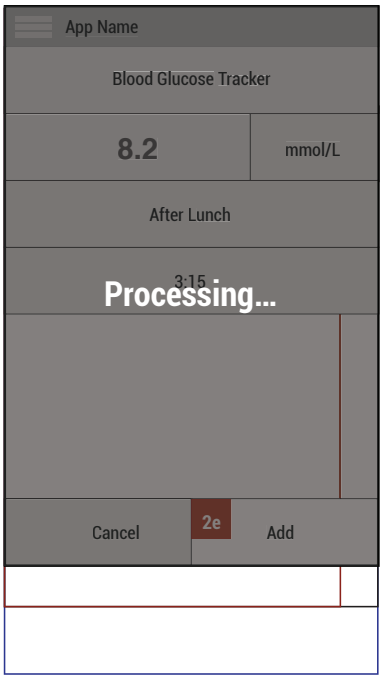
Sarah types in her BGL in beside the mmol/L button on the screen (2b).

Sarah selects 'after lunch' as her meal type on the screen (2c).

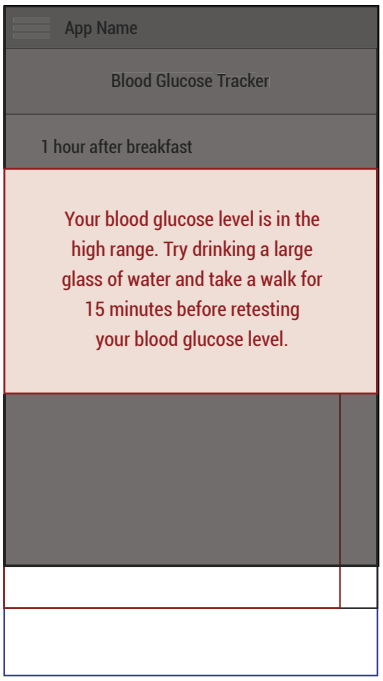
Figure 4. Scenario 2 task: Add a glucose level to the glucose tracker
Wireframes include the layout, content and implied functionality that would be required for "Sarah" to add her glucose level to the glucose level tracker as described in Scenario 2.



Sarah selects the 'add current time' on the screen (2d).



Information added (2e).



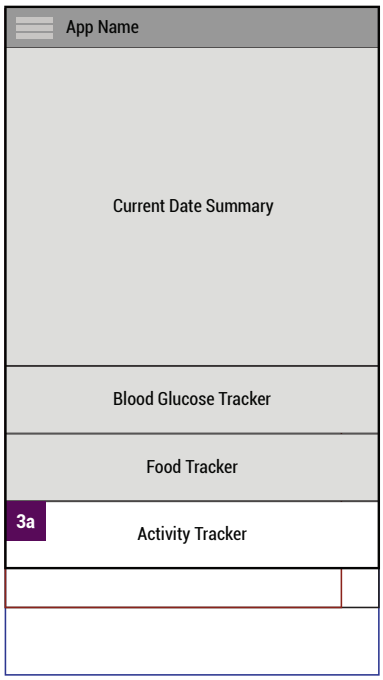
Diary shows that Sarah is over her target for glucose levels. A pop-up is triggered to ask her if she wants to take action in the moment.

Figure 5. Scenario 2 task: Add a glucose level to the glucose tracker
Wireframes include the layout, content and implied functionality that would be required for "Sarah" to add her glucose level to the glucose level tracker as described in Scenario 2.

Scenario 3 task: Add an activity to the activity tracker

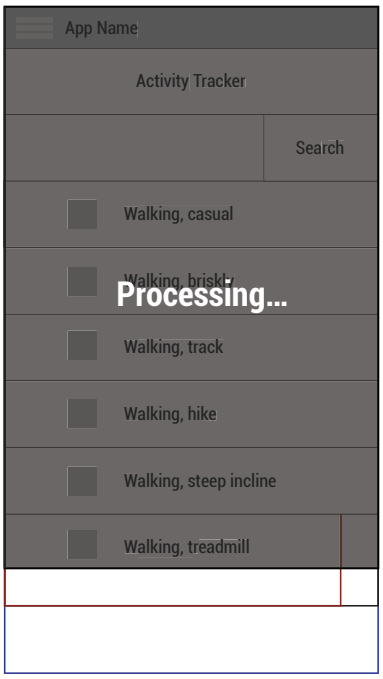
Scenario 3 satisfies the Requirements of Time-specific tracking of BGL, food, and activity (See *Figure 5 and 6*).

Based on her dietitian's advice, Sarah starts to track her normal activities. She usually goes for walks with one of her colleagues during her lunch hour on Mondays and Thursdays. When she gets back from her sixty-minute walk she opens her app to add her activity.

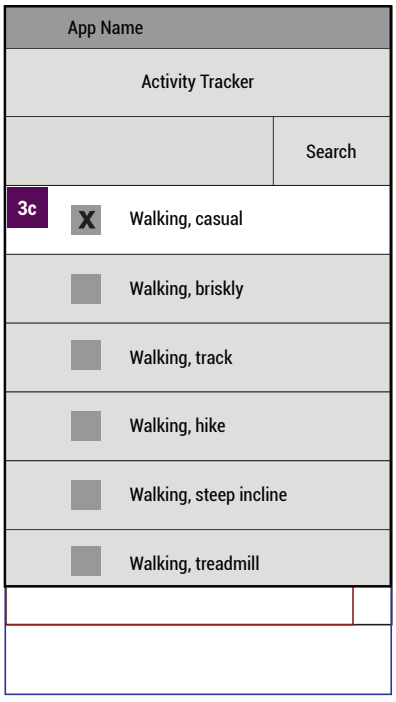


Sarah selects the Activity Tracker button from the home page (3a)

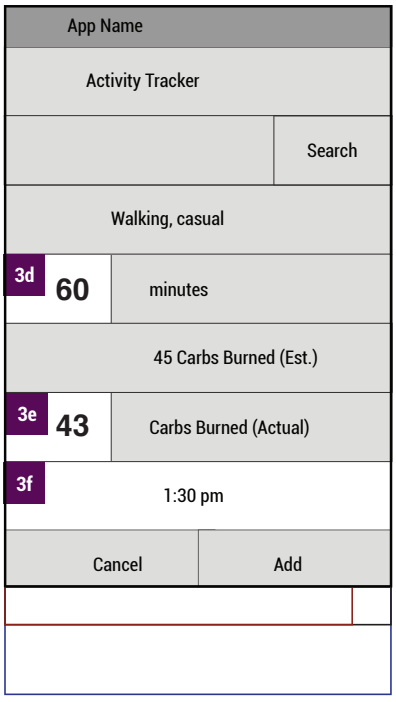
Sarah enters the activity into the search field and selects the search button (3b).



She waits a second or two for the system to find matches.



Sarah selects an activity (6c).



Sarah enters the duration of her activity (3d). She has a heart monitor so she can enter (3e) an exact number (that will over-ride the estimate. Sarah then changes the time to match the time of her activity (3f).

Figure 6. Scenario 3 task: Add an activity to the activity tracker

Wireframes include the layout, content and implied functionality that would be required for "Sarah" to add her activities to the activity tracker as described in Scenario 3.

High-fidelity prototype

A high-fidelity prototype was developed for usability testing. High-fidelity prototypes are similar in look and functionality to a final app making them ideal to evaluate content, visuals, interactivity and functionality (Benyon, Turner and Turner 2005, 254)

Wireframes (as shown above and on the previous pages) were used as a blueprint to guide the high-fidelity prototype development. The wires frames and prototype embodied the Requirements as determined by the analysis of the expert interviews and the literature review. They are:

1. Customization
2. Tracking of BGL, food, and activity
3. Diabetic focused nutrition facts
4. Relational serving size to food items
5. Acknowledging cultural differences

In order to ensure ease-of-use and keep the focus on the human-interaction aspects of the interface design, the high fidelity prototype was developed taking into consideration the usability heuristics for user interface design as identified in the literature review:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Recognition rather than recall
6. Aesthetic and minimalist design

The following pages highlight the key features of the layout of the prototype (BGL, food, activity trackers and report feature) and how they relate to the Requirements and the usability heuristics for user interface design.

The digital app prototype was developed to work on an Android tablet (*Figure 7*) and an Android smart phone (*Figure 8*). For usability testing the tablet option rather than the phone option, was used in order to make it easier for the researcher and observer to see how a participant engaged with the interface.

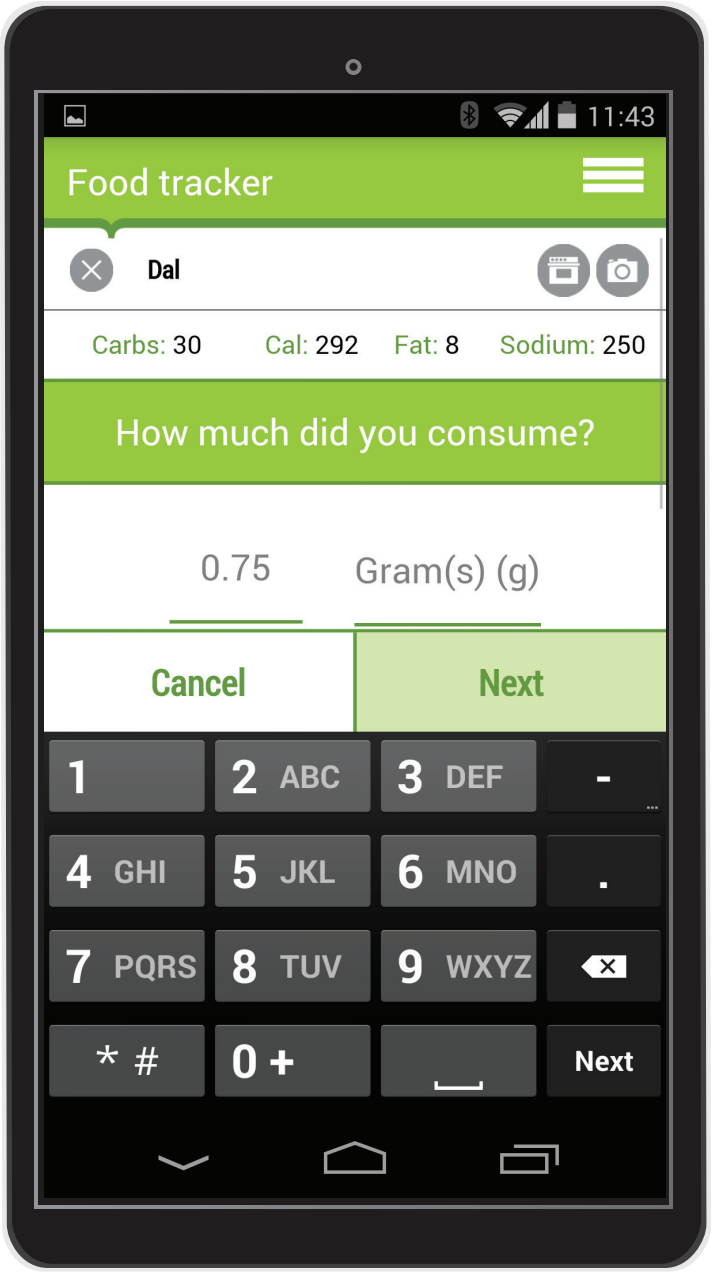


Figure 7. Andriod tablet

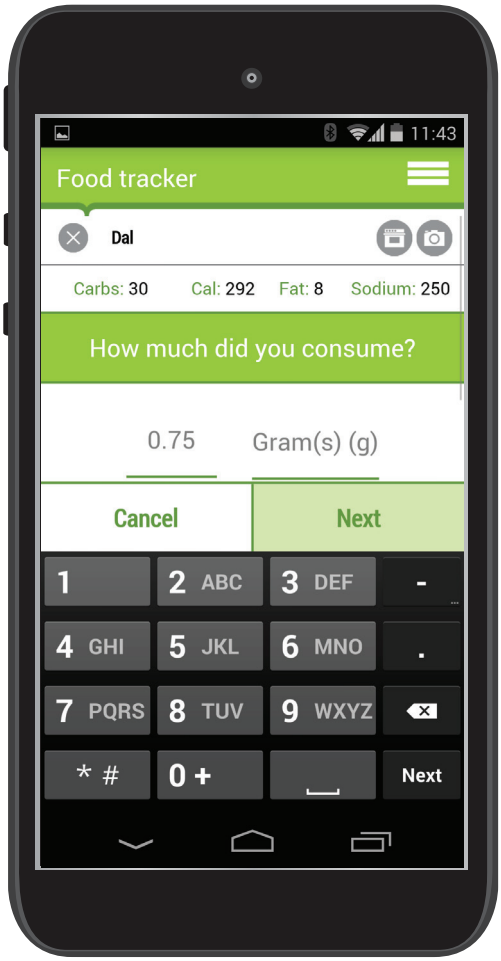


Figure 8. Andriod smartphone

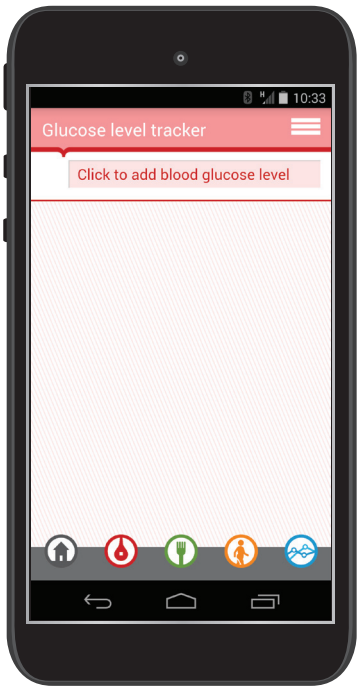


Figure 9. BGL tracker

Summary of the key features of the prototype

The digital app structured is comprised of 4 main components to support diabetes management: glucose level tracker, food tracker, activity tracker and a report feature to display the three sets of tracked categories into a multi-line chart.

Glucose level tracker

Primary action:

- Add BGL

Customization of action:

- Specify time
- Specify relationship to meal (before/after, or waking/before bed)

Feedback:

- Notification alerts for BGLs that are above or below target ranges including recommendations to take relevant actions

BGL summary display:

List items that have been previously added, displaying BGL reading in relationship to i) target ii) time of day and iii) meal (before/after) or waking/before bed.

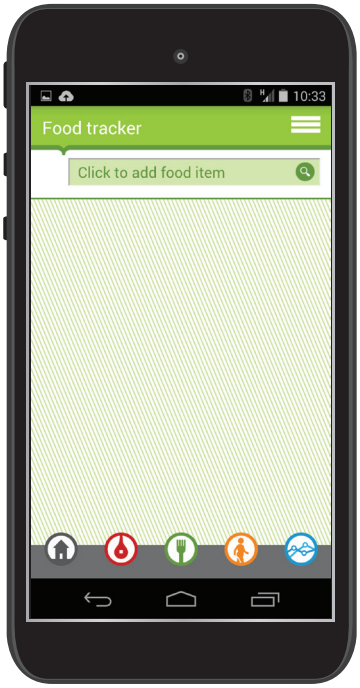


Figure 10. Food tracker

Food tracker

Primary action:

- Search food database + add food items

Customization of action:

- Specify portion size i) measurement (cup/ounces/grams) ii) plate (vegetables 1/2 a plate) iii) relational to body (carb=size of fist)
- Specify meal type (breakfast, morning snack, lunch etc..)
- Specify time

Feedback:

- Notification alerts for carbs that are above target range including recommendation to take BGL to see the effect of carb intake

Food tracker summary display:

List items that have been previously added, displaying food items in relationship to i) meal type (eg. breakfast) ii) portion size iii) time of day consumed iv) diabetic-focused nutrition facts v) summary of meal total vi) display recipe (where possible) and vii) take/display photo.

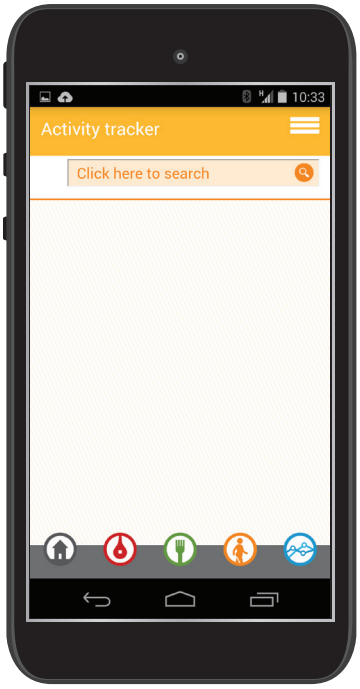


Figure 11. Activity tracker

Summary of the key features of the prototype (*continued…*)

Activity tracker

Primary action:

- Search activity database + add activity

Customization of action:

- Specify duration (hours, minutes)
- Specify time

Activity summary display:

List items that have been previously added, displaying BGL reading in relationship to i) target ii) time of day and iii) meal (before/after) or waking/before bed.

