UNIVERSITY OF CANBERRA

MOBILE HEALTH:

EMPOWERING PEOPLE WITH TYPE 2 DIABETES USING DIGITAL TOOLS

Sora Park, Sally Burford, Jee Young Lee and Luke Toy

NEWS & MEDIA RESEARCH CENTRE

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ABOUT THE RESEARCH TEAM

Research Team

Associate Professor Sora Park is Senior Research Fellow at the News & Media Research Centre at the University of Canberra. Her research focuses on the digital media, media markets and media policy. She has written widely on the economics of television, newspaper markets and other information industries. She is also interested in media user patterns in the digital media environment. She also has extensive experience in policy research and consultancy regarding digital media in South Korea. In the private sector, she has had various consultancy experiences for major internet and media companies such as KBS, NHN Corp and MBC.

Dr Sally Burford is an Associate Professor in Knowledge and Information Studies in the Faculty of Arts and Design at the University of Canberra and teaches postgraduate coursework and research students. She is the Associate Dean Education within the Faculty. Sally's research is in the area of knowledge and information practice – specifically, the practice of web information architecture and how social media is incorporated into existing information practices. She is also researching in digital mobility, in particular, mobile health. Alongside her research, Sally has considerable industry experience in managing online environments, in particular, online education and large enterprise websites.

Dr. Paresh Dawda is a practicing GP and is the Regional Medical Director for Ochre Health, an organisation that operates a number of integrated care clinics. He is also an Adjunct Associate Professor at the University of Canberra and is a Visiting Fellow at the Australian National University. Paresh holds a number of leadership roles at the Royal Australian College of General Practitioners, and other regional and national organisations. He has a passion for clinical leadership, quality and patient safety improvement centred around a vision of patient centred medicine as the golden thread that unites all his interests.

Dr. Leif Hanlen is the team leader for Text Analytics at Data61, where he focusses on enterprise text processing and human-in-the-loop approaches to natural language processing. Leif has a B.E. (Elec) and B.Sc (Comp Sci), and PhD from the University of Newcastle, Australia. He was previously Technology Director for Machine Learning at NICTA, and has developed research in text processing, wearable radio systems and radio propagation. His 140 academic publications have received over 900 citations.

Professor Chris Nolan is the Director of Diabetes Services in the ACT and a Professor of Endocrinology at the Australian National University Medical School. His medical and early research training were undertaken at the University of Melbourne. He graduated in Medicine in 1983 and completed his specialist training in Endocrinology at the Royal Melbourne Hospital in 1991. His PhD was supervised by Prof Joe Proietto and focussed on glucose metabolism and insulin action in pregnancy. He had further training in islet -cell research at the University of Montreal under supervision of Marc Prentki. His main clinical and research interests relate to diabetes. Under his leadership, the ACT Health Diabetes Service was recognised in 2015 as a Centre of Excellence by the National Association of Diabetes Centres. He has recently been invited to represent the ACT on the Australian National Diabetes Strategy 2016-2020 Implementation Working Group. In addition to administrative, clinical and teaching duties in Canberra, he directs an active diabetes research laboratory and clinical research program focusing on islet -cell failure in type 1 and type 2 diabetes, management of type 2 diabetes and the pathophysiology and management of diabetes in pregnancy.

Associate Professor Paul Dugdale is Director of the Centre for Health Stewardship at the Australian National University and Director Chronic Disease Management for Canberra Hospital and Health Services. He is also Chair of the Board of the Australian Healthcare and Hospitals Association. His research interests include health services and health systems development, governance and social theory. He has served on the board or as medical advisor to a number of innovation-focussed health and information technology companies.

John Burns has 18 years health administration experience in the United States and Australia. He is an Adjunct Professor of the University of Canberra, and is developing a program to provide final year nurse and allied health students the skills required to work more effectively within integrated teams, in primary care settings. The program focuses on sharing resources in the delivery of patient care, coordinating and contributing to patient case reviews, multi-disciplinary care management and improving the patient journey where a team based approach is applied. He is the Chief Operating Officer of VetPartners Australia.

Digital Trainer

Adrian Constance has over five years' experience assisting the public overcome technology hurdles at Libraries ACT. He was a lead trainer at the ACT Digital Hub at Gungahlin Library in 2013 and 2014, facilitating small groups and individual sessions on a wide range of digital topics with the ultimate aim of increasing digital literacy. During the mHealth pilot study, Adrian provided the digital skills necessary to give the participants the confidence to use the device and appropriate health applications for their individual needs.

Research Associates

Morris Carpenter is a lecturer and PhD candidate at the University of Canberra. He is also a research associate at the university's News and Media Research Centre and a member of its Health Research Institute. His doctoral research examines mHealth adoption for the self-management of type 2 diabetes. He has worked on research studies that examine digital engagement, online activity and mHealth.

Jee Young Lee is a PhD candidate at the University of Canberra, and a research assistant at the university's News and Media Research. Her doctoral research explores a user-centric inclusion framework for a digitalised society and the role of digital divide policy in addressing exclusion. She has worked on several research studies that focus on online behaviour and digital inclusion.

Luke Toy is the General Manager for Advocacy for Kidney Health Australia, and an Adjunct Professional Associate at the University of Canberra. Luke has a strong passion for working in the government sphere, previously having worked as Deputy Chief of Staff and Senior Adviser to the Federal Rural and Indigenous Health Minister and the Federal Defence Science and Personnel Minister. He has also been an Adviser within the National Security and International Policy Group of Prime Minister and Cabinet, the Department of Health and Ageing, and a Senior Speechwriter for the Federal Infrastructure and Transport Minister. He has an Honours in Communications (Media/Politics), a Masters in Public Policy and a Masters in Diplomacy.