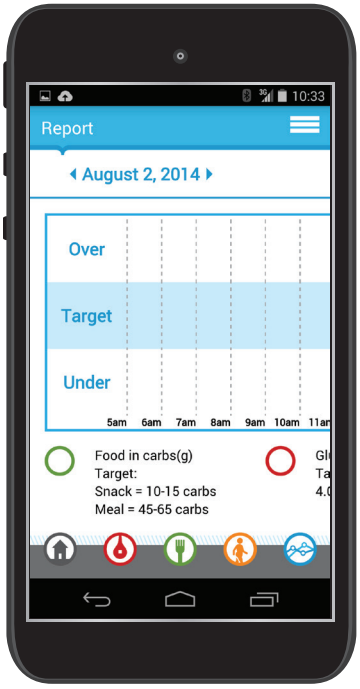


Figure 12. Report

Report

Primary action:

- Display tracked BGLs, food, activities in a multi-line chart in relationship to target ranges

Report display

- BGL reading in relationship to i) target (4.0-9.0 mmol/L) ii) time of day and iii) meal (before/after) or waking/before bed
- Food items in relationship to i) carb target range (snack = 10-15 carbs, meal = 45-56 carbs),ii) time of day consumed and ii) meal type (eg. breakfast)
- Activity in relationship to minutes
- BGL, food and activity in relationship to one another for analysis

The key features of the prototype

The following are more detailed descriptions of the digital app's components (BGL, food, and activity tracker and the report). Each component is described in terms of it's purpose, user actions and how the design features satisfy the Requirements and usability heuristics.

Home screen

The home screen (*Figure 13*) is the first screen a client sees when they open the digital app. For quick and easy navigation, the home screen features large icons for each of the key tracking options[7] (BGL [A], food [B], activity trackers [C]) and report feature [D], as determined by the Requirements.

User actions

A client can select from amoung one of the four features to input and/or view information relevant to diabetes management.

Requirement	Design feature
• Tracking of BGL, food, and activities	The home screen displays the tracking feature icons for each aspect of diabetes management, date and menu bar.

Usability heuristic	Design feature
• Aesthetic and minimalist design	Bright and vibrant colours are used to project a positive mood. Each distinct hue is used to help clients distinguish between features and easily determine where they are in the system. Simple lines, shapes, and minimal verbiage help to keep the digital app free of non-essential information for ease of use.
• Recognition rather than recall	Large representational icons [A-D] that relate to aspects of tracking, such as, a person walking for 'activity' (C) or a fork for 'food' (B) draw upon recognition as opposed to recalling abstract symbols that would have to be learned.
• Consistency and standards • User control and freedom	The home screen is converted into a static navigation bar (*Figure 14*.[E]) and consistently placed at the bottom of the screen ensuring that a client can access key functions from any page within the digital app for ease-of-use.

[7] Ultimately the tracking options that appeared on the home-screen/navigation bar would be pre-determined by the individual and their healthcare provider based on their goals and priorities. As stated by the Dietitian, an individual starting out with diabetes management may find tracking multiple actions and choices overwhelming. Thus a client could begin by simply choosing to track their BGL and add other items as they progress.

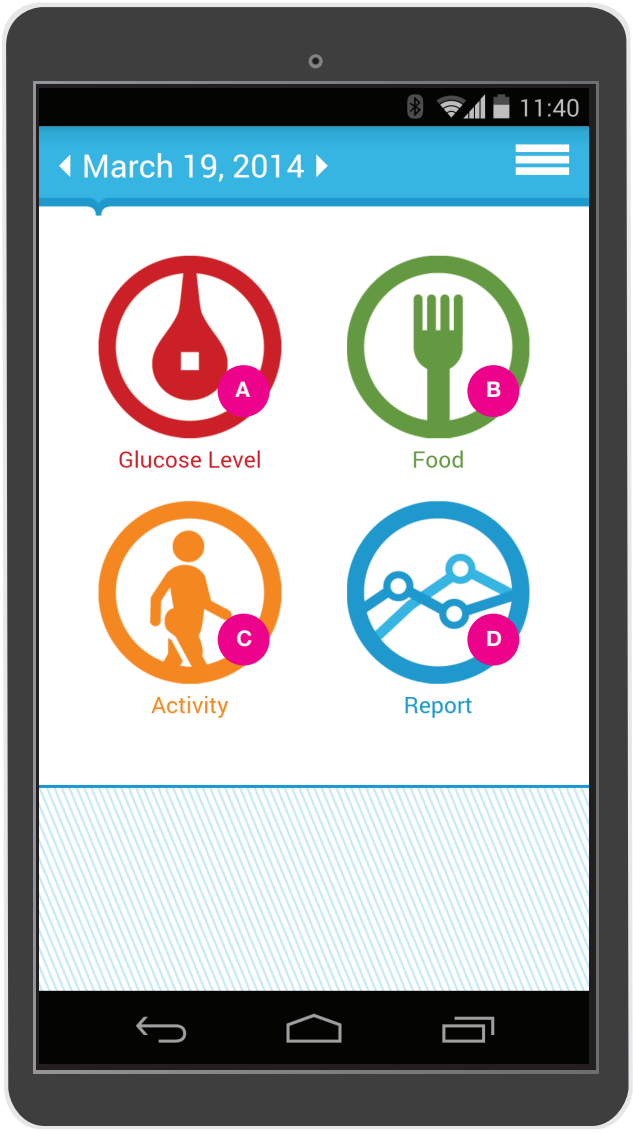


Figure 13. Home screen
The home screen displays the main components for each aspect of diabetes management.

Figure 14. Landing screen BGL, food, activity and report
When an icon is selected from the home screen, clients are taken to the corresponding component—BGL, food, or activity tracker or report.

Glucose level tracker

The glucose level tracker's (*Figure 15*) primary function is documenting BGLs. Observation of BGLs over time (and in relationship with food and activity tracking) can provide opportunities for clients to better understand how food intake and activity affect their BGLs.

User actions

The documentation of BGLs is achieved by selecting the red BGL tracker from the home-screen (*Figure 13*) or navigation bar (*Figure 14*.[E]) and the following 5 steps (*Figure 15*.[1-5]):

1. Select "Click to add blood glucose level"
2. Scroll through numbers to add the mmol/L reading from a BGL monitor.
3. Specify the number of hours after a meal or activity that a BGL reading is in relationship with.
4. Specify the time that a BGL reading was taken.
5. The BGL summary display list items that have been added, displaying BGL reading (*Figure 16.* [A]) in relationship to i) target range (B) ii) time of day (C) and iii) meal/activity or waking/before bed (D).

Requirement	Design feature
• Tracking of BGL, food, and activities • Customization	The glucose level tracker allows clients to easily document details of their BGLs such as, BGL reading, time of day, relationship to meal/activity. This customizable approach will help minimize the time healthcare providers have to spend deciphering their clients results. It also makes it simple for a client to document the necessary details and be provided with a display of how their BGL readings relate to their personal target range (*Figure 16*.[B]) .

Usability heuristic	Design feature
• Visibility of system status	If a BGL added (*Figure 15*.[1-4]) is higher/lower than the target range set by the client and their healthcare provider, feedback[8] can be provided instantly through a pop-up (*Figure 17*.[A]). The main screen is grayed out (*Figure 17*.[B]) to highlight the pop up window to prompt a user to respond. A client can accept or reject recommendations offered to help lower/raise the BGL to bring it closer to the target range.

[8] Feedback in the context of this app is also used as a mechanism to support understanding: If a client's BGL is too low or too high a call to action or pop-up display (*Figure 17. [A]*) is triggered to encourage in-the-moment action.

Figure 15. Glucose level tracker

The glucose level tracker's primary function is documenting BGLs. The 5 screens included in this figure show the steps a client needs to take to document their BGL in the digital app.

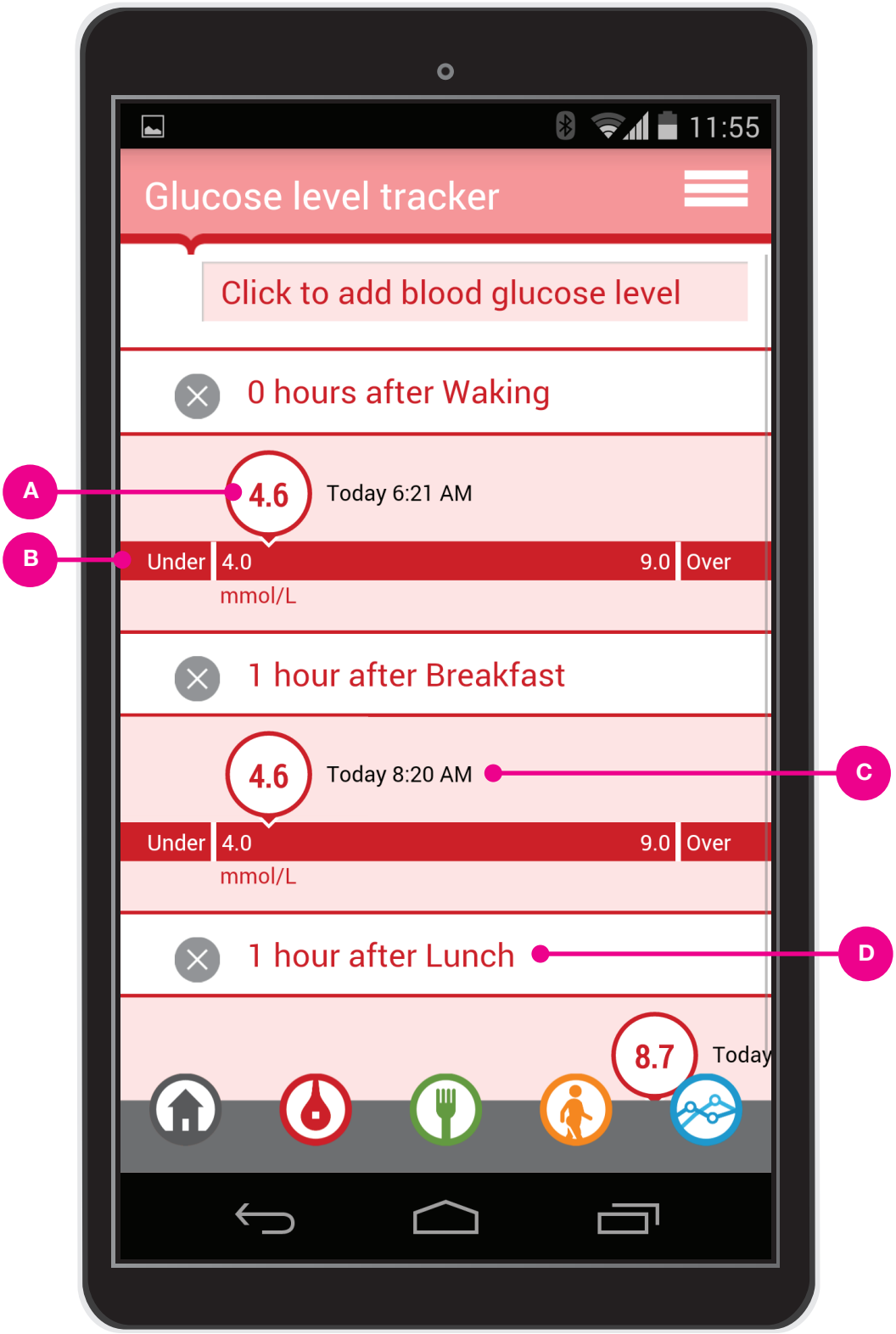


Figure 16. Glucose level tracker summary display

The glucose level tracker allows clients to easily document details of their BGLs such as, BGL reading, time of day, relationship to meal/activity.

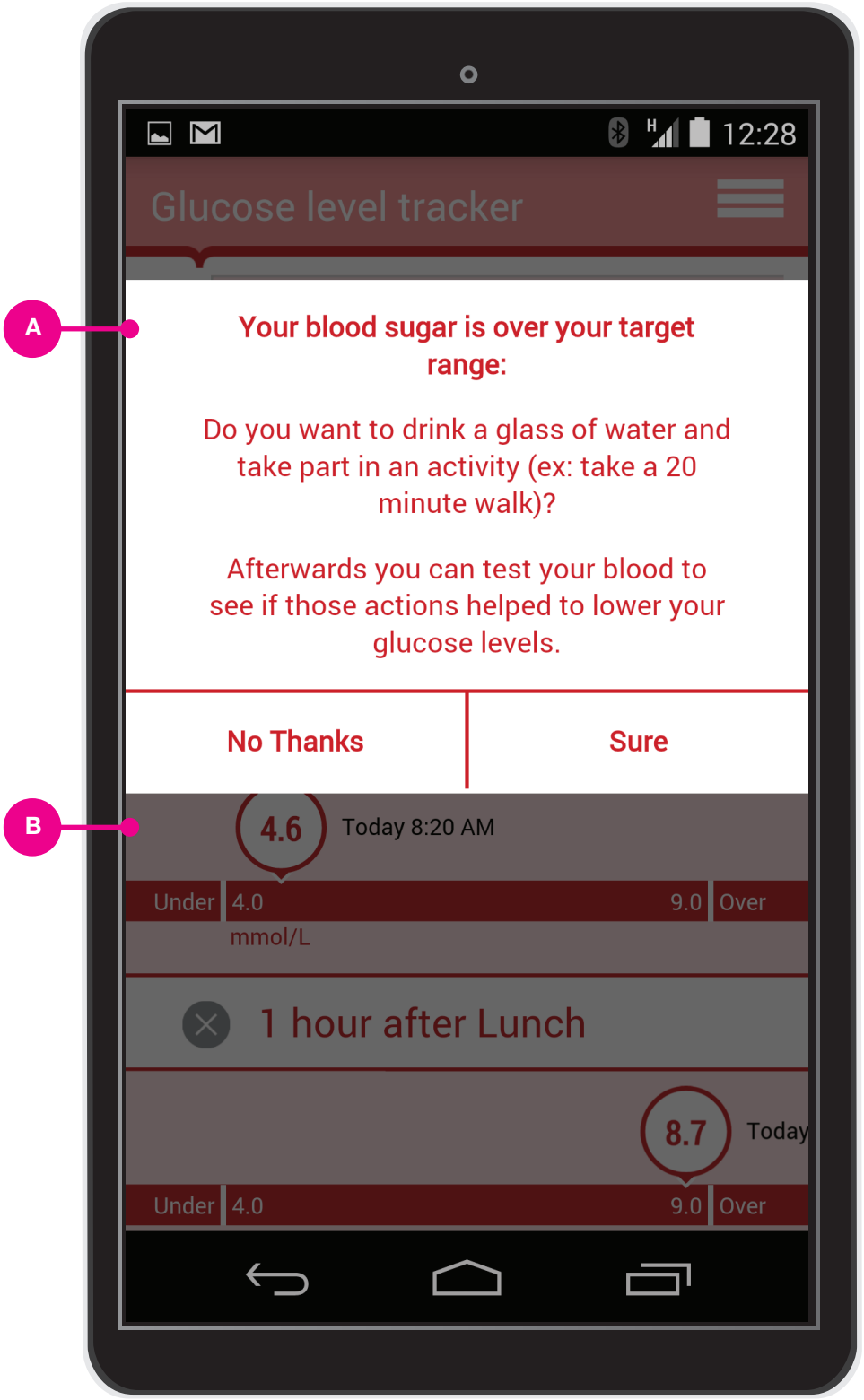


Figure 17. Glucose level tracker feedback pop up
If a BGL added is higher/lower than the target range set by the client and their healthcare provider, feedback can be provided instantly through a pop-up.

Food tracker

The food tracker's (*Figure 18*) primary feature is a searchable database of foods with the ability to select and save food items. As with the BGL, the food tracker provides feedback and recommends in-the-moment action if a client goes over their carb target range.

User actions

The documentation of food items is achieved by selecting the green food tracker from the home screen (*Figure 13*) or navigation bar (*Figure 14*.[E]) and the following 8 steps (*Figure 18*.[1-7]):

1. Select "Click to add food item"
2. Keyboard pops up in order for the client to type in the food item they wish to add.
3. Specify the portion size relational to body (carb=size of fist), measurement (cup/ounces/grams or plate method (carb=1/4 the plate).
4. Specify the meal type.
5. Specify the time that a food item was consumed.
6. If meal exceeds carb target range than a call to action display is triggered to encourage in-the-moment action (recommendation to test BGL in an hour).
7. If recommendation is accepted a reminder is set for an hour to remind client to test BGL.
8. The food summary display list items that have been added, displaying food item(s) (*Figure 19*.[B]) in relationship to i) meal (A) ii) time of day (C) iii) portion size (D) and iv) display of diabetic-focused nutrition facts (E).