Report design

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EXECUTIVE SUMMARY

Diabetes: A Growing Problem

Diabetes is a major health problem, and one that is a significant burden on the health system. According to the World Health Organization, the number of diabetes patients worldwide will have reached 366 million by 2030[1]. In Australia, diabetes is the sixth leading cause of death and the death rate continues to rise[2]. In the last 15 years it has doubled, and Diabetes Australia estimates that around 1.7 million Australians have diabetes, with 500,000 of those unware of their condition. Sadly, 280 Australian's develop diabetes every day. Diabetes can increase the risk of heart disease, stroke, blindness, kidney failure and amputation. Furthermore, it is estimated that the total annual cost impact of diabetes in Australia is $14.6 billion dollars.

Managing Diabetes in the Community

Type 2 diabetes results from the body's ineffective use of insulin and/or inability to produce insulin and accounts for approximately 90% of all diabetes diagnoses. Simple lifestyle changes such as maintaining an optimal body weight, engaging in physical activity and adopting a healthy diet are essential to the management of type 2 diabetes.

However, each of these activities requires substantial commitment by someone living with diabetes. Self-management of an illness requires a considerable level of knowledge, discipline and self-regulation. Characteristics of successful self-management include accountability, motivation for change and active participation. Peer support and community resources are also effective activities of engaged individuals.

The mHealth project *Mobile health: Empowering people with type 2 diabetes using digital tools* was designed around the recognition that ongoing lifestyle modification is a continuing effort, beyond consultation with medical professionals. It is about everyday choices and feeling empowered and informed about the decisions that can improve health outcomes.

When people visit a medical professional, it is typically a short appointment available to get important advice and encouragement – the mHealth program was about expanding that window – so that a form of support, information and communication could be ongoing, helping patients make better everyday choices.

Mobile Health

The first step of this the mHealth project was for the News & Media Research Centre at the University of Canberra to work with National ICT Australia (NICTA), the ANU Medical School, Canberra Hospital, Ochre Health Medical Centre Bruce and ACT GP Super Clinic to consider what would be most effective in helping support those living with type 2 diabetes.

A co-design workshop was convened, and practitioner participants agreed that a trial program should allow patients sufficient autonomy and encourage them to try new tools independently. Rather than implementing a highly structured intervention, discussions at the workshop suggested an 'exploratory' program, where patients were invited to engage in various digital activities relating to their health management. Sufficient digital literacy training and support were provided, on the assumption that it would be more likely to induce behavioural changes among diabetes patients in the long term.

Three key areas that needed to be addressed to facilitate successful outcomes for mHealth programs were identified:

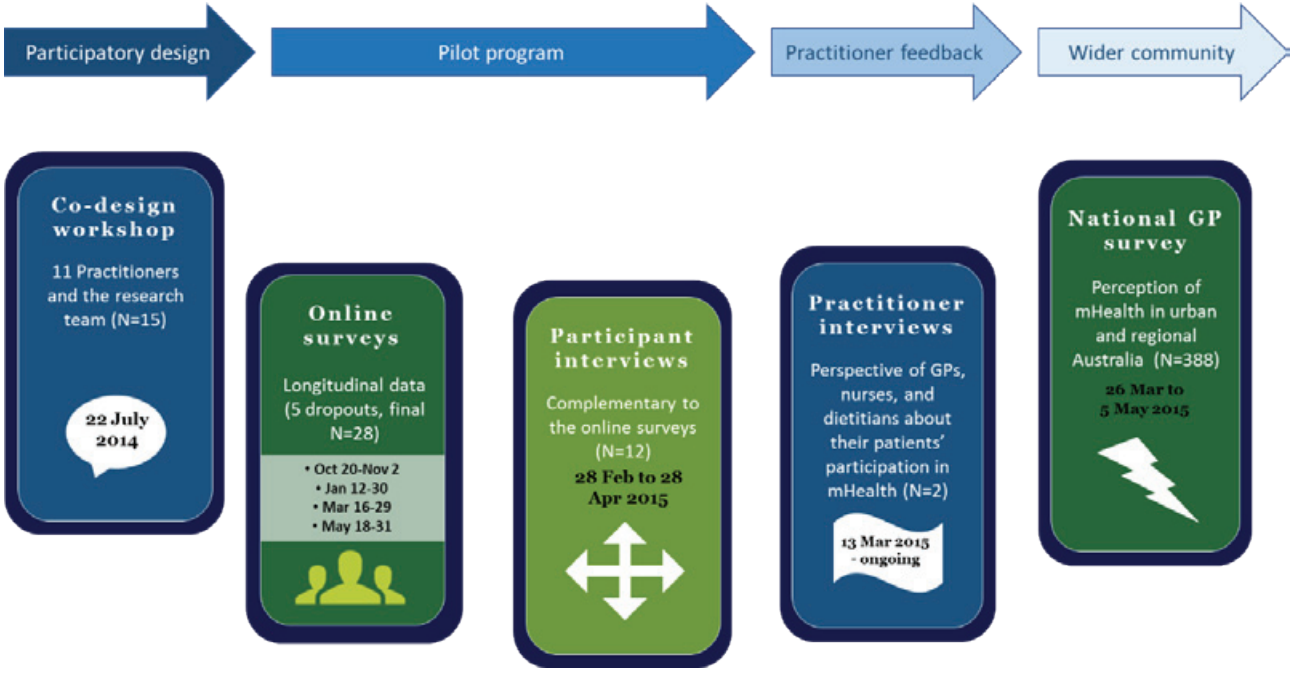
- motivating patients to record their health metrics using a mobile device and to use authoritative health information;
- facilitating patients' empowerment through their use of a mobile device for self-management, thus giving them a sense of autonomy and ownership; and
- seamless integration into the existing healthcare delivery system.

Mobile tablet devices (iPads) with appropriate applications (apps) were provided to patients recruited at the GP Super Clinic (Bruce). Internet equipped tablets were considered appropriate due to their straightforward software, their 'always on' and 'always with' nature, usability and screen size. Apps supporting the key areas of blood glucose, exercise, diabetes information, diet and community were installed on the supplied devices.