Requirement	Design feature
• Tracking of BGL, food, and activities • Customization • Diabetic-focused nutrition facts	The food tracker (*Figure 18)* allows clients to document details of their food choices in relationship to meal, time of day, portion size and diabetic-focused nutrition facts (carbs, calories, fat, sodium). This customizable approach, especially when compared with more rigid approaches to the dairy method such as *My Fitness Pal* will help to minimize the time healthcare providers spend deciphering their clients results and prevent the need for clients to print and write out the BGLs they had in relationship to their food choices.
• Acknowledging cultural difference	Acknowledging cultural difference can be as simple as including a diverse range of cultural food options (e.g. Jamaican dishes) or educational components such as videos or recipes (*Figure 19/20*.[F]). A video could demonstrate a variety of food preparation techniques to honour non-North American approaches and could help healthcare providers gain insight into cultural nuances of an individual's food preparation and recipe content (*Figure 19/20*.[G]), potentially helping them offer more relevant support and advice. For clients, apart from providing the option to select from pre-populated foods from their own culture, a more varied selection of foods could be used to introduce new food and food preparation techniques.

Usability heuristic	Design feature
• Match between system and the real world	Acknowledging cultural difference supports a greater match between the system and the real world to support both the client and healthcare providers (see 'acknowledging cultural difference' above).
• User control and freedom	Users often chose the wrong function or change their mind. To stop, redo, or remove an action should be simple (Nielsen 1995). The prototype features several options to to make changes as easily as possible. The "x" button (*Figure 18.*[C]) allows an individual to easily remove a previously added item. When adding items in any of the functions a "Cancel" button (*Figure 18.*[B]) is clearly visible to make stopping an action simple. The navigation bar has been removed to prevent accidental selection and to provide space for a keypad for ease-of-use (*Figure 18.*[A]).

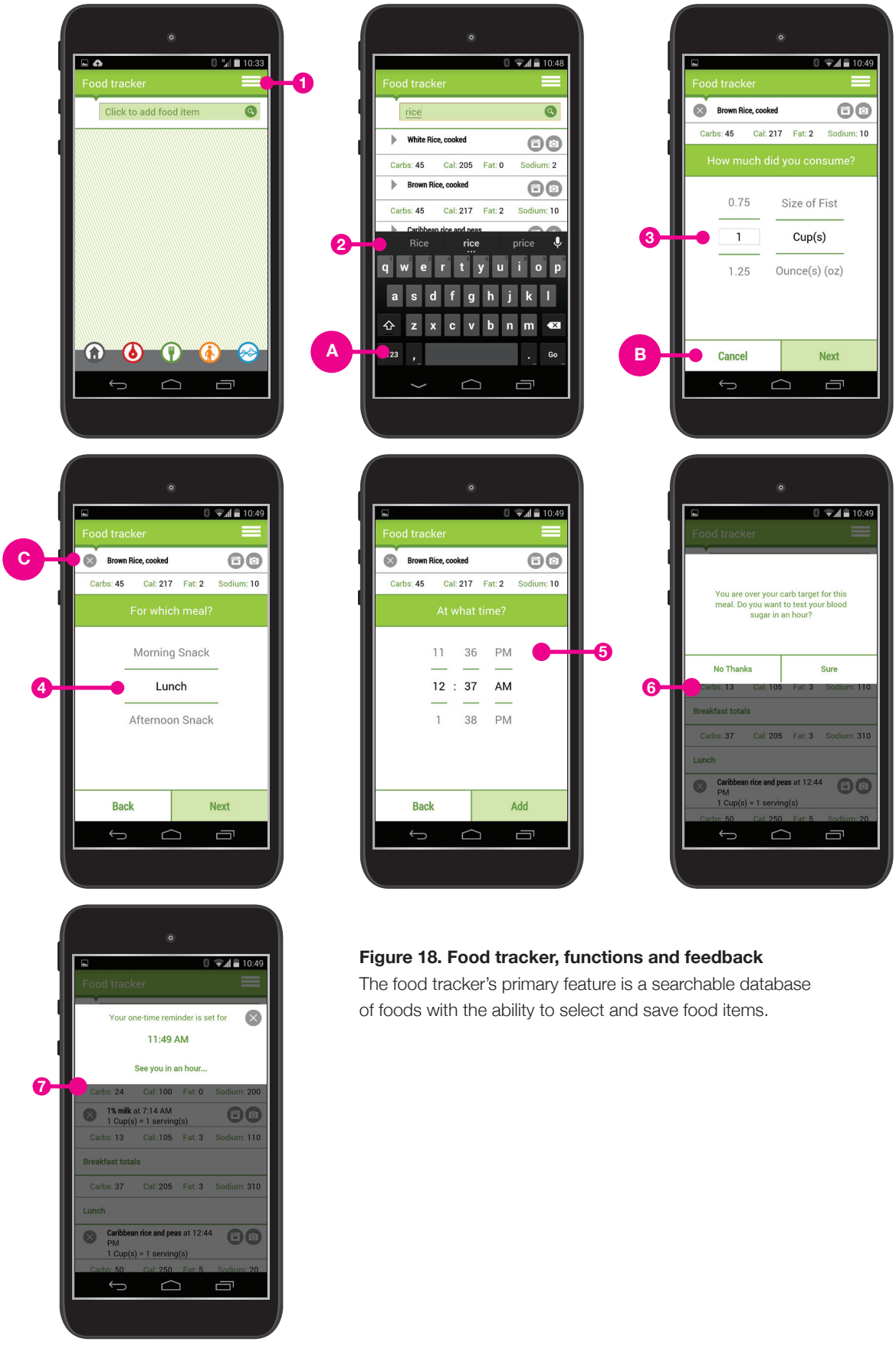


Figure 18. Food tracker, functions and feedback
The food tracker's primary feature is a searchable database of foods with the ability to select and save food items.

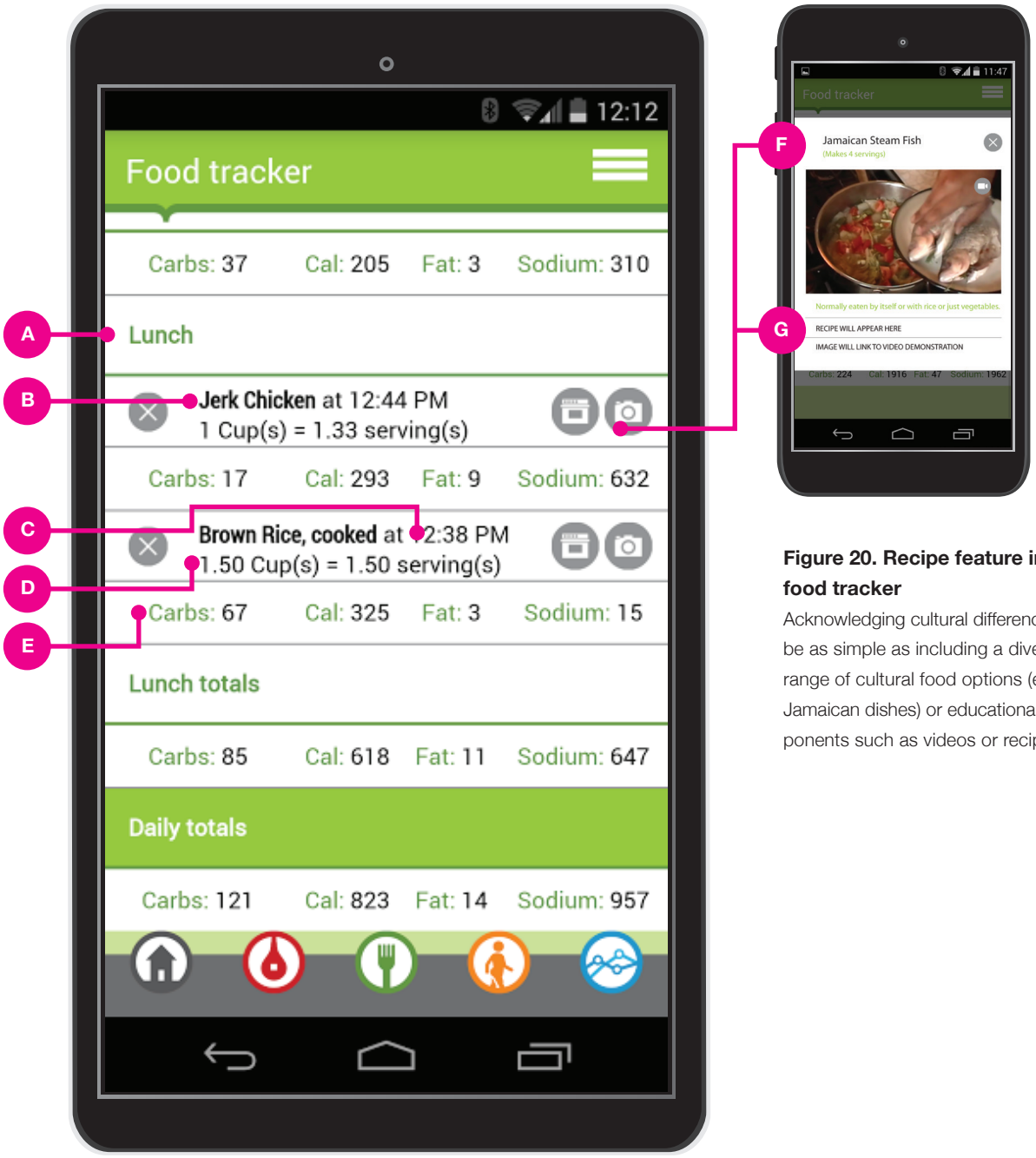


Figure 19. Food tracker, summary display

The food tracker allows clients to easily document details of their food choices in relationship to meal, time, diabetic-focused nutrition facts day, portion size and diabetic-focused nutrition facts.

Figure 20. Recipe feature in food tracker

Acknowledging cultural difference can be as simple as including a diverse range of cultural food options (e.g. Jamaican dishes) or educational components such as videos or recipes.

Activity tracker

The activity tracker's (*Figure 21*) primary feature is a searchable database of activities with the ability to select and save activities. Engaging in activities/exercise can help to maintain and/or lower BGLs[8]. By tracking activities and observing the effect those activities have on their BGL, clients are able to make more informed choices about the type of activities they engage in and the duration.

User actions

The documentation of activities is achieved by selecting the yellow activity tracker from the home screen *(Figure 13*) or navigation bar (*Figure 14*.[E]) and the following 5 steps (*Figure 21* [1-5]):

1. Select "Click to search"
2. Keyboard pops up in order for the client to type in the activity they wish to add.
3. Specify the duration of activity.
4. Specify the time of activity.
5. The activity summary display (*Figure 22* [A,B,D]) list items that have been added, displaying activity (A) in relationship to duration (B) and time of day (D).

Requirement	Design feature
• Tracking of BGL, food, and activities • Customization	The activity tracker allows clients to easily document details of their activities in relationship to duration and time of day.

Usability heuristic	Design feature
• Consistency and standards • Visibility of system status	Consistency of colour palette from the home screen to the navigation icon to their respective components (for example the yellow and various levels of saturation of that yellow are used predominately in the activity tracker symbol (*Figure 22.*[E]). Consistency of colour provides orientation for the client within the digital app. The various levels of saturation of colour and similar wording across like elements such as "click here to search" (*Figure 22.*[C]) make recognition of key actions easier, enabling an individual to learn patterns of interaction more quickly.

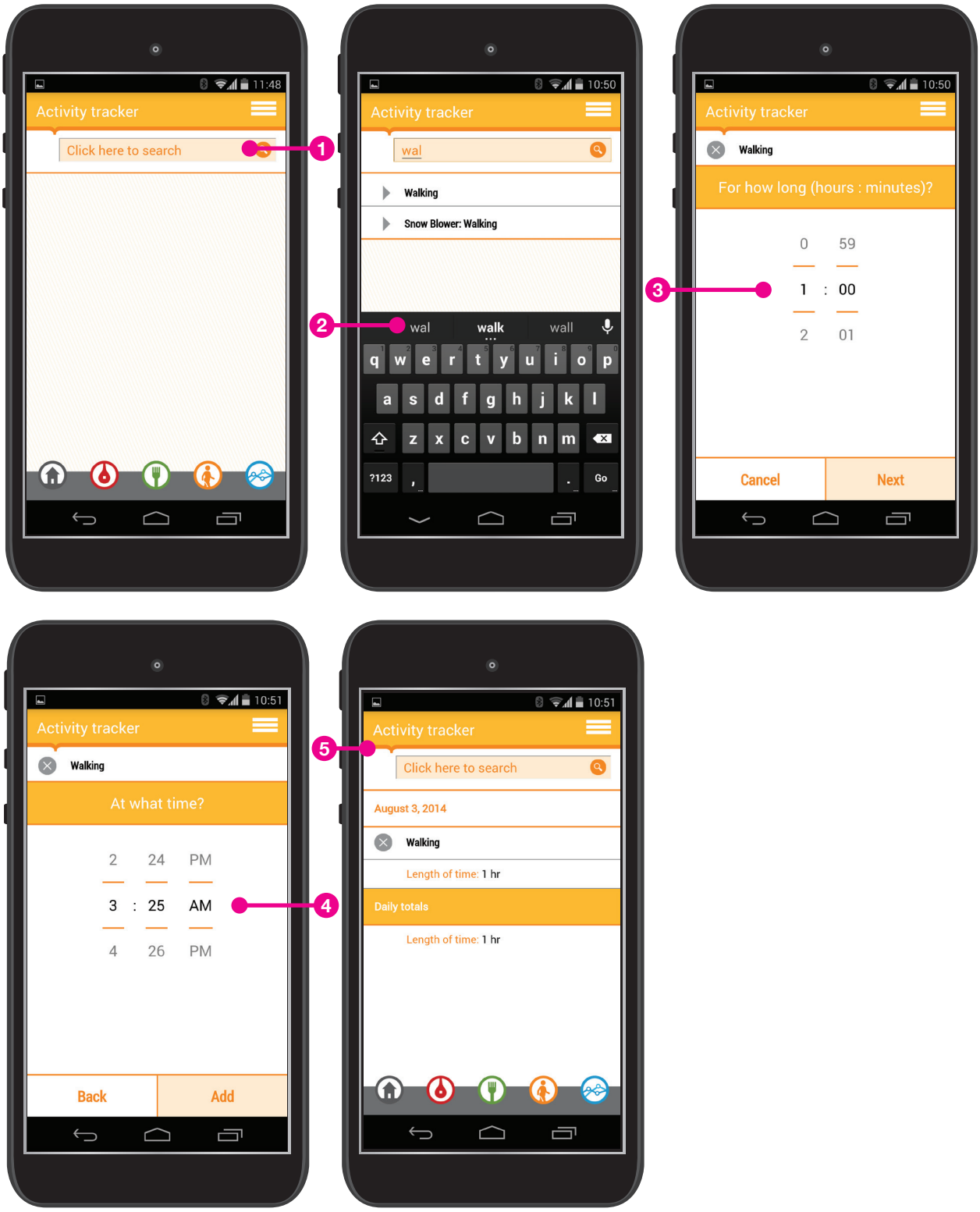


Figure 21. Activity tracker function

The activity tracker's (Figure 19) primary feature is a searchable database of activities with the ability to select and save activities.