Providing a digital literacy support system was a unique element of this program. Training was offered to participants as part of the pilot program. Both structured group and on-demand individual training were provided by a professional trainer at the Clinic. While participants

[1] Diabetes Fact Sheet. Geneva: World Health Organization, 2014. http://www.who.int/mediacentre/factsheets/fs312/en/

[2] Causes of Death, Australia, 2011 Canberra: Australian Bureau of Statistics, 2013. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3303.0Chapter42011



Data collection

were encouraged to use the mHealth apps and attend training sessions, they were not mandatory. This was to observe how participants adjust to a mHealth program at their own pace in their daily routines, enabling a more sustainable mHealth program to be developed based on the outcomes of the program.

Both qualitative and quantitative methods were adopted to observe the behavioural changes that occurred during the pilot program. By collecting both qualitative and quantitative data, the team was able to gather sufficient data regarding both health management and digital literacy outcomes. Participants were surveyed and interviewed throughout the program. In addition, a national GP survey was also undertaken to better understand adoption and potential of technology use in primary care more broadly.

Key Findings

The program identified the strong need for training support in acquiring digital literacy. It was necessary not only for technical learning but also to build the confidence of novice users. Furthermore, it was noted that continuous training and support is essential, as well as individual lessons. Ultimately, digital engagement requires long term learning and repeated exposure. Importantly, different types of users need different programs, as they learn at a different pace and have different needs.

Typologies of use were identified, depending on the different levels of digital engagement and health behaviour exhibited by the participants. This included:

- ***Active uses:*** Some of the participants were actively engaged in recording, tracking and observing aggregate data. Through visualised and integrated data, they were able to appreciate the value of their own 'small data' set. They wanted to learn more about technologies and become more sophisticated users of digital devices.
- ***Functional uses:*** Learning new technologies was not a major motivation to participate in the program. These users either already had sufficient skills or acquired the ability to use the apps for effective self-management. The ease of access to mobile devices was a crucial element for functional use.
- ***Limited uses:*** Some of the participants used the device minimally and for specific purposes.

Finally, a key finding was that mHealth must be embedded in patients' everyday lives, as well as in the broader healthcare context. Digital tools cannot be provided in isolation and should be embedded in all uses of mobile devices. This mirrors the requirements of those living with diabetes, to embed vigilance into their everyday life.

Key Statistics

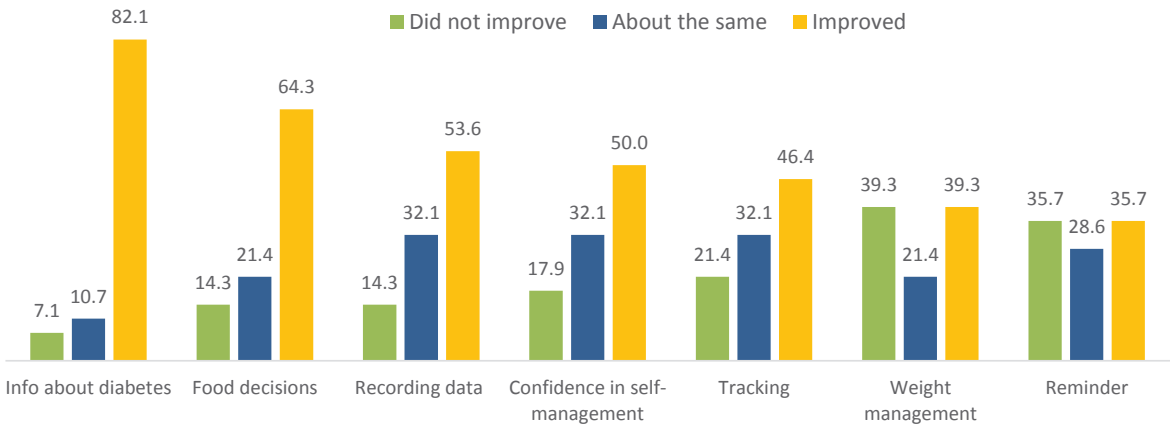
The program highlighted a number of key points. Firstly, training can significantly improve digital skills. After seven months, 90% of the participants were using their iPads more than once a day. This contrasts sharply with the statistics at the beginning of the program, where 32% indicated they had never used an iPad before, and a further 29% had very limited experience. When asked if they were confident enough to use the iPad at the end of the pilot program every participant answered yes.

The program also showed that training improves not only digital skills, but the ability to use digital tools for health management. For example, at the time of sign-up, only 46% searched online for information but at the end of the study, 82% used the internet to obtain information about diabetes management. The majority of training participants (90%) felt that the iPad helped manage their diabetes. In contrast, only 44.4% of those who did not participate in the training felt that the iPad helped them. Most of participants perceived that their diabetes conditions had been improved during the program. After nine months, 61% said they experienced an improvement in their disease and had gained confidence through the mHealth study.

In addition, 75% of the participants stated that they gained more confidence with food choices, particularly because of the portability of the device when making food selections. About 32% of the participants experienced an increase in satisfaction of exercise plans. iPads encouraged greater access to official information, with 86% accessing information from ACT Health during the first 5 months of the program.

The top uses of the iPad for diabetes management were to regularly monitor themselves, acquire knowledge and resources, and to use as an aid to change lifestyle.

The study also highlighted, surprisingly, that age is not a significant barrier, with 82% of participants 50 years or older.



Areas of improvement (after 9 months)

Want further training after program

57%

Improved digital skills

93%

Potential for Improved Outcomes

Introducing new technologies into type 2 diabetes patients' care is a complex process that involves various dimensions of the health condition, self-management and digital literacy. For those who are not experienced in digital technologies, adjusting to a new device adds to the challenge.

Many self-management programs that utilise digital technologies often lack the provision of technical support and assume participants will be able to figure out the best uses of the technology. For a sustainable engagement with mHealth tools, continuous digital literacy programs and technical support are both crucial elements. The pilot program highlighted that it is possible to embed an iPad into the everyday context of patients, so that they can adjust to the device and apps at their own pace. The program demonstrated that patients can feel better supported and empowered to manage their diabetes in the community, feel more connected to others with diabetes, and make lifestyle improvements.

Participants were able to track their progress successfully, and indeed many reported using the iPad and their 'on screen' results to inform discussions with their GPs. In two cases patients used their iPads to source information that revealed that they had previously undiagnosed conditions, which they brought to the attention of their GPs. More broadly, the participants gained valuable digital skills, in many cases where none existed previously.

82% **Will continue to use iPad for diabetes management after program**

61% **Gained confidence in iPad skills through mHealth program**

GPs' Perspective

A survey of GPs in Australia conducted in 2015 reveals that the majority of GPs believe that the use of mobile tablet devices could increase the quality of care (64%). At the same time, they were concerned about increased workload and privacy/security issues. In the context of diabetes management, GPs thought that mobile devices had a potential for improving self-management through monitoring, checking and reminding activities. However, for communication and seeking professional advice, mobile tablet devices were perceived to have lesser value. Experience with mHealth was prevalent among GPs. More than half reported that they knew of patients using apps to self-manage their health (64%), and 54% of GPs have looked up mobile health apps. Financial barriers were seen as the most critical when introducing mHealth into primary care.

The need for digital training for GPs was also identified through the survey. Digital literacy of GPs was a significant factor that influences the perception of how mHealth can be utilised to benefit type 2 diabetes patients. Those who have higher digital literacy tend to have a more optimistic view of introducing mobile technologies into patients' self-care. An educational need was identified by practitioners both in the form of retraining GPs as well as embedding training in the curriculum for the emerging workforce.

Way Forward and Policy Considerations

Ultimately, this program demonstrates that mHealth can provide a mechanism to empower and form healthier disease management habits within motivated patient groups, and can have boarder psycho-social benefits. For patients it can improve self-management of type 2 diabetes, and create a stronger sense of responsibility when managing their health.

This also fits within current policy considerations around better management of chronic disease at community levels; stemming the burden of disease progression on the health and hospital system as our population ages. MHealth has potential to benefit coordinated primary care efforts. Furthermore, equipping patients with the ability to engage in health management and record keeping in a digital form creates a pathway to broader eHealth engagement.

Such a program is also cost effective. In this program devices and internet subscription were provided to patients at a cost of approximately $1,600 per person. The cost falls considerably if participants supply their own device, approximately $240 per person.

Over a longer period improved management of disease would also be expected to save money through reduced complications, consultations and hospital admissions. And there are the flow on benefits stemming from better health, improved digital literacy and increased social connectedness. Therefore this program can be seen as a cost effective intervention.

The next step is to realise the wider rollout of this mHealth program, including and working with relevant organizations who may be able to provide a 'digital hub' for training sites, and with other GP Super Clinics and primary care sites across Australia to identify individuals who may benefit. Considering the near ubiquity of smart phones and tablet devices, the potential for scaling up this program is significant. Ongoing refinement of the qualitative and quantitative data will also allow policy makers to understand the additional benefits of mHealth interventions, including the cost savings generated to the primary and acute care sectors.

INTRODUCTION

According to the World Health Organization, the number of diabetes patients worldwide will have reached 366 million by 2030[3]. In Australia, diabetes is the sixth leading cause of death and the death rate continues to rise[4]. Diagnosis and treatment of diabetes are crucial, as the condition poses other risks such as heart disease, stroke, blindness, and kidney failure. Type 2 diabetes results from the body's ineffective use of insulin or/and inability to produce insulin and accounts for approximately 90% of all diabetes diagnoses. Diabetes Australia estimates that 1.7 million Australians have diabetes, with 500,000 of those unware of their condition. 280 Australian's develop diabetes every day.

Type 2 diabetes is a chronic condition that is managed by medication and by diet, exercise, and other everyday activities of the individual. Simple lifestyle changes such as maintaining an optimal body weight, engaging in physical activity and adopting a healthy diet are effective methods of managing diabetes. The disease requires active self-management, and, to be effective, an individual with diabetes must acquire sufficient knowledge about the illness and exert self-regulation. Self-management of an illness requires a considerable level of knowledge, discipline and self-regulation. Peer support and community resources also contribute to an individual's management of this disease.

With the prevalence of mobile phones, numerous mobile health (mHealth) programs have been designed and implemented to improve patient self-care and strengthen healthcare systems in the last decade. Ease of use, portability and ubiquity all point to the potential of mobile devices for use in preventing, diagnosing and treating illnesses, as well as increasing access to health services and lowering costs. The benefits of using mobile devices are in the continuous access to the internet that they provide and the proximity of device to user. Mobile devices are both 'always on' and 'always with' the user. This enables an accessible tool that is well integrated into daily life. Devices such as this provide the opportunity to have access to additional information, communication and support beyond the periods when a patient is in a medical consultation.

Mhealth is "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices"[5]. There are many potential benefits of mHealth programs. Mobile applications (apps) may be used for positive health promotion, physical fitness, treatment adherence and disease management.

With its connectivity and proximity to its user, the mobile tablet device has the potential to help individuals with type 2 diabetes manage their day-to-day routine of self-care. For some, however, adapting to a new digital device is not an easy task. Learning how to use digital devices and reaching an adequate level of digital literacy takes time and effort. Digital devices are used within the user's socio-cultural context and mHealth programs cannot be separated from other uses of a mobile device. However, little is known about the process of how patients adapt to the devices used in mHealth programs. In order to implement a sustainable program, careful examination of how mHealth tools are adopted and utilized by individuals within the broader social context is needed.

This report outlines a project aimed at developing evidence-based strategies to support wider adoption of mobile tablet devices in healthcare, initially focusing on type 2 diabetes. A multi-disciplinary team of researchers from the University of Canberra, NICTA, ANU Medical School and Canberra Hospital, in collaboration with Ochre Health Medical Centre Bruce, conducted the project at the ACT GP Super Clinic.