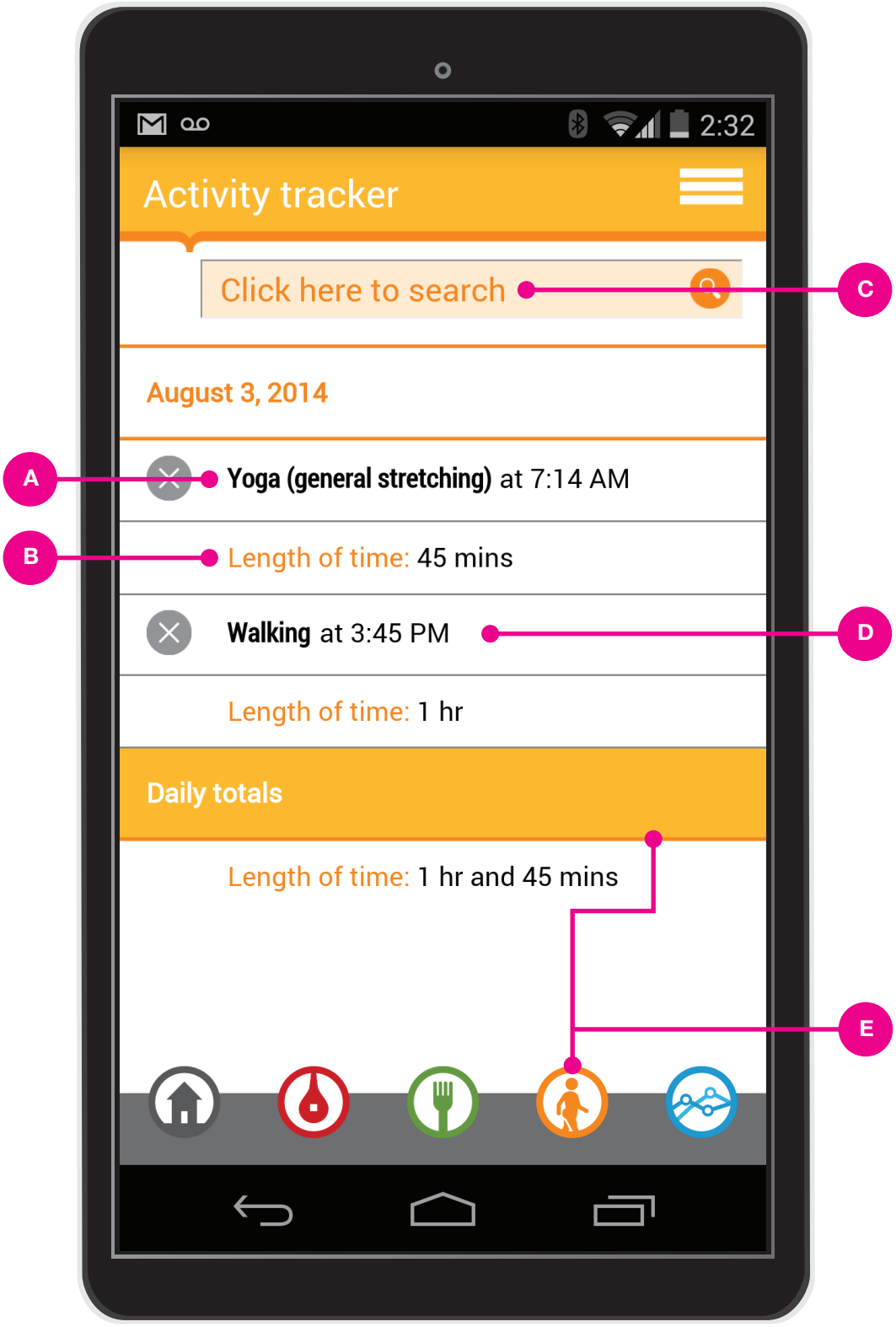


Figure 22. Activity tracker summary display
The activity tracker allows clients to easily document details of their activities in relationship to duration and time of day.

Report

The primary feature of the report (*Figure 23*) is the display of tracked BGLs, food, and activity plotted onto a multi-line chart in relationship to personalized target ranges.

Clients could benefit from a report feature as it compiles multiple datasets together into one display with the potential to reveal some of the cause/effect relationships between BGL, food intake, and activity.

A reporting feature that visualizes the relationship between the tracked items (BGLs, food items, and activities) could offer the potential to support healthcare providers, as stated by the Dietitian, by reducing the time they spend deciphering their client's tracking.

User actions

The report is a summary display (*Figure 23)* of the items documented through the BGL *(A),* food (B), and activity (C) tracker. A client would access the report by selecting the blue report icon from the home screen *(Figure13*) or navigation bar (*Figure 14*.[E]):

1. BGL reading (*Figure 23.* [A]*)* in relationship to i) target (1) (ii) time of day (2) and iii) meal type (3) (before/after) or waking/before bed.
2. Food items (*Figure 23.* [B]*)* in relationship to i) carb target range (4) ii) time of day consumed (5) and iii) meal type (6).
3. Activity (*Figure 23.* [C]*)* in relationship to i) minutes (7) and ii) time of day (8).

Requirement	Design feature
• Tracking of BGL, food, and activities • Customization	The report allows clients and healthcare providers to easily view the details of tracked BGLs, food, and activity. The tracked data is plotted onto a multi-line chart in relationship to personalized target ranges.

Usability heuristic	Design feature
• Visibility of system status	Clients could benefit from a report feature because it compiles multiple datasets together into one display. The report can reveal some of the cause/effect relationships between BGL, food intake, and activity.

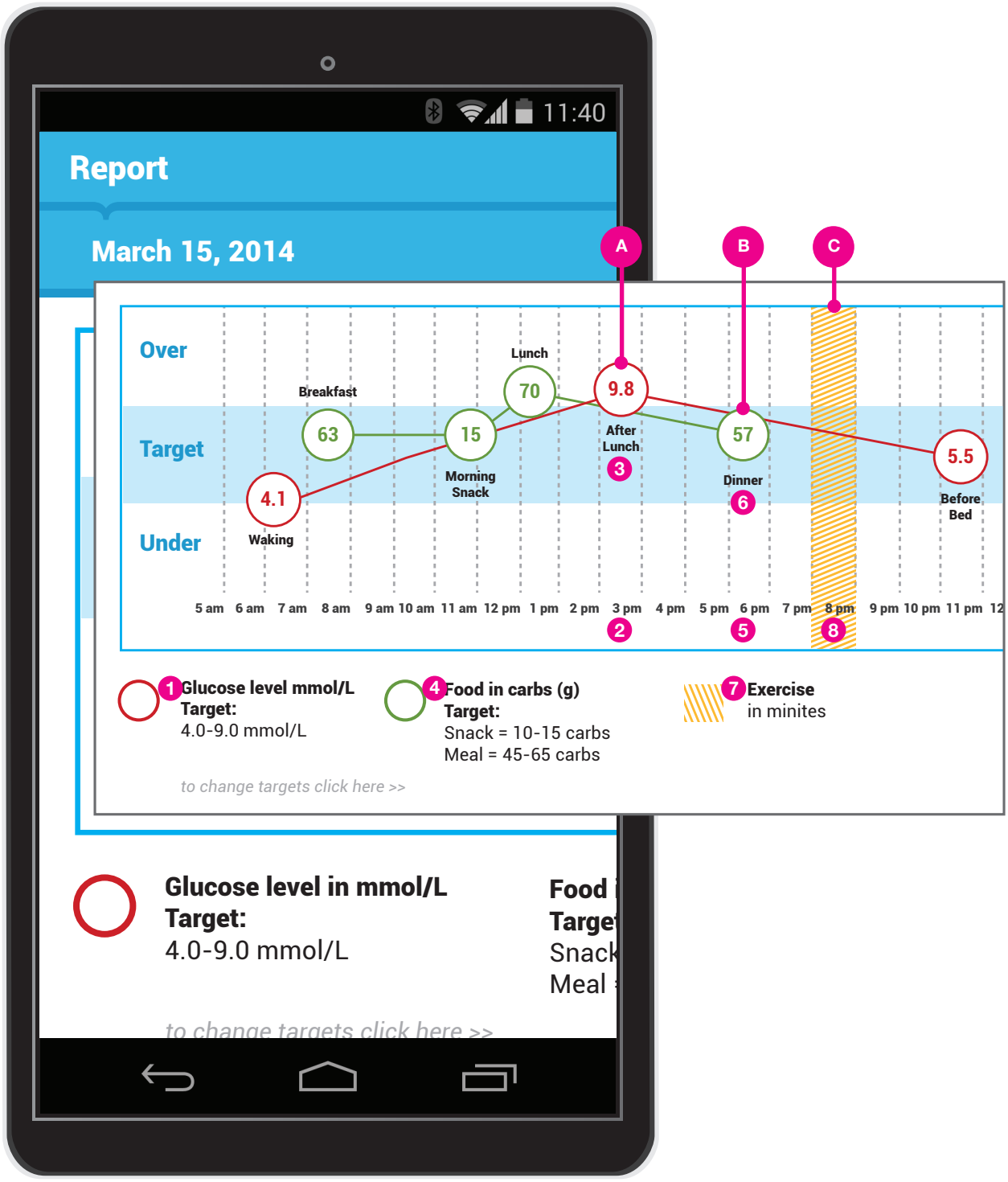


Figure 23. Report

The primary feature of the report is the display of tracked BGLs, food, and activity plotted onto a multi-line chart in relationship to personalized target ranges.

Usability study results

The usability study was conducted to identify issues with content, functionality, and the interface design to improve capabilities of the digital app. The study included 1) a questionnaire 2) five task-based scenarios. Five healthcare providers, who work with clients who have type 2 diabetes participated in this study.

Participants

Four out of five participants identified as Health Coaches (A, B, C, D, E) while the other identified as an Exercise Physiologist. One participant Health Coach A had participated in the expert interview phase.

Questionnaire

The questionnaire data helped to establish basic context of the participant's area of expertise and priorities in diabetes education, self-identified experience with technology and digital interfaces, and how their clients currently collect information. The matrix diagram (*see Appendix O*) represents data gathered from questions 1,2,3,5,6 and part of 7 (*see Appendix F for full questionnaire*).

1. Position in clinic and perceived role in supporting those with type 2 diabetes

While the participants indicated that their primary role was in the area of exercise prescription; four out of the five participants identified with client education as their role in the management of diabetes. Health Coach B, for example, states:

> Supporting positive behaviour change…making sure those with diabetes fully understand the mechanisms of the disease, how it can be managed so they can live like anyone else, and provide emotional and mental health support.

Health Coach E, answered these two questions focused on exercise, but later revealed (during the tasks and follow up questions) that they did discuss and work with their clients on aspects of diabetes management other than just exercise.

This suggests that all understood their area of expertise as part of a bigger system and that a key element was educating clients on many components of diabetes management such as BGL monitoring and food intake.

2. Experience with mobile devices and the Internet

When asked about levels of experience using mobile devices and the Internet, two participants identified themselves as advanced users and two identified as expert users. Given each participant's approach, observation and engagement, with the tasks there was no obvious discrepancy with their stated levels of experience.

3. Current data collection methods used by participants and their clients

With the exception of Health Coach B participants indicated that they used 2-3 different methods of tracking when working with clients. All five participants used the *nexJ* app[9] While each participant found the *nexJ* digital app supported the tasks it was developed for, Health Coach B stated it suffered from technical issues (connectivity, trouble shooting errors.) Health Coach A witnessed some clients struggling with navigation.

Health Coach D listed using *Glucose Buddy*[10] for BGL monitoring, *My Fitness Pal*[11] for exercise logging and tracking, *nexJ* for lifestyle factor logging and diary[12] methods. However, the apps did not provide feedback or details other than BGL, food and exercise tracking logging/tracking. Health Coach A and Health Coach E both used a diary (paper/pen) method for those who were not comfortable with digital technologies but found clients often forget to add or avoid adding certain information. Health Coach A also mentioned that the diary method did not provide instant feedback.

Task-based scenarios

Task-based scenarios (*see Appendix G*) are a series of events generated to test activities that would be supported by the digital app. In order to evaluate it's capabilities and make further improvements participants were observed while they engaged in the following five tasks:

1. Add a food item to the digital app
2. Add a second item to the food tracker
3. Test blood glucose levels
4. Add an activity to the tracker
5. Analyze and describe report displays

The following results from the task-based scenarios are organized in relation to the five Requirements identified in the expert interview phase:

1. Customization
2. Tracking of BGL, food, and activity
3. Diabetic-focused nutrition facts
4. Relational serving size to food items
5. Acknowledging cultural differences

---

[9] *nexJ* is a digital app used by Health Coaches at the Black Creek Community Health Centre to support those with type 2 diabetes. Clients can track lifestyle factors such as mood, blood pressure, BGLs, food choices (though photos), exercise etc. This digital app also allows for a Health Coach to have remote contact with their clients.

[10] *Glucose Buddy* is a digital app that focuses on logging and tracking of blood glucose, food, exercise and medication.

[11] *My Fitness Pal* is a digital app that focuses on logging and tracking of food and exercise. Note: not diabetes-centric.

[12] Diary method is typically a notebook that a client carries with them to manually log food choices and BGLs.

Each result is coupled with a design implication that is used to generate the final recommendation list for this study.

1. Customization

Customization was a key concept revealed in the data analysis from the expert interviews. Several results from the usability study focus on the value of customization for both the client and the healthcare provider.

1 a) Customization needs to be obvious and allow for healthcare provider support

Health Coach D and E expressed concern that the digital app offered generalized recommendations or that an individual was expected to figure out personal targets on their own. They looked for reassurance during the tasks that the targets and recommendations would be determined by advice from healthcare providers. For example Health Coach E stated:

> …you mentioned that feature is customizable. I'm assuming the targets would be discussed with the health care provider so that the client is aware of their targets and they're able to put it in appropriately as opposed to taking the general recommendations or take that on for themselves.

Health Coach D had a similar comment:

> I'm not sure if these kinds of prompts are customizable by a clinician. That way, you can set up prompts that are specific to each client …depending on what medication, or level of physical activity each client is at.

1: Customization

1 a) Customization needs to be obvious and allow for healthcare provider support

GAP REVEALED

The fact that the digital app is customizable to the individuals needs is not obvious. Customization of information is important for sustainable diabetes management, but participants were concerned that the app could make clients feel that they have to take goal setting on all by themselves.

DESIGN IMPLICATION

As recommended by Health Coach D more personalized labeling (e.g. adding the word "my" to titles such as "my report," "my BGLs") of the digital app could help remind individuals that the interface is customized to their needs and that the targets are suited to them specifically. This could also be addressed through training for use of the digital app emphasizing, that, ideally, targets should be set in conjunction with a healthcare provider and be based on the individual's goals and needs.

1 b) Report could offer more in-depth information

Each participant expressed how a visual of the day's glucose readings, food intake, and activity could help foster awareness and to make cause/effect connections with individuals they worked with. Several mentioned that in the *nexJ* app they used reporting was only available on a web portal so a reporting feature that is accessible through the digital app might be beneficial to the clients.

Health Coach C repeatedly tapped on the glucose level and food circles (*Figure 24*) while talking aloud what they saw in the report component.

When asked what she/he was looking for when she/he tapped the screen, they stated that they wished more details could be revealed:

> If you tap on here maybe it shows "oh you had the sub that day" and you're like "Oh so when I have subs for lunch maybe my sugar is high"…

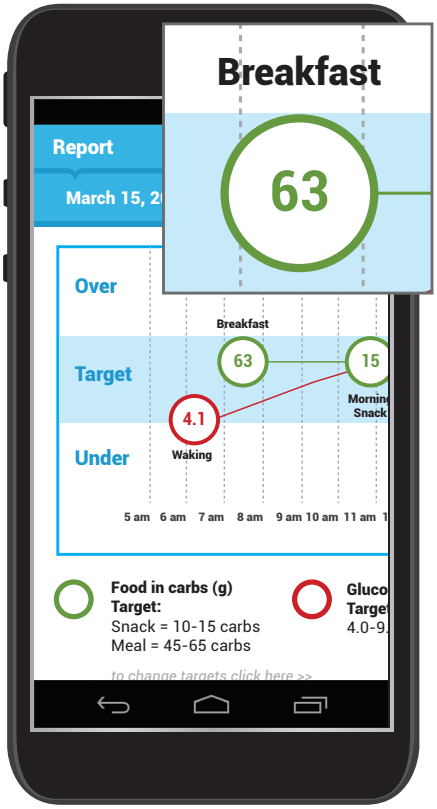


Figure 24. Reporting chart
Display shown on a smart phone
Participant repeatedly tapped the circles containing BGL (Waking 4.1) or carb (Breakfast 63) readings in the hopes of revealing more detailed information.

1: Customization

1 b) Report could offer more in-depth information

GAP REVEALED

As stated by Health Coach C, the report feature should have the ability to display more specific details of the tracked items to make more relevant use of the information collected.

DESIGN IMPLICATION

BGL/Food/Activity circles on the report could be designed to expand when selected to reveal more information (offering more user control and freedom) such as the particulars of what they ate or the intensity of the activity they engaged in.

1 c) Title display needs to remain on the screen

Health Coach E, while not stating it verbally, had to keep referring back to the titles of over/target/under as they read the report (*Figure 25*). This suggests that users would experience difficulties in recalling where they are in the report if the titling scrolls off the screen.

1. Customization

1 c) The report does not adequately display titling to keep the system visible

GAP REVEALED

Current title display in the report feature is hidden from view when a user views items later in the day which could lead to confusion as to how an item relates to a target range (contradicting usability heuristic 1: visibility of system status).

DESIGN IMPLICATION

Report layout needs to be redesigned so that the main titles stay on the screen so that a user can easily see where an BGL/food/activity item is in relation to their target.

Figure 25. Reporting chart
(Display shown on a smart phone)
When scrolling horizontally the titling of "Over","Target", and "Under" is lost making it challenging for the user to recall whether an item is in target or not.

2. BGL, food and activity tracking

2 a) Food tracking could benefit from photography option that includes descriptive text

All participants expressed support for the design of the food tracker as they liked knowing what a certain item or food contained. The digital app they use currently, the food tracker only took a photo of the meal. Some of them found the photo-only method of food tracking challenging in terms of supporting a client if they did not recognize a food item or know the content of a food item. Health Coach E recommended the inclusion of a photography feature coupled with the option to record a portion size to better understand how their client perceived a food portion or to gain better clarity on the content of the image:

> If you can pair taking the picture along with the portion size you can look at it visually and see 'this is what half a cup of rice looks like' …

2. Tracking of BGL, food, and activity

2 a) Food tracking could benefit from a photography option that includes descriptive text

GAP REVEALED

While the prototype included an option to photograph a food item, none of the participants mentioned or selected the photograph icon. Interestingly four out of the five participants mentioned the value of a photography option for food tracking. Thus, the use of a stand-alone photo does not provide sufficient information.