The main objectives of this project were to: (i) Understand and overcome barriers to mHealth adoption among type 2 diabetes patients; (ii) Understand how Australian GPs perceive and understand the state of mHealth in their practice; and (iii) Increase digital engagement of health practitioners and patients through mHealth models of service.

The project consisted of four stages: participatory research design via workshops; participant recruitment; mHealth intervention with 28 type 2 diabetes patients including digital training and data collection, and a national GP survey; and the analysis and modelling

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[3] Diabetes Fact Sheet. Geneva: World Health Organization, 2014. http://www.who.int/mediacentre/factsheets/fs312/en/

[4] Causes of Death, Australia, 2011 Canberra: Australian Bureau of Statistics, 2013. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3303.0Chapter42011

[5] mHealth: New horizons for health through mobile technologies: Based on the findings of the second global survey on eHealth, Global Observatory for eHealth Series, 3. World Health Organization, 2011. http://www.who.int/goe/publications/goe_mhealth_web.pdf

of the data. Because mHealth is novel, we devised a participatory research design to capture the perspectives of Super Clinic healthcare practitioners and researchers. The outcome of the participatory workshops was a loose-knit mHealth pilot program design for type 2 diabetes patients. The program continued for 10 months. Participants were given mobile tablet devices (iPads) and were offered on-demand digital training and support. The researchers monitored participant choice, behaviour and engagement using online surveys and semi-structured interviews.

The project was conducted in the following stages from April 2014 to June 2015.

- Stage 1: Detailed participatory design of mHealth program (including apps selection) for diabetes patients at the ACT Bruce GP Super Clinic.
- Stage 2: Participant recruitment, and pre-population and distribution of mobile tablet devices followed by training sessions.
- Stage 3: Longitudinal data collection from patients, and follow up data collection from participants and practitioners, including a national GP survey.
- Stage 4: Development of models to facilitate effective uses of mobile tablet devices in healthcare engagement.

Mobile tablets were found to be particularly useful for accessing quality information to meet the individuals' needs, as well as empowering users in managing their chronic condition. Apps that targeted controlling food intake, exercising, and recording blood glucose levels were widely and effectively used in type 2 diabetes self-management. The project outcomes, however, provide a strong signal that technology provision alone is not successful. Digital training and support are essential components of a mHealth initiative.

Health care practitioners in Australia were optimistic about the role of mobile devices in managing chronic illnesses such as diabetes. However, they suggested that financial, system and technological barriers should be addressed in order to facilitate effective digital health environments in primary care.

This research project demonstrates the potential of mHealth. Once mainstreamed, these digital initiatives have the capacity to merge face-to-face consultation with mobile health interactions according to specific needs. Current healthcare models can shift toward new and flexible modes.

METHODOLOGY

This project adopted multiple data collection methods in order to provide a rich and grounded picture of how patients and practitioners engaged in this mHealth initiative. First, a participatory design workshop with practitioners and the research team was held in order to comprehensively design a mHealth pilot in a primary healthcare setting. From the co-design workshop, the research team identified core features of a mHealth program for type 2 diabetes patients and designed a 10 month pilot program. At the site of the pilot program, a GP Super Clinic, individuals with type 2 diabetes were recruited from the patient population. During the course of the study, digital training and support was provided on demand and participant data were collected via online surveys. Additional participant interviews were conducted for triangulation. Healthcare practitioner interviews were conducted at the site of the study (and are continuing). Finally, a national survey of GPs was conducted to capture the perceptions of front-line health care providers about mHealth adoption in Australia. **Figure 1** provides an overview of the data collection throughout the project.