DESIGN IMPLICATION

Including an option to photograph a food item, coupled with descriptive text, could accommodate a broader selection of circumstances and potentially address some of the barriers revealed in the expert interviews (comprehension, time management and language/literacy). For example, an image could be used to compare a portion of food with a visual, as a time-saving feature, or if the client could not find an item in the tracker.

2 b) The activity bar needs more details

Participants recognized that the yellow bar represented activities but were looking for more details on the type, intensity, and duration than what was offered on the report.

> The exercise, I'm not sure how that's displayed because it's just one line across the whole target range. I'm not sure what the intensity was, or how long I did it for, or what type it was. (Health Coach D)

> …If you're doing cardio exercises versus resistance exercises your blood glucose level may be different after each type. (Health Coach E)

2. Tracking of BGL, food, and activity

2 b) The activity bar needs more detailed content

GAP REVEALED

The activity bar in the report needs to be more consistent with the other categories and offer more detailed tracking options contradicting usability heuristic 3: user control and freedom.

DESIGN IMPLICATION

The visual representation of activity displayed on the report should be more consistent with the BGL and food trackers. This would also include adding intensity of exercise (through a percieved exertion scale) along with type of activity and duration.

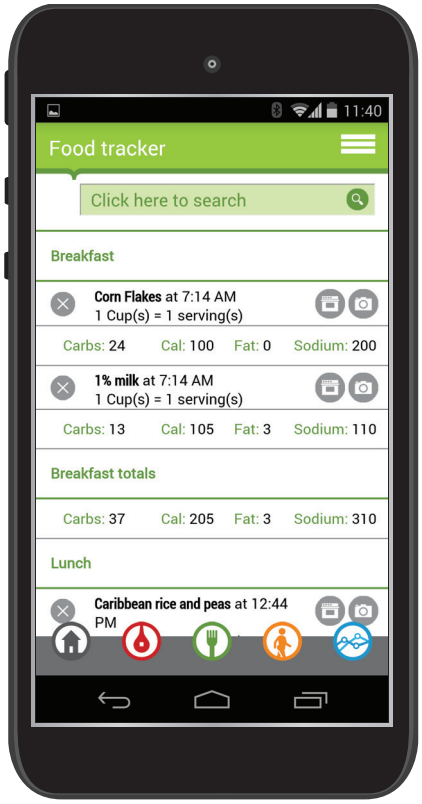


Figure 26. Display of items added
(Display shown on a smart phone)
Display of previously added items could be overwhelming.

2 c) Control to view as much or as little information as an individual wishes

Participants, with the exception of Health Coach B, expressed concern during the first task (the addition of a meal to the food tracker.) They felt that too much content on the screen could be overwhelming for their clients (see *Figure.26*)[13].

> It may be a lot of information, especially when you start adding [many foods]. It may be a lot numbers looking at you and you may not be quite sure what to do. (Health Coach E)

> I'm seeing a lot of information on one screen that just popped up. (Health Coach D)

> There's just too much text…(Health Coach C)

[13] The prototype was pre-populated to ensure the reporting chart had enough content to be read in task 5. This meant that the first encounter participants had with a tracking page was overwhelming as stated by three out of the five participants. The researcher, at first viewed this as a mis-step in the generation of the prototype, but upon reflection this provided rich feedback that may not have occurred if a generous amount of content was not built up though out the completion of the tasks.

2. Tracking of BGL, food, and activity

2 c) Control to view as much or as little information as an individual wishes

GAP REVEALED

Showing the entire day's food entries (unless an individual choses to see them displayed) could be overwhelming contradicting usability heuristic 3: user control and freedom.

DESIGN IMPLICATION

Include the option to display all or some of the content in the trackers (BGL, food, activity) so that an individual can control how much or how little information they wish to see.

2 d) The activity tracker needs more details and more relevant and customizable activity choices

Health Coach C recommended a much more simplified database of activities as many individuals have limited mobility or activity options:

> … [CDA] does have some recommendations on exercise and theirs aren't very detailed … It's encouraging very minimalistic types of activities. (Health Coach C)

Two of the five participants felt the activity tracker did not offer enough detail to allow them to adequately support clients and provide the opportunity for clients to see how varieties in exertion can affect their BGL. Health Coach D and E recommended including a 'rating of perceived exertion scale':

> Rating of Perceived Exertion, which is a subjective scale that is what they to self-monitor one's physical activity. It's a good measure of progress in a client. (Health Coach D)

> The exertion scale could be good to include as well. For example if you're doing cardio versus resistance exercises your blood glucose level may be different after each type. (Health Coach E)

2. Tracking of BGL, food, and activity

2 d) The activity tracker needs more details and more relevant and customizable activity choices

GAP REVEALED

The activity tracker offered too many activity options and was missing details that could be beneficial to the individual contradicting usability heuristic 2: match between system and the real world.

DESIGN IMPLICATION

As per the feedback provided by Health Coach C, the activities database could be revised to be in-line with activities recommended by the CDA or be modifiable so that a healthcare provider can offer personalized activity or exercise choices. It is recommended that a perceived exertion scale be added to activity tracker.

2 e) Technical limitations of the prototype kept mechanical shortfalls in focus vs functionality in relation to diabetes management.

The intent with the time specific tracking feature was that a user would scroll through the numbers, but limitations of the prototype meant that users would have to tap up or down to change the time-stamp. Each participant commented on the challenges of changing the time on the tracking features. For example Health Coach D stated:

> So again I have to tap through each number until I get to 20. I'm not able to scroll.

Thus it could be inferred that this technical limitation prevented participants from focusing on the time-specific tracking feature.

One participant, Health Coach D, mentioned the time-specific tracking aspect which suggests that more descriptive time-specific tracking of the BGL in relation to a meal could be valuable and worth testing further:

> Compared to the app that I use, it's a lot more simplified…[entering the blood sugar] allows you to actually be more specific "after lunch"…the app that I use just put a time stamp on it…

2. Tracking of BGL, food and activity

2 e) The activity tracker needs more details and more streamlined activity choices

GAP REVEALED

Technical limitations of the prototype prevented participants from focusing on time-specific tracking in relation to diabetes management (contradicting usability heuristic 2: match between system and the real world).

DESIGN IMPLICATION

The next iteration for testing should include scrolling to select time. Given that Health Coach D mentioned the value of the feature and the mention of the need for time-specific tracking in the expert interviews, suggests that the feature could be beneficial to healthcare professionals and their clients.

3. Diabetic-focused nutrition facts

3 a) Nutrition facts should have the option to display a traditional format and offer a customizable display

Health Coach D uses a website (Wolfram/Alpha) that generates customized nutrition fact labels as a support tool when working with clients. Health Coach D, prefers this more "traditional label style" approach as she/he sees the value of presenting information in a context her/his clients would see on packaged foods.

Health Coach E would prefer the nutritional fact display to be more customizable as some of the clients they work with may wish to view different nutritional components based on their individual need.

Health Coach C questioned the need for nutrition facts altogether and suggested that they may be more of a benefit to the healthcare provider over the client:

> All that information may be more helpful for the healthcare provider. I find it helpful, but people,I don't know if I ever necessarily talk to them about carbs or sodium or calories…to regular people it doesn't mean anything…

3. Diabetic-focused nutrition facts

3 a) Nutrition facts should have the option to display a traditional format and offer a customizable display

GAP REVEALED

Nutrition facts may be more relevant to the healthcare provider than the client. Health Coach D would like to have the option to display a more traditional label format and Health Coach E would like to be able to customize the nutrition facts display.

DESIGN IMPLICATION

Nutrition facts displayed on the digital app should be customizable so that a client and healthcare provider can focus on nutrition content relevant to individual need. A more traditional format option should also be included to support a match between the system and the real world.

4. Relational serving size to food items

4 a) Relational serving size options could be beneficial in helping healthcare providers understand how an individual is eating and perceiving what they eat.

Health Coach A expressed that the relational serving size to food items could be beneficial to the clients they work with:

> That's very helpful [relational serving size portion] … especially in how I work with my clients because then you can talk about portion size and satiety… and because we don't really know what everyone's eating…

Health Coach E also supported a feature that offered a relational portion sizes:

> [With] some apps your able to take a picture of the meal, but there is nothing to compare it to… Take a picture [of a food item] and document the portion size … then look at it visually to see 'this is what half a cup of rice looks like next to whatever it is that you're eating'.

Health Coach D stated that having relational serving sizes could be a more accessible approach for estimating quantities than measurements/calculations and may be more in-line with the tactics currently used:

> …For most people the quantitative measure of grams or weight is probably not going to be helpful because they're not going to know…so I would say the plate and definitely the size of fist is helpful…

The perceptions stated above infer that relational serving-size option offer a more-real world approach as to how an individual can document their food portions, help healthcare providers better understand how a client perceives a portion size, and reinforces the educational tactics used by the healthcare providers.

4. Relational serving size to food items

4 a) Relational serving sizes reinforce educational tactics used by healthcare providers

GAP REVEALED

Healthcare providers find it challenging to understand what a client is eating and how the client is perceiving the portion size of what they are eating and measuring the weight of food items is not always realistic.

DESIGN IMPLICATION

Relational serving sizes should be included in future iterations. Usability testing would reveal how well clients estimate proportions using measurements/calculations and relational serving sizes.

5. Acknowledging cultural differences

5 a) Preparation of culturally specific foods also needs to be inclusive of low socio-economic status needs

Health Coach A and C noticed the inclusion of more culturally sensitive food choices in the prototype database and the value that these choices could offer the individuals they worked with.

Health Coach D expressed concern that the inclusion of recipes could result in a reminder that certain foods are too expensive for some of the clients they work with:

> I'd be kind of wary in terms of having the same recipes appear for a wide range of clients. Again, I'm all about individualizing plans … physical or mental abilities, cultural background, the amount of resources they have available to them. "I would like to make this, but I can't afford these ingredients;" or, "My culture doesn't really like this food." The fact that it doesn't automatically appear is good, so the client has the option of selecting it.

5. Acknowledging cultural differences

5 a) Preparation of culturally specific foods also needs to be inclusive of low socio-economic status needs

GAP REVEALED

The digital apps attempts to be culturally sensitive by including recipes could cause unintended harm for those with low socioeconomic status usability heuristic 2: match between system and the real world.

DESIGN IMPLICATION

Keep the display of recipes optional, so that a client can control whether or not they wish to use the feature. Recipe display should also be easy to modify or augment by both the client and the healthcare provider in order to make a recipe more relevant to the clients circumstances.

Recommendations

The following is a list of recommendations for the next iteration of the digital app:

Customization

1. As stated by Health Coach D more overt personalization could better support the client. This could be achieved by ensuring the wording/labeling used supports the customizable nature of the digital app by including words such as “my” and “your” into headings and legends. Instructions during the preference setup could also remind individuals that they should work with their healthcare provider to set goals and identify needs.

2. The report feature should have the ability to provide more detailed content. The ability to reveal more details on a specific entry on the report could be added to support stronger cause/effect connections. For example, if an individual had a high BGL after lunch, they could select "lunch report" to get a list of the content of that meal.

3. Based on feedback during the completion of the tasks, the option to take a photo of a meal should be to added to the food tracker. This could allow for flexibility and efficiency of use in order to accommodate a variety of individuals’ needs in relation to documenting food choices. For example, someone who wants to better understand portion sizing could take photos to share with their healthcare provider for discussion and advice.

Tracking BGL, food, and activity

4. Two of the five participants felt the activity tracker did not offer enough detail to allow clients to see how various levels of exertion can affect BGLs. It is recommended that a perceived exertion scale be added to the activity tracker. As per the feedback provided by Health Coach C, the activities database could be revised to be in-line with activities recommended by the CDA.

5. Participants commented on the layout of the interface design, often referring to it as a "streamlined" approach that they felt kept the layout clean and consistent. With the inclusion of a perceived exertion scale to the activity tracker, the visual representation in the report could become more consistent to the other categories, potentially adding to the ease-of-use that participants responded to positively.

6. The next iteration for testing would need to have a more true-to-reality feature for changing time (scrolling to select time) to avoid confusion during testing. Given that Health Coach D mentioned the value of the feature and the mention of the need for time-specific tracking in the expert interviews, it was inferred that the feature could be beneficial to healthcare professionals and their clients and warrants further testing.

Diabetic-focused nutrition facts

7. Nutrition facts displayed on the digital app should be customizable so that a client and healthcare provider can focus on nutrition content relevant to individual need. A more traditional format option should also be included to support a match between the system and the real world.

Relational serving sizes to food items

8. Relational serving sizes were deemed to be a valuable way for clients to estimate portions. Usability testing would reveal how well clients estimate portions using measurements/calculations and relational serving sizes.

Acknowledging cultural differences

9. As recommended by Health Coach D, the recipe display should be kept optional so that an individual can control if they wish to use the feature. This feature should also be easily modifiable for the client or healthcare provider in order to make a recipe more relevant to individual circumstances.

LIMITATIONS

This study has provided valuable information for the design of a digital app for those with type 2 diabetes and their healthcare providers.

While four health coaches and one exercise physiologist volunteered for usability testing, a larger participant pool including more professions (e.g.: dietitians, psychologists, social workers) from within the diabetes healthcare team would allow for a more diverse set of perspectives with a greater possibility for uncovering more nuanced feedback on the prototype.

The discrepancies in rating task difficulty (*see Appendix P*) were minimal. Typically the researcher gave a higher difficulty rating, which may suggest the researcher was more sensitive to difficulties than the observer, given their commitment to the project. This did not effect the results, as the same outcomes were reported. To ensure bias is not affecting observations, additional observers could be added for future studies.

The lack of testing with those who have type 2 diabetes limits the results of the study. While the first round of testing with healthcare providers provided valuable feedback, ideally these results would culminate into a second iteration to be tested with clients with type 2 diabetes to collect their perceptions and needs in the context of using a digital interface and self-care strategies. This was outside of the scope for this study and could be considered in future studies.

It is important to recognize that a digital app cannot suit everyone's information needs. This study assumes that users would have some degree of health and technology literacy as well as an interest in using a digital app. In order to be sensitive to the needs of individuals with low health and/or technology literacy, education and training could help to provide the necessary skills to use the digital app and resolve some of the issues around the complexity of the technology.

There is also an assumption that someone interested in using a digital app has access to a smart phone or tablet. To support those with low socioeconomic status who may not have access to smart phones, funding from federal, provincial, or private sources would need to be considered by healthcare providers looking to include a digital app into their programing.

CONCLUSION

The goal of this study was to see how information design could support existing strategies and education provided by healthcare providers and assist Canadians living with type 2 diabetes in making more personally relevant choices in relationship to their type 2 diabetes management needs.

The use of expert interviews helped to identify needs of those with type 2 diabetes and the healthcare providers who support them. Armed with the healthcare providers perspectives and insights, the prototype components were designed to address both the needs of the client in self-care strategies and type 2 diabetes management from the healthcare provider perspective.

The support tool could allow individuals to track and observe their food intake, activities, and BGL readings to create visual representations of this information, and to see the relationship among their actions, choices, and their body's response. Using the digital app could, potentially, lead to fewer misunderstandings and challenges to understanding and applying information on the part of the individual with type 2 diabetes. The digital app also allows the healthcare provider the opportunity to encourage collection of relevant information in a format that showcases the cause/effect of an individuals' choices. This could lead to less time spent deciphering logs and more time working with individual on their needs and goals.

Further studies should include user testing with individuals with type 2 diabetes to collect their perceptions and needs in the context of using a digital interface and self-care strategies. This should include revisions based on those outlined in the recommendation section in this study, such as:

- Adding modifiable functions and better visual prompts that help an individual recognize that the digital app is customizable and testing to see if that contributes to more successful diabetes management;
- Testing scenarios that could reveal how well clients estimate portions using the measurements/ calculations and relational serving sizes offered in the digital app;

- Adding the ability to reveal more details on a specific entry on the report and generating tasks to test whether or not offering more in-depth details support stronger cause/effect connections.

The key concept revealed during this study it is that information is context dependent. This means that information is never isolated from the system or circumstance in which it exists. In the context of this study information was intertwined with the complex circumstances of clients and the healthcare providers they work with. The need for human-centered design, that honoured the relevance of individual circumstance, was apparent at each stage—from the literature review, to expert interviews, to the usability study. Thus, designing for information need is critical to challenges such as diabetes management and sustainable self-care strategies for those with type 2 diabetes.

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Appendix A: Sample interview questions

Establishing Questions

1. What are the strategies available to individuals with type 2 diabetes?
2. What type of support does the health system provide?
3. What precipitates the visit—prevention/treatment/support for a family member? Who normally recommends them to the clinic? [Prompt: Do you have anyone seeking out preventative strategies ie: people who do not have type 2 diabetes, but are at risk of developing it?]
4. What are some of the most prominent barriers to success in maintaining consistent blood glucose levels that you see in the people you treat?

Healthy Eating and Lifestyle Choices

5. Do you or your clinic use a particular healthy-eating strategy as a way for people to manage their type 2 diabetes? Please explain.
6. Everyone has different perspectives and motivations when it comes to making changes that will benefit their health. Can you describe an instance where a particular healthy-eating strategy was not successful and how you helped that individual?
7. What type of behaviours do you encourage? [Prompt: food choices, portion control, exercise, mental health practices]
8. What are some of the reasons you hear people give for why they have difficulties following a strategy or program to help them maintain their type 2 diabetes?

Labels

9. Many of my findings so far have inferred that the structure and content presentation on nutrition fact labels does not support a person as well as it could in making healthy choices. Several studies suggest that there is a need for greater education to teach people how to read labels. In your experience have you found that your patients encounter difficulties in understanding a nutrition facts label? Please explain. [If not, are there any scenarios/examples you can share where a patient has been challenged or experienced difficulties in making food choices?]

Appendix A: Sample interview questions continued…

Services and Programs

10. Have you ever used technology, service or program to help a person manage any aspect of their type 2 diabetes? If so, what device, service or program did you use? [Prompt: Food diaries, depression/stress support, blood glucose tracking]

Conclusion

11. Is there any other information that you would like to share about your experience helping people manage type 2 diabetes that you think would be beneficial to this study?

Appendix B: office of research ethics approval certificate

YORK
UNIVERSITÉ
UNIVERSITY

OFFICE OF RESEARCH ETHICS (ORE)

5th Floor,
Kaneff Tower,
4700 Keele St.
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www.research.yorku.ca

Certificate #:	**STU 2013 - 144**
Approval Period:	**10/11/13-10/11/14**

Memo

To: Nancy Snow, Department of Design, nsnow@yorku.ca

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics
(on behalf of Duff Waring, Chair, Human Participants Review Committee)

Date: **Friday, October 11, 2013**

Re: Ethics Approval
How Information Design Can Support Canadians with Type 2 Diabetes

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I am writing to inform you that the Human Participants Review Sub-Committee has reviewed and approved the above project.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics

Appendix C: Solicitation of interview participants

Hello XXX,

I have been provided your name and contact information from XXXX.

My name is Nancy Snow and I am a Masters student of Design at York University. I will be developing and testing components for an app to support people with type 2 diabetes.

As I am not an expert in nutrition or nutrition therapy, I would like to conduct semi-structured interviews with professionals who work with people with type 2 diabetes to ensure I am creating something that has the potential to support people and not something that could be misleading, factually incorrect or difficult to understand.

Also, as many studies have supported the value of educational support in successful maintenance of blood glucose levels and heart-healthy diets my intent is that an app such as this would be used as a tool in relationship to professional support and education.

Benefits of participating in an interview such as this could be seen in the sharing of your expertise that could contribute to a beneficial visual representation of nutrition facts or that could lead to improved understanding on the part of those struggling to manage their type 2 diabetes.

If you feel this is something that you could volunteer no more then 45 minutes of your time for I can make arrangements to come to your place of work at a time that is ideal for you and your schedule.

Attached is an informed consent form for you to read and understand the scope of the interview and your rights in regards to this process. If you agree to participate an email [or letter] will follow shortly that will include the base questions for the interview so that you may have advanced knowledge of what you will be asked.

Thank you for your time. Please do not hesitate to contact me if you need further clarity or if you have any questions.

Nancy Snow, Mdes Candidate
York University
nsnow@yorku.ca

Appendix D: Informed consent form for interviews

How Information Design Can Support Canadians With Type 2 Diabetes
Informed Consent Form for Interviews

Researcher/Interviewer:
Nancy Snow
nsnow@yorku.ca
Masters of Design (MDes) York University

Purpose of Research:
This study will examine representations of nutritional content in the form of a digital application (app) to explore how information design can support already existing tools such as professional education and assist Canadians living with type 2 diabetes, especially those who are newly diagnosed, in making more informed choices and to better understand the content of the food they eat as it relates to their dietary needs.

Scope of research:
Research Opportunity:
Canadians place a high level of significance on the Nutrition Facts label yet many cannot easily understand the content or identify how the content relates to their health.

Research question:
What kind of graphic and/or character-based system is easy-to-understand and can help provide relevant information from the Nutrition Facts label for a Canadian with type-two diabetes?

Intent of interview:
A semi-structured expert interview with a nurse educator, registered dietitian, and a family physician will be conducted to ensure multiple perspectives and insight is collected that will inform the choices of content and structure of an app in order to create a comprehensive support tool. The content of the interviews along with the information gathered in the literature review and analysis will inform the development of a prototype app for testing with the target audience of Canadians with type 2 diabetes and health-care providers that work with this group of people, such as nurse educators, registered dietitian and family physicians.

What will be required of you:

You will be asked to participate in a semi-structured interview about your approach and strategies for type 2 diabetes management. The interview session should take no more than 45 minutes of your time.

Risks/Benefits:
There are no known risks to participating in this study. Benefits of participating in an interview such as this could be seen in the sharing of your expertise that could contribute to a beneficial visual representation of nutrition facts or that could lead to easier to understand support tools for others that are struggling to manage their type 2 diabetes.

Appendix D: Informed consent form for interviews continued…

Voluntary participation:
Your participation in the research is completely voluntary and you may choose to stop participating at any time. If you decide to stop participating, it will not influence your relationship or the nature of their relationship with researchers or with staff of York University either now or in the future.

Incentives:
You will be offered a coffee, tea or beverage (approx. value no greater than $5.00) while the interview is being conducted.

Withdrawal from the study:
You may stop participating in the study at any time, for any reason, if you so decide. Your decision to stop participating, or to refuse to answer particular questions, will not affect your relationship with the researchers, York University, or any other group associated with this project. In the event that you withdraw from the study, all associated data collected will be immediately destroyed, wherever possible.

Confidentiality:
All information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. Confidentiality will be provided to the fullest extent possible by law.

Storage of Data:
Data will be labeled with no identifiable information on any individuals. Each interview will be labeled with a randomized number for tracking purposes or incase of a follow up study. A list with names and the randomized number will be stored securely in a separate locked office. The letters of consent, audio recorded interviews and transcripts will be collected and stored digitally in the office of Nancy Snow and kept for five years.

Data Dissemination
Data collected during this interview will be analyzed and used to develop the structure, content and approach for a digital app prototype of that will be tested with persons who are living with type 2 diabetes. This data will also be used in writing a support paper that will accompany the prototype.

Questions about research?
This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this project please feel free to contact: Sandra Gabriele, Associate Professor. Department of Design, York University, 4008 TEL Building, 4700 Keele Street, Toronto, Ontario M3J 1P3 Canada, telephone 416 736 2100 ext. 77448 or email, sandrag@yorku.ca
If you have any questions about this process, or about your rights as a participant in the study, your may contact the Senior Manager and Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University, telephone 416-736-5914 or email ore@yorku.ca

Appendix D: Informed consent form for interviews continued…

Legal Rights and Signatures:

"I _____ consent to participate in an interview on type 2 diabetes management for the study **How Information Design Can Support Canadians With Type 2 Diabetes** conducted by Nancy Snow from York University. I have had the opportunity to ask questions about the study and my rights as a participant. I understand the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form.

_____ **Date**

Participant

_____ **Date**

Principal Investigator: Nancy Snow

Appendix E: DECIDE framework

DECIDE framework

Determine purpose

The purpose of this usability study was to discover gaps in procedures (for example is an action common to BGL tracking missing in the digital app interface?) or content and to test the functionality and visual design of the interface to improve capabilities of the digital app. Healthcare providers were targeted participants because of their expertise, insight and perceptions of what may be challenging or beneficial to individuals who have type 2 diabetes in terms of presentation of content and ease-of-use.

Explored questions

The explored questions were focused around appropriateness and ease-of-use of the components offered in the digital app prototype:

- Does the design of the interface support the activities and tasks of those with type 2 diabetes?
- Does the design of the interface augment and extend the care the healthcare worker provides?
- Is the labeling and language used in the interface appropriate and understandable?

Choose data collection/materials

At the beginning of the study a basic questionnaire (*see Appendix F*) was administered to healthcare providers to establish:

- Their position and how they define their role in relationship to their clients.
- Their priorities (ex: tracking BGLs, exercise etc.) in diabetes management.
- How clients currently log their data (food, BGL, etc.)

Appendix E: DECIDE framework continued…

Healthcare providers participated in five structured tasks (*see Appendix G*) role-playing a person with type 2 diabetes, using a talk-aloud protocol with a researcher and observer (referred to as 'observers') present to document words and actions.

Based on information provided in the expert interview phase, the structured tasks were designed with specific goals individuals with type 2 diabetes may be interested in achieving.

A talk-aloud protocol allowed the participant to verbalize their actions while conducting a task so the observers would be able to better understand the relationship between thoughts and actions. This helped observers understand what a participant was trying to do while engaging with a task. Audio for each session was recorded.

Observers used an opinion-based rating system (*see Appendix P)* and visual layout of an intended pathway for each task (*see Appendix Q-U)* to document the perceived levels of difficulty experienced by the participant. This was used for efficiency and consistency in data collection and to determine patterns in the participants' approach of interaction and highlighted areas of confusion or opportunities to improve the capacity of the digital app. It also helped to answer questions such as: When do participants follow the assumed path? Do they veer off the path and, if so, where do they go and what do they do? What do they look for in terms of labeling or flow?

Each session closed with a few open-ended questions (*see Appendix E*) to ensure participants had the opportunity to offer additional feedback about the digital app as it related to their experience and expertise.

Appendix E: DECIDE framework continued…

Identify practical issues

Usability participants were recruited via participant recruitment posters (*see Appendix H*) posted through the Black Creek Community Health Centre and sent to those who participated in the expert interview phase.

The following equipment was used to display the prototype and collect data:

- Nexus 7 tablet to display prototype for use during testing.
- Audio recorder and laptop for recording dialogue.
- Questionnaires, Opinion-based rating system and visual layout of intended pathway sheets, protocol script and informed consent forms.

Decisions on ethical issues

This study was reviewed and approved by the Office of Research Ethics at York University (*see Appendix B and V*). Before the usability studies were conducted, each participant reviewed the contents of the consent form (*see Appendix I*) and were given an opportunity for questions before signing the consent form.

Evaluate, interpret and present

Information collected from the healthcare providers in the form of a questionnaire was analyzed to:

- Identify levels of web/mobile expertise as this could affect a participant's ability to evaluate the digital apps functionality.

- Establish the priorities of the healthcare provider in relation to diabetes self-care management to see if there are similarities to those established in the expert interview phase.

Appendix E: DECIDE framework continued…

Audio recordings of the tasks were transcribed by an outside source and open coding procedures were used to identify themes. Information from the transcriptions were also cross-referenced with the information collected manually by the observers in the attempt to find nuances that may have been overlooked if a participant did not provide enough verbal feedback.

Appendix F: Questionnaire for usability study

(7 questions): Questions to be answered before the study.

Please answer the following questions by checking the box beside the response that applies to you.

1. Did you participate in the "expert interviews" conducted at the beginning of this study?
❑ Yes
❑ No

2. Which of the following most closely describes your position at the clinic?
❑ Dietitian
❑ Exercise physiologist
❑ Family physician
❑ Health coach
❑ Nurse Practitioner
❑ Other

_____

3. What is your primary role in a diabetes management health care team?

_____

_____

_____

4. What should be the goal in supporting those who are living with type 2 diabetes?

_____

_____

_____

5. How would you define your level of experience using a mobile device (e.g., smartphone, tablet)?
❑ None
❑ Novice
❑ Intermediate
❑ Advanced
❑ Expert

Appendix F: Questionnaire for usability study continued…

6. How would you define your level of experience using the web/internet (e.g., banking, youtube)?
❑ None
❑ Novice
❑ Intermediate
❑ Advanced
❑ Expert

7. To the best of your knowledge do you and/or your clients use any of the following digital apps or methods for diabetes management? If yes, please indicate in the lines below what tasks you use them for, what you feel is beneficial in using them and what you feel could be improved (Select all that apply).

❑ dbees.com

_____

_____

❑ diabetes pilot

_____

_____

❑ glooko

_____

_____

❑ glucool diabetes

_____

_____

❑ glucose buddy

_____

_____

❑ iBGstars

_____

_____

❑ LogFrog

_____

_____

Appendix F: Questionnaire for usability study continued…

❑ OnTrack

_____

_____

❑ my fitness pal

_____

_____

❑ nexj health coach

_____

_____

❑ diary (paper/pen)

_____

_____

❑ Other

_____

_____

❑ unsure

Appendix G: Script for talk-aloud protocol and tasks

Project Brief:
My name is Nancy Snow and I am a Masters of Design student at York University.
I have been developing components for a digital app to support people with type 2 diabetes. It is greatly appreciated that you, as healthcare provider that works with those who have type 2 diabetes, are able to take time out of your schedule to help improve this potentially useful technology.

A demonstration…
In order for us to understand your thought process as you engage with the digital app, we ask that you speak aloud your thoughts as you move through the interface.

(Nancy to demonstrate this by talking aloud her process of going into a new app on her phone.)

To begin…
The intention of the digital app is to offer someone a customizable tracking tool so that they can identify what they want to pay attention to at any particular moment in a way that they feel is most comfortable to them. While our research has shown that there are many aspects to self care in diabetes management, interviews conducted with healthcare providers in phase one of this study highlighted three key areas that many people with type 2 diabetes wish to focus on: 1) glucose level tracking 2) food tracking 3) activity tracking.

You will be asked to complete five (5) tasks in relation to these three core components.

The following are tasks that the clients you work with could be expected to engage in with the digital app. Thus, imagine you are a client while you attempt each task and consider what aspects may be beneficial or what aspects may pose potential challenges.

Also consider how the features in the digital app would support you or hinder you in your work with your clients. There will be an opportunity at the end of all 5 tasks to provide additional feedback.

It is important to note:
The purpose of this usability study is to discover gaps in procedures or content, test functionality and the visual design of the interface to improve capabilities of the digital app.

Thus the **goal of prototype testing is the usability and function of the digital app and is in no way testing your abilities.**
Before we begin, are there any questions?

Once we begin the tasks I would prefer not to answer any questions about how the digital app works, as one of the goals with the testing is to determine ease of use. However, if you become really stuck I can step in with a prompt.

As demonstrated, please make sure to talk aloud all thoughts that come to mind as you work your way through the task. Please identify when you feel you have completed the task with a statement such as "I am done the task."

We will begin now…(Nancy to touch screen and hand device to participant start)

Task #1: Add food to the digital app (task 1, image 1)

On your way home from work you decide to have dal and roti for dinner as you have some left over from the previous night's meal. You eat 1 cup of dal and ½ a cup of rice. Here is an image that shows you what you have eaten, the portion and at what time.

Please add your meal to the digital app.

Task #2: Add another item to the food tracker (task 2, image 1)

You realize that you also had a glass of milk so you decide to add that to the food tracker as well. Here is an image that shows you what you have eaten, the portion and at what time.

Please add your drink to the digital app.

Task #3: Test blood glucose levels (task 3, image 1)

After adding the drink to your digital app you have realized that you are over the target carb range that you have set for a meal of 45g to 65g. The digital app asks you if you are interested in testing your blood sugar an hour from now to see how your body responds to the meal you have just eaten. You have selected yes and the reminder is set.

An hour passes and you test your glucose level with your blood glucose meter.
Here is an image of your blood glucose meter with the reading you are to add.

Please add your glucose level to the digital app.

Task #4: Add an activity to the tracker (task 4, image 1)

You decide to take a walk around the neighbourhood to see if that has any affect on your glucose reading. You walk for 20 minutes. When you come home you add a 20 minute walk to your digital app.

Here is an image of your 20 minute walk.

Please add your activity to the digital app.

Task #5: Report (task 5, image 1)

At the end of your day you add your final glucose reading to your digital app.
Here is an image of your blood glucose meter with the reading you are to add.

Please add your glucose level to the digital app.

You then decide to look at the report for the day to see if you remembered to add everything and to see how your body responded to the day's meals and activities.

Please go to the report and explain how you would interpret the information there?

After the 5 tasks are complete:

1. Was there anything that you had hoped the digital app offered but you didn't see in relation to the tasks you completed?
2. Do you think any of the features in the components you tested could be a benefit to the individuals you work with?
3. Do you have any suggestions for improvements?
4. [any questions that arouse during the talk-aloud ask here]

Appendix H: Participant recruitment poster

Volunteers Needed

Do you work with those that have type 2 diabetes? Volunteers needed to test the functionality of a digital app prototype.