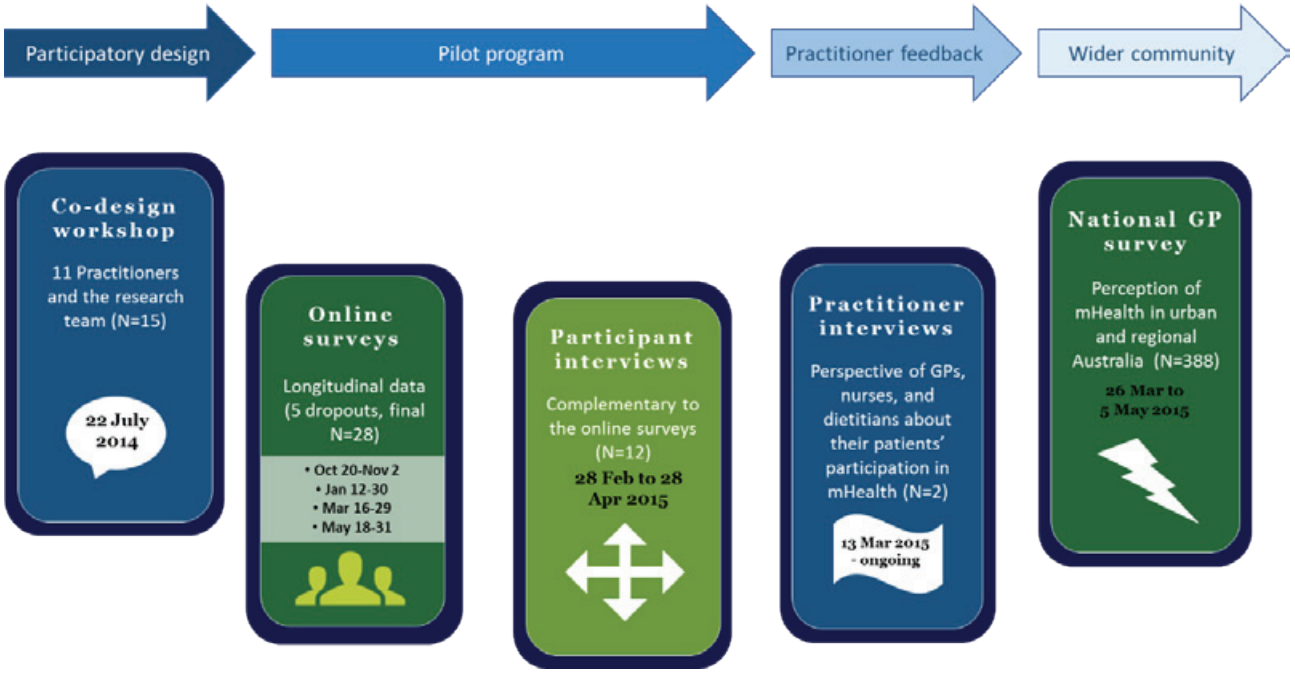


Figure 1: Data collection

The site

The site and context for the study was an Australian GP Super Clinic. GP Super Clinics were an initiative of the Australian government, which sought to contribute towards a stronger primary healthcare system. Under one roof, an interdisciplinary team of health professionals, such as GPs, practice nurses, dieticians and psychologists deliver a set of services focused on health promotion, thereby creating a fluid and complex set of relationships and activities. The ACT GP Super Clinic (Bruce) was the location for this study.

Participatory research design

All health professionals play an important role in the smooth operation of the Super Clinic and were invited to contribute to the participatory design of the research. Collectively, administrators, nurses, GPs and managers can better inform a digital health program that encompasses all aspects of infrastructure, devices, applications, communication and patient care. Multiple, unique perspectives and experiences have contributed to the design of this mobile health intervention with intention of creating a more complete and nuanced pilot study.

The research team crafted an engagement strategy and a means of active co-design of the research. The busy work of medical and administrative staff in a large medical clinic and the Australian Medicare policy framework was a prominent consideration. Whenever general practitioners were engaged in participatory research design, they were not accruing an income.

Thus, an effective and time-efficient strategy for the participation of medical staff in the research design was essential. Facilitated and structured workshops were adopted as the strategy for the design engagement, to ensure that all had a voice. Existing power structures were minimised, the dialogue remained focused, and the activity of design was effective and efficient. To create a structured, efficient and democratic environment, the early phases of structured dialogic design were adopted. The research team carefully crafted a trigger question asking: How could you and your diabetes type 2 patients use a mobile tablet device to assist in the management of this health condition? This question was provided to all participants in advance of the workshop, and to encourage clarity and focus, all 15 participants (that included 4 research team members) were asked to consider it and prepare at least one short statement in response and forward it to the research team for compilation ahead of the workshop. Some participants contributed more than one statement. At the workshop each participant was allocated time to speak to their statement(s) to provide further explanation. In a round-robin manner, a facilitator who was experienced in structured democratic dialogue gave each participant equivalent opportunity to contribute to the conversation.

Clustering statements into similar categories is the next step in structured dialogic design. This activity was undertaken at the conclusion of the first workshop by the research team to save group time. The analysis was presented back to the GP Super Clinic staff at the next workshop for their comments and possible refinement, however no changes were deemed necessary. **Table 1** presents the profile of the healthcare participants who took part in the co-design workshop.

PSEUDONYM	POSITION	GENDER	YEARS OF EXPERIENCE
Cooper	GP	M	30
Daniel	GP	M	39
Declan	GP	M	44
Emma	GP	F	8
Kaitlyn	GP	F	20
Mason	GP	M	30
Peter	GP	M	22
Colin	Endocrinologist	M	30
Alyssa	Nurse	F	37
Kira	Nurse	F	5
Audrey	Nurse	F	8

Table 1: Summary of practitioner participants

Longitudinal study: The pilot program

With the participatory design of the intervention in place, publicly available mobile health apps and informative websites were examined for suitability in supporting the intent of each invitation. Apps that were free or of minimal cost were sought via the Apple App Store and the customer reviews of the apps and their usability informed the selection process. Focusing on ease of use, the research team evaluated and selected good-quality apps to enable each invitation to be enacted and pre-populated the mobile tablet devices. Thus, all patients received an iPad with identical starting screens of apps and websites, and with the liberty to customize it in any way for their own initiatives and online activities.

In order to implement a mHealth pilot program and ensure participants have access to the technologies, device and internet subscription was included in the research budget. Participants were given an iPad with 3G subscription during the program. Patients were informed that after their full participation in the study over a ten month period, they would own the tablet.

Participant recruitment started on 6 August, 2014 and the quota was filled by 22 August 2014 (N=30). The recruitment was primarily based on a first-come, first-served principle. However, the GPs and nurses were deeply involved in the recruitment and the team relied on their assessment and recommendation of potential participants. In these cases, the nurses invited patients via phone. This was because diabetes patients visit their GPs in two or three month intervals and the narrow window of 2-3 weeks may not have covered the full spectrum of available patients. Follow-up phone calls were made between 25 and 28 August to confirm participation. Information sessions were held between 28 August and 6 September. Wi-FI and 3G enabled iPads with 16GB were distributed at the information sessions.

At the session, participants were either asked to supply their Apple ID or required to make one so that they could download apps and be in touch with the research team during the following 10 months. In the first month, four patients dropped out of the study and returned their devices. In the second month two more patients dropped out. The main reasons were personal but one withdrew because he lacked interest in learning how to use the device and two dropped out because they felt that they could not learn to become adept users after several training sessions. Three additional participants were recruited and added to the cohort.

The results reported here include data from the final pool of 28 participants whose profile is summarised in **Tables 2 and 3**. Data were collected in four intervals: the first online survey was administered during October 20 and November 2 (6-8 weeks after distributing the devices); the second one was conducted during January 12-30, 2015; the third survey was conducted during March 16-29, 2015; and the fourth survey was conducted in May 18-31, 2015. The surveys included both open-ended and close-ended questions.