My name is Nancy Snow and I am a Masters of Design student at York University. I will be developing and testing components for a digital app to support Canadians with type 2 diabetes.

The Study:
Canadians place a high level of significance on the Nutrition Facts label yet many cannot easily understand the content or identify how the content relates to their health.

This study will examine components of a digital application (app) to see how design can add support to already existing networks such as professional education and assist Canadians living with type 2 diabetes, especially those who are newly diagnosed, in making more informed choices and to better understand the content of the food they eat as it relates to their dietary needs.

What you will be asked to do:
Each participant will be required to complete five tasks and a short pre-questionnaire. The entire process should take no longer then one hour.

Benefits:
Benefits of participating in a prototype test such as this are a great way to share your expertise that could lead to easier to understand support tools for people to manage their type 2 diabetes.

If you feel this is something that you could volunteer no more then a hour (1 hr) of your time please contact me at the email below to schedule a time that is most convenient for you to participate. Testing will take place at the York/TD Community Engagement Centre or at York University.

Nancy Snow, MDes Candidate
York University
nsnow@yorku.ca

Appendix I: Informed consent form for prototype testing participants

Informed Consent Form for Prototype Testing Participants
Study name: How Information Design Can Support Canadians With Type 2 Diabetes

Researcher:
Nancy Snow, nsnow@yorku.ca, Masters of Design (MDes) York University

Purpose of Research:
This study will examine representations of nutritional content in the form of a digital application (app) to explore how information design can support already existing tools such as professional education and assist Canadians living with type 2 diabetes, especially those who are newly diagnosed, in making more informed choices and to better understand the content of the food they eat as it relates to their dietary needs.

Scope of research:
Research Opportunity:
Canadians place a high level of significance on the Nutrition Facts label yet many cannot easily understand the content or identify how the content relates to their health.

Research question:
What kind of graphic and/or character-based system is easy-to-understand and can help provide relevant information for a Canadian with type-two diabetes?

What will be required of you:
Each participant will be required to complete five sets of tasks designed to emulate the usage of a digital app for the management of type 2 diabetes. The prototype testing will assess ease of use, accuracy of content structure and visual presentation. This study should take no more then one hour of your time to complete.

Risks/Benefits:
There are no known risks to participating in this study. Benefits of participating in a prototype test such as this are a great way to share your life experience of living with type 2 diabetes or working in a healthcare-provider role that supports those with type 2 diabetes. The sharing of your perspective could lead to easier to understand support tools for those that are struggling to manage their type 2 diabetes.

Voluntary participation:
Your participation in the research is completely voluntary and you may choose to stop participating at any time. If you decide to stop participating, it will not influence your relationship or the nature of their relationship with researchers or with staff of York University either now or in the future.

Incentives:
During the prototype testing sessions you will be offered coffee, tea or beverage (approx. value no greater than $5.00) while you fill out the pre-questionnaire or a 5.00 gift card for later use.

Withdrawal from the study:
You may stop participating in the study at any time, for any reason, if you so decide. Your

decision to stop participating, or to refuse to answer particular questions, will not affect your relationship with the researchers, York University, or any other group associated with this project. In the event that you withdraw from the study, all associated data collected will be immediately destroyed wherever possible.

Confidentiality:
All information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. Confidentiality will be provided to the fullest extent possible by law.

Storage of Data:
Data will be labeled with no identifiable information on any individuals. Each interview will be labeled with a randomized number for tracking purposes or incase of a follow up study. A list with names and the randomized number will be stored securely in a separate locked office. The letters of consent, audio recorded interviews and transcripts will be collected and stored digitally in the office of Nancy Snow and kept for five years.

Data Dissemination
Data collected during the prototype testing will be analyzed and used to further develop the structure, content and approach of the digital app prototype. This data will also be used in writing a support paper that will accompany the prototype.

Questions about research?
This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this project please feel free to contact: Sandra Gabriele, Associate Professor. Department of Design, York University, 4008 TEL Building, 4700 Keele Street, Toronto, Ontario M3J 1P3 Canada, telephone 416 736 2100 ext. 77448 or email, sandrag@yorku.ca. If you have any questions about this process, or about your rights as a participant in the study, your may contact the Senior Manager and Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University, telephone 416-736-5914 or email ore@yorku.ca

Legal Rights and Signatures:
"I _____ consent to participate in an interview on type 2 diabetes management for the study **How Information Design Can Support Canadians With Type 2 Diabetes** conducted by Nancy Snow from York University. I have had the opportunity to ask questions about the study and my rights as a participant. I understand the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form.

_____ **Date**
Participant

_____ **Date**
Principal Investigator: Nancy Snow

Appendix J: Customization (Requirement Sheet)

CUSTOMIZATION

Category *Coding from interviews*	**Source** *credit, #*	**Current Situation** *What is currently happening*	**Aspiraton** *What par.wishes they could do*	**MoSCoW** *Priority (Must, Should, Could, Want)*
AWARENESS (Cause and effect | context)	HC1 p 9	"I mean, it's really dependent on the client and where they are with their food. Like if they want to set smaller goals, then, and if they want to do something else then that's fine as well.	N/A	Must
AWARENESS (Barriers | access)	HC1 p 14	"It can be a useful tool—it's just how it's presented	Make the information presented more useful	Must
AWARENESS (Barriers | access)	HC1 p 2	They all come in with so many different circumstances, and every time they come in, obviously individually, you know, something else is wrong, something else has happened, you know. Life hits them, like it's all of us. And I want them to know that it's still possible to move forward — right now, what can we do right now?"	Honour the individual	Must

Appendix K: Tracking (Requirement Sheet)

TRACKING

Category *Coding from interviews*	**Source** *credit, #*	**Current Situation** *What is currently happening*	**Aspiration** *What par.wishes they could do*	**MoSCoW** *Priority (Must, Should, Could, Want)*
AWARENESS (cause and effect)	D1 p 7	Uses my fitness pal (+ similar apps) to track food intake.	Wishes there was a place to document BG level and time of day when taken to discern patterns of food/BGL relationship	Must
AWARENESS (cause and effect)	D1 p 7/8	Uses my fitness pal (+ similar apps) to track food intake. Snacks lumped together so has to ask "When did you eat this?" (GOAL: LOOKING AT PATTERNS)	Wishes snacks could be time-of-day sensitive	Must
AWARENESS (cause and effect)	HC2 p 1	99% of the time when clients exercise their blood sugar level goes down. (GOAL: CAUSE AND EFFECT)	Track activity	Must
AWARENESS (cause and effect)	HC1 p 15	Clients found it beneficial to see changes over time. To see how they could effect their BGL. "Having McDonalds once a week instead of everyday"	Track food and blood glucose to see relational connection	Must
AWARENESS (cause and effect)	HC1 p 1	Tracking so they can see the changes in the blood glucose, even if they are not making any changes	Track glucose levels	Must
AWARENESS (cause and effect)	HC1 p 16	See you ate this and your blood sugar is this	Track food and blood glucose to see relational connection	Must

Appendix L: Relational Serving Size To Food Items (Requirement Sheet)

RELATIONAL SERVING SIZE TO FOOD ITEMS

Category *Coding from interviews*	**Source** *credit, #*	**Current Situation** *What is currently happening*	**Aspiration** *What par.wishes they could do*	**MoSCoW** *Priority (Must, Should, Could, Want)*
AWARENESS (barriers | access)	D1 p 14	Label reading education. Serving size realistic to what someone is eating. E.g. whole can of soup not challenging to assess portion of can defined as serving size (GOAL: ACCURATE ACCESS)	Serving size was more relationale to what is served.	Must
STRATEGY (tactic | self-sustaining)	D1 p 13	Visual/physical representations of food are tactics used to address language/numeracy issues. (GOAL: COMPREHENSION)	n/a	Must
AWARENESS (barriers | comprehension) STRATEGY (tactic | self-sustaining)	HC1 p 9/10	Method from dietitian but seems reluctant to promote it. "It can be effective in helping weight lose and balances the all food groups."	Thinks what the clients eat and what their goals are take precident.	Must
AWARENESS (barriers | access)	D1 p 14	"Yeah. So another kind of challenging area for patients and for us too is the whole eating out."	Carb focus when eating out can be a challenge because how do you know what you are eating?	Must
AWARENESS (barriers | access)	HC1 p 8	Serving size is all about value in take out so everything is multiple servings	"And I always try to figure it out myself, you know. Ok, so dahl probably has beans, so there's your protein. It probably has this, so that's this. Ok, so it's kind of figuring it out myself and what's best for the client."	Could
TACTIC (tool |digital)	HC1 p 8	Food app from NexJ that allows people to photograph food	Precieved rating scale to show how some identifies with food choice	Could
TACTIC (tool |digital)	HC2 p 6	Food app from NexJ that allows people to photograph food	Precieved rating scale to show how some identifies with food choice	Could

Appendix M: Diabetic-focused Nutrition Facts (Requirement Sheet)

DIABETIC FOCUSED-NUTRITION FACTS

Category *Coding from interviews*	**Source** *credit, #*	**Current Situation** *What is currently happening*	**Aspiration** *What par.wishes they could do*	**MoSCoW** *Priority (Must, Should, Could, Want)*
STRATEGY (tactic | self-sustaining)	HC1 p 10/12	Comprehension issues around carb's	Make the information more personally relivant	Must
AWARENESS (barriers | comprehension)	HC1 p 13	GOAL: FOOD IN CONTEXT	Make the information more personally relivant	Must
AWARENESS (barriers | access)	HC2 p 6	"I don't like how it says carbs and then it says sugar, so sometimes it can be very misleading." AND"it's not an effective way to help people make decisions, yeah."	Make the information presented more useful in decision making	Must
AWARENESS (barriers | access)	HC1 p 14	"It can be a useful tool—it's just how it's presented	Make the information presented more useful	Must
AWARENESS (barriers | comprehension)	D1 p 11/12	Label reading education. Much time and resource is spent on label reading. (GOAL: COMPREHENSION)	Share/access applied coping skils	Must

Appendix N: Acknowledging Cultural Differences (Requirement Sheet)

ACKNOWLEDGING CULTURAL DIFFERENCES

Category *Coding from interviews*	**Source** *credit, #*	**Current Situation** *What is currently happening*	**Aspiration** *What par.wishes they could do*	**MoSCoW** *Priority (Must, Should, Could, Want)*
AWARENESS (Barriers | access)	HC1 p 5&18	Dietitians in this particular clinic us CFG, but it does not help those who eat outside of north american norms	Access to data relivant to cultures outside of north american cuisine	Must
AWARENESS (Barriers | access)	HC 2 p 3	"You have to learn about other people's cuisines 'cause the stuff that you see in the Canadian Food Guide, nobody eats that." PLUS these are the groups of people with the highest risk.	Access to data relivant to cultures outside of north american cuisine	Must

Appendix O: Usability study questionnaire matrix diagram

QUESTIONNAIRE		HEALTH COACH "A" MARCH 20	HEALTH COACH "1" MARCH 20	HEALTH COACH "B" MARCH 20	HEALTH COACH "C" MARCH 21	HEALTH COACH "D" MARCH 21
Did you participate in the expert interviews conducted at the beginning of this study	1					
Yes			●			
No		●		●	●	●
Which of the following most closely describes your position at the clinic	2					
Dietitian						
Exercise physiologist			●	●	●	●
Family physician						
Health coach		●		●		●
Nurse practitioner						
Other-kinesilogist						●
How would you define your level of experience using a mobile device (e.g., smartphone, tablet)	5					
None						
Novice						
Intermediate						●
Advanced		●			●	
Expert			●	●		
How would you define your level of experience using the web/internet (e.g., banking, youtube)	6					
None						
Novice						
Intermediate						●
Advanced		●			●	
Expert			●	●		
To the best of your knowledge do you and/or your clients use any of the following digital paps or methods for diabetes management	7					
Dbees.Com						
Diabetes pilot						
Glooko						
Glucool diabetes						
Glucose buddy					●	
IBGstars						●
Logfrog						
Ontrack						
My fitness pal			●		●	
Nexj health coach		●	●	●	●	●
Diary (paper/pen)			●		●	●
Other						
Unsure						

Appendix P: Opinion-based rating system
(detail from Appendix I: Visual task sheet)

Opinion-based rating

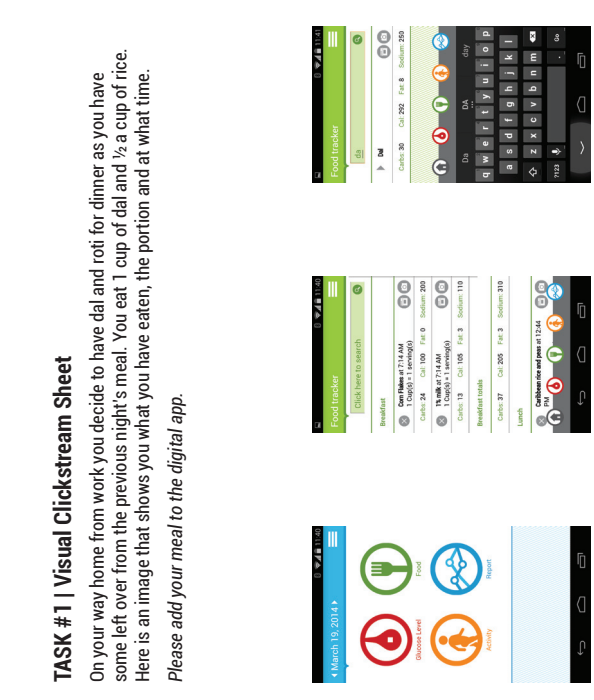
0	0	Task completed with no perceived difficulty or frustation.
1	1	Task completed, perceived slight difficulty or frustation.
2	2	Task completed with some deadends and attempts.
3	3	Task completed with multiple deadends and attempts.
F	4	Task not completed. (Point of failure _____)

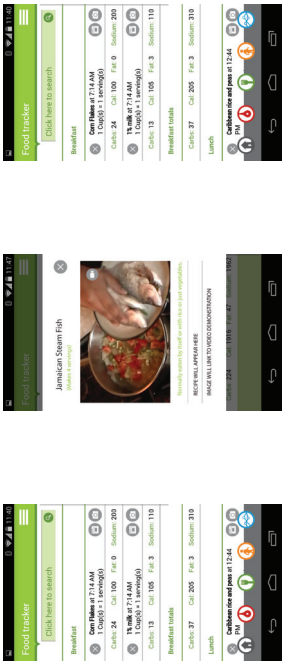
Appendix Q: Task-based scenario sheet Task #1

TASK #1 | Visual Clickstream Sheet

On your way home from work you decide to have dal and roti for dinner as you have some left over from the previous night's meal. You eat 1 cup of dal and ½ a cup of rice. Here is an image that shows you what you have eaten, the portion and at what time.

Please add your meal to the digital app.



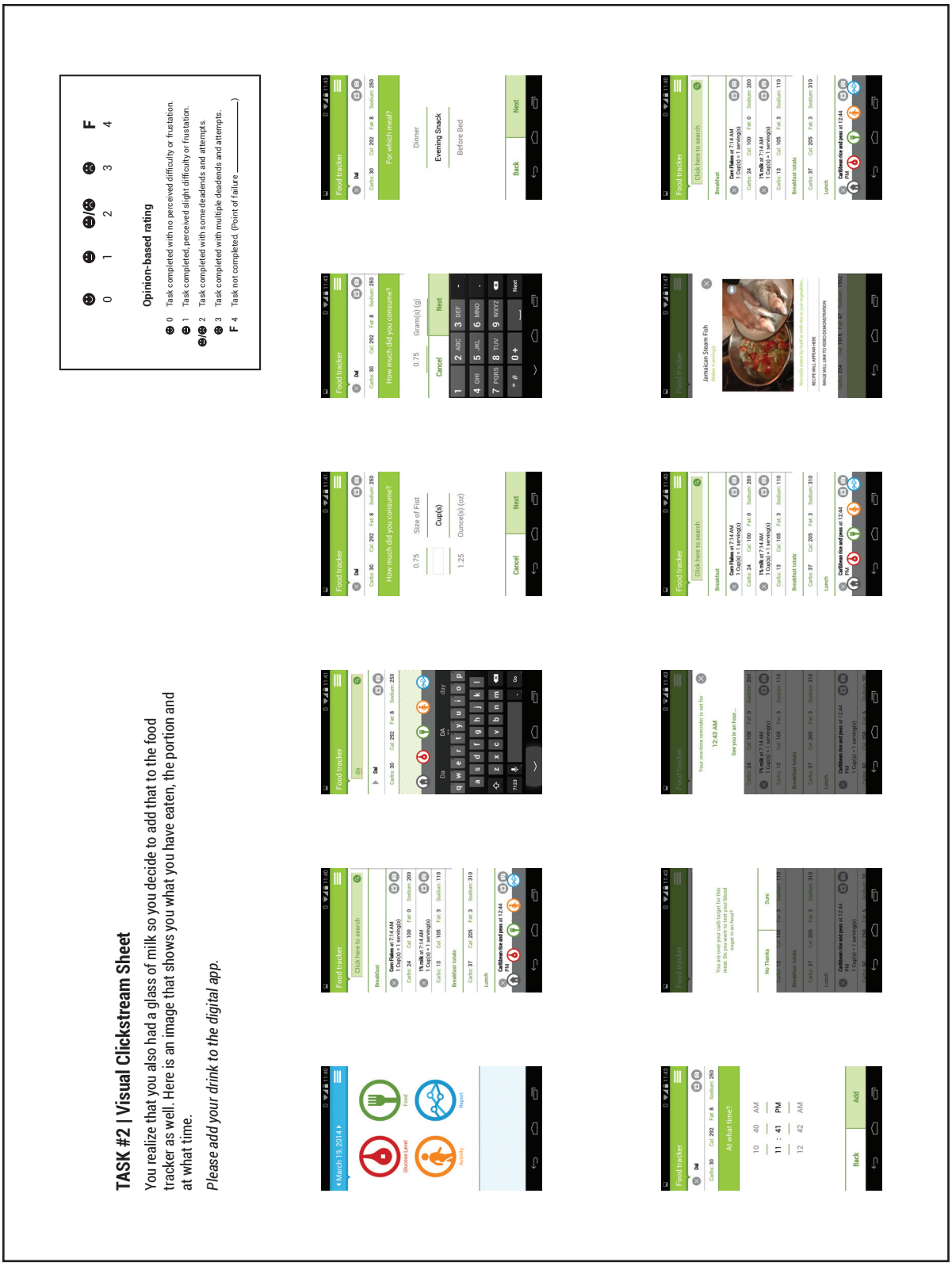


Opinion-based rating

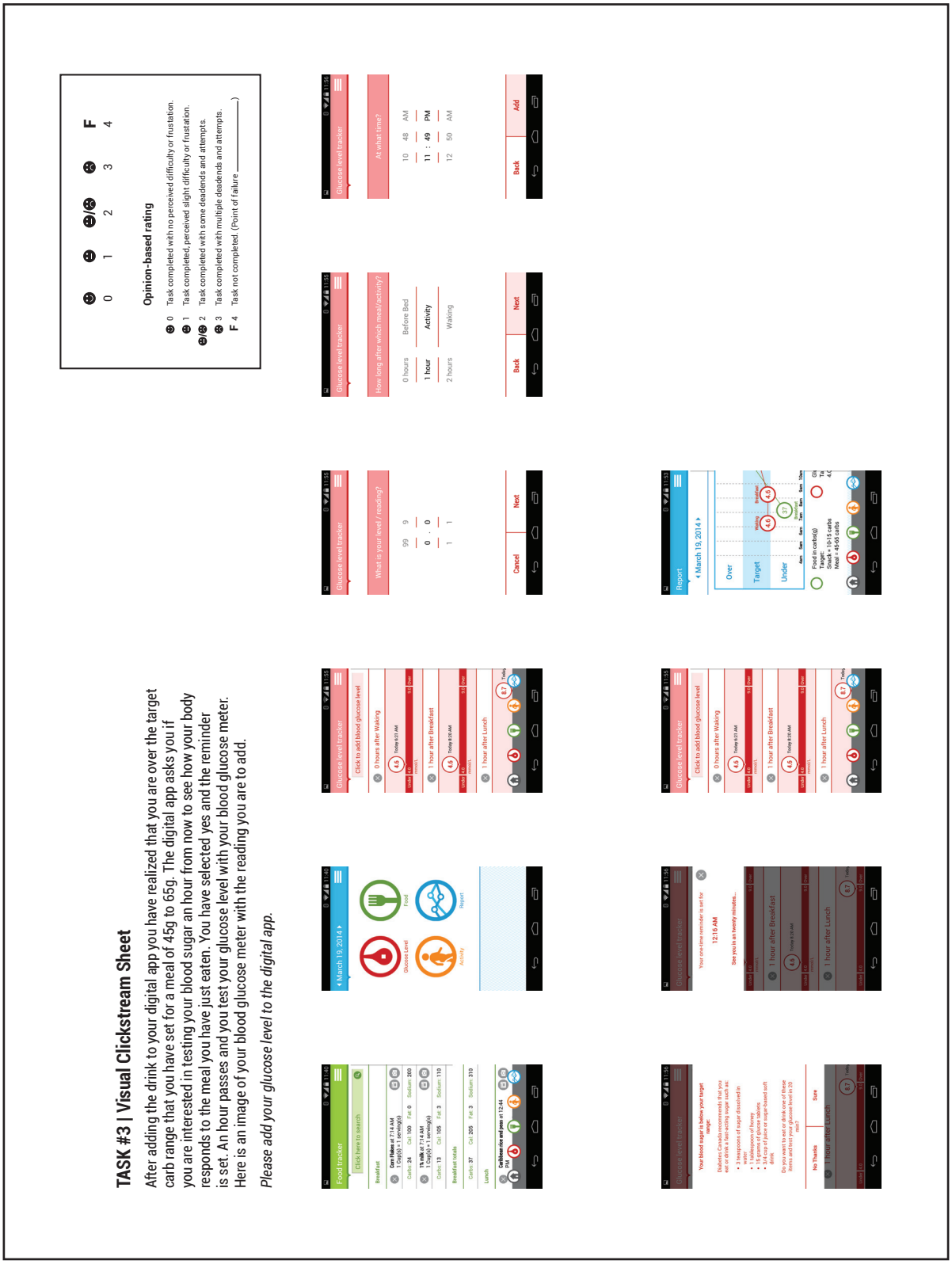
😀	😐	😐/☹	☹	☹	F
0	1	2	3	4	

- 😀 0 Task completed with no perceived difficulty or frustation.
- 😐 1 Task completed, perceived slight difficulty or frustation.
- 😐/☹ 2 Task completed with some deadends and attempts.
- ☹ 3 Task completed with multiple deadends and attempts.
- F 4 Task not completed. (Point of failure _____)

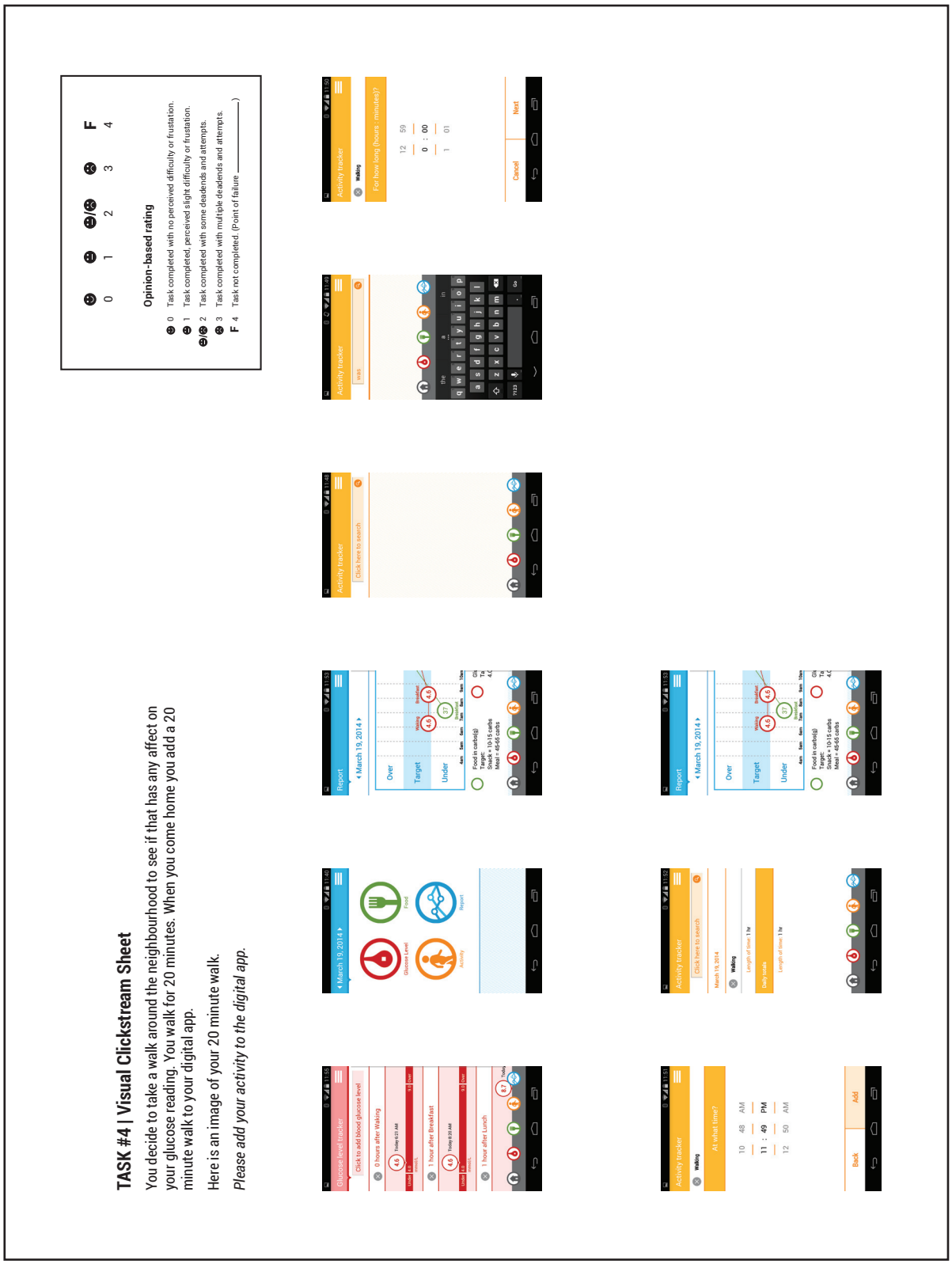
Appendix R: Task-based scenario sheet Task #2



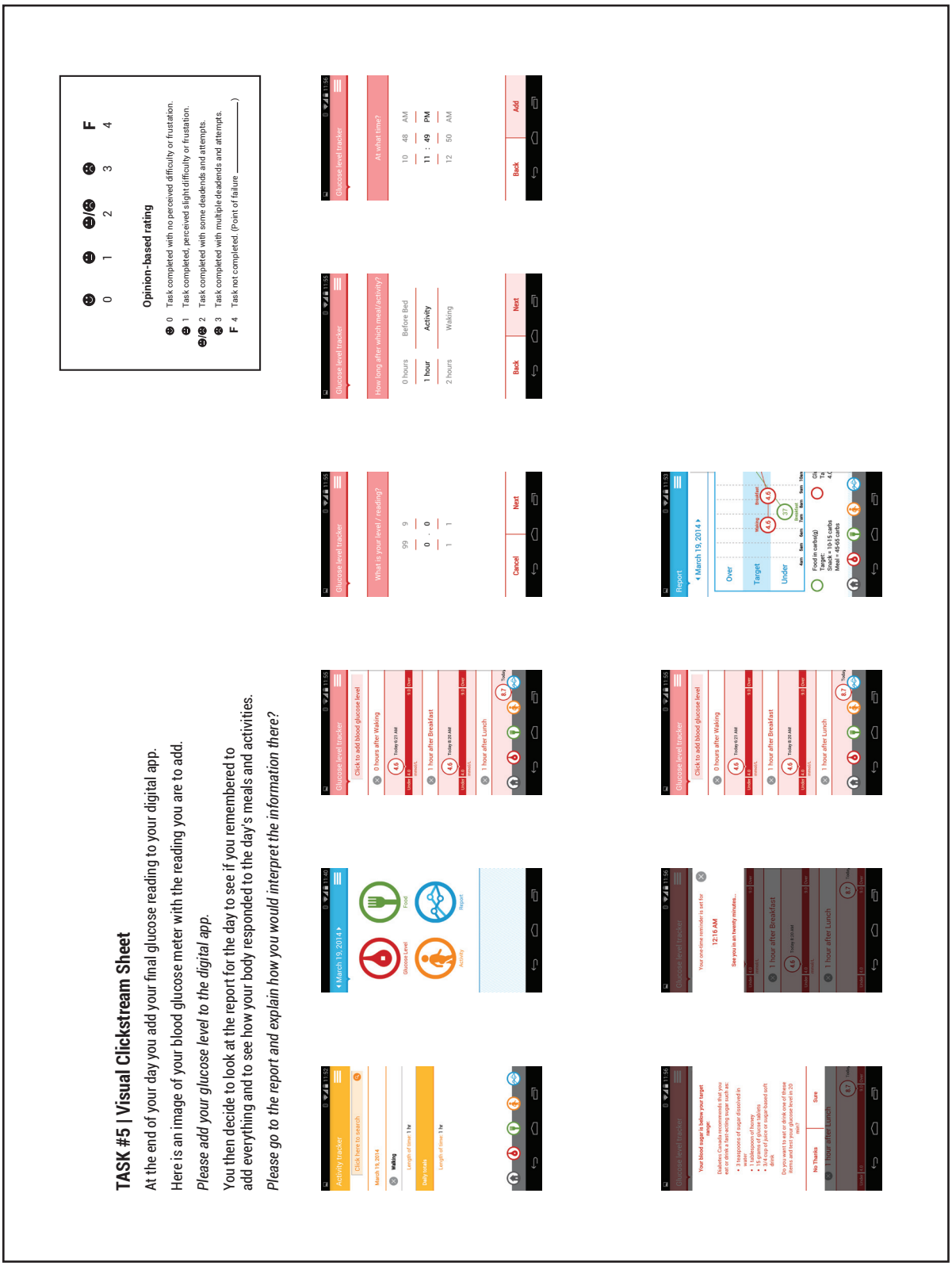
Appendix S: Task-based scenario sheet Task #3



Appendix T: Task-based scenario sheet Task #4



Appendix U: Task-based scenario sheet Task #5



Appendix V: Office of research ethics approval certificate amendment

YORK
UNIVERSITÉ
UNIVERSITY

OFFICE OF RESEARCH ETHICS (ORE)

5th Floor,
Kaneff Tower,
4700 Keele St.
Toronto ON
Canada M3J 1P3
Tel 416 736 5914
Fax 416 650 8197
www.research.yorku.ca

Certificate #:	**STU 2013 - 144**
Approval Period:	**10/11/13-10/11/14**

Memo

To: Nancy Snow, Department of Design, nsnow@yorku.ca

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics
(on behalf of Duff Waring, Chair, Human Participants Review Committee)

Date: **Friday, October 11, 2013**

Re: Ethics Approval
How Information Design Can Support Canadians with Type 2 Diabetes

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I am writing to inform you that the Human Participants Review Sub-Committee has reviewed and approved the above project.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics

Appendix W: Opinion-based rating system from visual clickstream sheet

OBSERVATION		HEALTH COACH A MARCH 20	EXERCISE PHYSIOLOGIST 1 MARCH 20	HEALTH COACH B MARCH 20	HEALTH COACH C MARCH 21	EXERCISE PHYSIOLOGIST 2 MARCH 21
Task 1	1					
0 = No Frustration						
1 = Little Frustration		R O		R O		
2 = Medium Frustration					R O	
3 = High Frustration			O			R O
4 = At What Point of Failure			R			
Rationale		**number scrolling vs tapping**	**could not find how to add food**	**number scrolling vs tapping**	**number scrolling vs tapping**	**number scrolling vs tapping 1/2 cup**
Task 2	2					
0 = No Frustration		R O		R	O	R O
1 = Little Frustration			R O	O		
2 = Medium Frustration					R	
3 = High Frustration						
4 = At What Point of Failure						
Rationale		~	**changing portion sizes**	**adding time(observer)**	**number scrolling vs tapping (researcher)**	~
Task 3	3					
0 = No Frustration		R O	R O	R O	R O	
1 = Little Frustration						
2 = Medium Frustration						
3 = High Frustration						
4 = At What Point of Failure						
Rationale		~	~	~	~	
Task 4	4					
0 = No Frustration		O	O		O	
1 = Little Frustration		R	R	R O	R	R O
2 = Medium Frustration						
3 = High Frustration						
4 = At What Point of Failure						
Rationale		**number scrolling vs tapping (researcher)**	**number scrolling vs tapping (researcher)**	**number scrolling vs tapping**	**number scrolling vs tapping (researcher)**	**number scrolling vs tapping**
Task 5	5					
0 = No Frustration		R O		R O		R O
1 = Little Frustration			R O		R O	
2 = Medium Frustration						
3 = High Frustration						
4 = At What Point of Failure						
Rationale		~	**"0" hours before bed**	~	**"0" hours before bed**	~