	N	%
Never used one before	9	32.1
Not very well	1	3.6
OK for simple things	7	25
Very well	11	39.3
Total	28	100

Table 2: Level of skills and experience with iPads before the study

		N	%
Gender	Male	16	53
	Female	12	47
Age	30-39	1	3.6
	40-49	4	14.3
	50-59	10	35.7
	60-69	9	32.1
	70-79	4	14.3
Job	Full time	9	32.1
	Part time / Casual	2	7.1
	Do not do paid work	17	60.7
Education	Year 10 or equivalent	7	25
	Year 12 or equivalent	2	7.1
	Diploma/advanced diploma/associate degree (TAFE)	12	42.9
	Bachelor's degree (university)	3	10.7
	Postgraduate degree	4	14.3
Income	≤ $18,000	3	10.7
	$18,001 - $50,000	6	21.4
	$50,001- 100,000	8	28.6
	$100,001- 180,000	7	25
	$180,001 +	2	7.1
	Choose not to answer	2	7.1
Region	Major cities	25	89.3
	Inner Regional Australia	2	7.1
	Choose not to answer	1	3.6
Duration of diabetes	< 1 year	9	32.1
	1-4 years	6	21.4
	5-10 years	6	21.4
	11 years +	7	25
Family	Living with children	15	55.6
	No children at home	13	44.4
Total		**28**	**100**

Table 3: Characteristics of participants

Participant interviews

Mid-way in the study, participants were invited to participate in interviews. The purpose of these semi-structured interviews was to confirm the findings of the first two online surveys and to gain insights that might not have been identified in the survey. A total of 12 patients participated in the interviews as recorded in **Table 4**. A 20 dollar iTunes gift card or equivalent was given as gratitude for their extra time. Interviews were mostly held at the GP Super Clinic. One interview was conducted at the participant's home (Table 4). Each interview lasted approximately one hour and all interviews were conducted by the Project Leader. The interviews were recorded with the participants' consent, and transcribed.

VARIABLE		N
Gender	Female	7
	Male	5
Age	50s	4
	60s	3
	70s	2
Training	Training participant	11
	Non participant	1
Digital literacy before program	Low (1-2)	3
	Average (3-5)	7
	High (6-7)	2
Total		**12**

Table 4: Interviewee characteristics

GP survey

An online survey of 388 GPs in Australia was conducted during 26 March and 5 May 2015 using a quota sample based on the GP Workforce Statistics. The sample consisted of 54.4% male and 45.6% female GPs, 26.5% below forty, 30.7% in their forties, 25.5% in their fifties, and 17.3% in their sixties. 58% were located in major cities. An email list of national GPs (23,194) was used as the initial sampling frame. Four waves of emails were distributed to 6,844 GPs, resulting in 388 responses. A summary of the sample is provided in **Table 5**.

VARIABLE		N	%
Gender	Male	211	54.4
	Female	177	45.6
Age	under 40	103	26.5
	40s	119	30.7
	50s	99	25.5
	60 or above	67	17.3
Employment status	Salaried	38	9.8
	Sole practice	22	5.7
	Group practice	304	78.4
	Other	24	6.2
Region	Major city	225	58
	Non-major city	163	42
Total		**388**	**100**

Table 5: Summary of GP respondents

FINDINGS

Participatory research design workshop

Two broad topics were identified: patient engagement and self-management, and health system integration. Mobile tablet devices used by patients for their self-management of chronic disease was the priority, yet a vision was also expressed for mobile technologies to provide seamless access to the existing digital health systems. A loose-knit and fluid mHealth model was developed wherein patients with various levels of health and digital literacy could be accommodated. In order to encourage sustainable changes, mobile devices were situated within the patients' everyday settings. **Table 6** describes the outcome of the workshop that was later used in designing the pilot program.

TOPIC	SUB-TOPICS	TYPE OF ACTIVITIES
Self-management (24)	Compelled (8)	Mandatory and authoritative information (1)
		Day to day managing of planning, caring, reminding and recording (7)
	Empowered (16)	Communication (1)
		Education (4)
		Information not prescribed by the practitioners (4)
		Autonomy and self-reflection (7)
Healthcare system integration (7)		Seamless monitoring (4)
		Shift to digital records (3)

Table 6: A model of mHealth
Numbers in brackets indicate the number of statements that were classified in the categories.

Self-management activities using mobile devices

Self-management was analysed in greater detail revealing six categories of concrete activity that diabetes patients might undertake using a mobile tablet device; these six activities were framed as invitations to patient participants. At the same time, two behavioural stances that are typical of type 2 diabetes patients were identified in the statements. Further, it was possible to categorise the six activities within the two behavioural stances or themes that were named empowered and compelled.

Throughout the first workshop, the healthcare professionals spontaneously and frequently commented on their awareness of an empowered, self-reliant and engaged person, motivated to use the tablet device to improve their health. Invitations 1 – 4, listed in **Table 7**, are activities that reflect the actions of an empowered individual. The four activities centre on diet and nutrition, exercise, keeping a journal, and communicating using a mobile tablet device and associated apps as tool.

CATEGORY	INVITATION
Food intake and diet	Planning your diet – diet is an important part of managing your health. Use the iPad to: • investigate which food is best for you, • find suitable recipes online, • design your own recipes, • design a menu for a week, • create shopping lists for the ingredients you will need, • reflect on the success and usefulness of planning your diet online!
Journaling	Journaling – In your daily activities and your management of your diabetes, it is likely that you will have successes and challenges. We encourage you to reflect on when things go well and when you have difficulties. Use an online journal to write about your daily experiences – it is a way of learning about what works for you.
Exercise	Exercise – physical activity is good for everyone! Could your iPad help you with an exercise routine? We encourage you to explore online sites that give good information about exercise routines or classes. Investigate apps that might support your exercise routines. Choose activities and routines that support your lifestyle. Use your iPad to get fit!
Communication	Communication – Many people find it helpful to talk to others in similar circumstances, whatever that may be - social support is important to most of us. We will set up a means for you to communication to everyone else who has signed up to be part of this research – you may choose to meet them and 'talk' online. Perhaps you would prefer to join a wider and established online community of people who have diabetes type 2?

Table 7: Invitations for *empowered* behaviour

In contrast, the second theme of compelled describes a diabetes patient who mechanically records blood sugar levels most of the time, and does only what they must in order to live with their disease. Autonomy and self-motivation is less likely. This form of patient engagement in their healthcare was also familiar to, and quickly identified by, the clinicians. Invitations 5 and 6 in **Table 8** are directed at the people who feel compelled by an authority to undertake specific activities to manage their diabetes. Invitations to record Blood Sugar Levels and access authoritative information are directed at the patient who feels compelled by an authority to undertake specific activities to manage their diabetes.

It is important to note that the two behavioural clusters of invitation are not intended to fix the behaviour of a particular individual in any one category. Each person with diabetes can engage with the overall intervention in any way they choose, accepting all six compelled and empowered invitations or any combination of the six.

CATEGORY	INVITATION
BSL	We have added some Apps that you may use to regularly record your Blood Sugar Levels and Blood Pressure. Choose one and see if it suits you more than recording this data in a booklet. If you find it useful, don't forget to print the information or take the iPad when you next visit the Doctor.
Authoritative Information	There is a lot of information on the web, some of it good and some of it not so helpful. We will provide a portal on the iPad screen that will take you to information about diabetes type 2 that has authority and is provided by experts. You can use it when you need.

Table 8: Invitations for *compelled* behaviour

Incorporating mobile tablet devices into healthcare systems

This research identified the potential of adding mobile tablets to the technological healthcare landscape. Suggestions of seamless reporting of recorded data, access to e-records, and aggregation of data were made. However, this pilot study restricted itself to patient and healthcare practitioner engagement with the tablet as a stepping stone to greater technological integration. Potentially, mobile devices may serve as a gateway to other digital health systems and drive the demand for this to occur, as well as familiarise patients with concepts of eHealth initiatives more broadly.

Design of the mHealth pilot program

This research project did not develop technology, systems or software. It sought to utilise mobile tablet devices and existing apps that were developed for type 2 diabetes self-management and to make them available to individuals to use in an exploratory manner. It intended, as part of the enquiry, to give the patient participants significant choice and freedom in using the tablet and associated apps. They were not required to engage with the given technology in any specified way. A fluid and open engagement based on suggestion and invitation was established drawing on notions of user-controlled customization. Users are given increasing control and choice in the way that new media is configured, instilling them with a sense of ownership. Accordingly, the way in which people with type 2 diabetes chose to participate in the project would be collected as data, rather than designed into the intervention.

In the mHealth program, patients with various levels of digital skills were given adequate time to adapt to the devices and applications, ultimately giving them an opportunity to learn and appropriate the technology independently. Because patients came with different levels of digital literacy, the approach was individualized so that each could learn at their own pace. During the implementation of the mHealth pilot program, adequate training and support was provided in addition to access to devices and digital tools. These efforts enabled mobile digital engagement to be integrated into a program of self-management, whereby patients comfortably engaged in both compelled and empowered activities in order to find effective ways of managing their diabetes condition.

This mobile health research project with type 2 diabetes patients and their healthcare team was situated in the real-world of chronic health management, with multiple stakeholders and perspectives. It explored the place of the tablet device in the mobile health phenomenon. In order for this study to be successful in its own right, rather than thwarted by circumstances, much care and attention was given to include participants in the study in its design. The outcomes reported in this section set the stage for the ongoing, grounded and complex next phase of the research that included an interdisciplinary research team, a new and comprehensive GP Super Clinic with an array of health and support staff, patients with a chronic health condition requiring continual self-management and varied capability to achieve and an ever-increasing digital society.

Longitudinal study: The pilot program

This study tackled the longer term management challenges among diabetes patients with an exploratory mHealth pilot program by inviting 28 patients to use iPads to help manage their health condition during the course of 10 months. By the provision of on-demand digital training, we enabled participants to learn at their pace and adjust to the device and apps that were suitable to their needs and circumstances.

Digital engagement using the mobile tablet device was guided in the form of six invitations that participants could accept in any combination. No particular activity using the iPad in diabetes self-management was required, thereby establishing a patient-centric mobile health intervention. The participants' digital engagement was fully supported throughout the study. Training was provided on-demand to suit individual needs and digital literacy levels. It was important to rule out lack of digital skill as a cause for non-engagement in the mHealth program.

Participants clearly indicate that the mobile device and its apps were enabling tools in the self-management of diabetes type 2, and, as a result, report achievements in better health and well-being. The mobile tablet is an optimal computing device for diabetes self-management in its screen size and quality, portability, seamless access, and ease of use. Participants report the ease in which it was taken outside of the home, but emphasise the value of its integration in the daily rhythm of life in various locations within the home. The seamless integration into the daily routine, the visual display of accumulated data, continuous access to information, and the ability to link various types of information and data were the main sources of empowerment.

Digital literacy is a multidimensional concept that involves not only the technical skills required to be able to manipulate the device but also the understanding of what is available through the technology and the user's engagement. We have found that gaining confidence as well as continued support were crucial in improving the engagement among the participants. This was particularly important for users to be able to use the device continuously and not just 'try out' the functions. While studies on non-users of digital technologies emphasise the importance of motivation to encourage them to become users, we found that in addition to motivation, sustainable support from either a trainer or close family and friends were critical to maintaining the motivation. Knowing that they had someone to turn to was a crucial factor that enables the user to continue with the routine.

The results suggest that there are two conditions to be met for a mHealth program to be effective. First, the patients must have a certain level of digital literacy for them to actively engage with the mHealth tools with confidence. Second, they need to be motivated to manage their health condition and believe in the effectiveness of their self-management activities. Self-management requires high engagement in both practical and cognitive tasks, which are hard work.

Empowering diabetes patients to self-manage

The findings reported below are from the three most accepted invitations for digital engagement at 9 months (**Figure 2**). They are diet management, recording of biometrics, and access to authoritative information about the disease of diabetes.

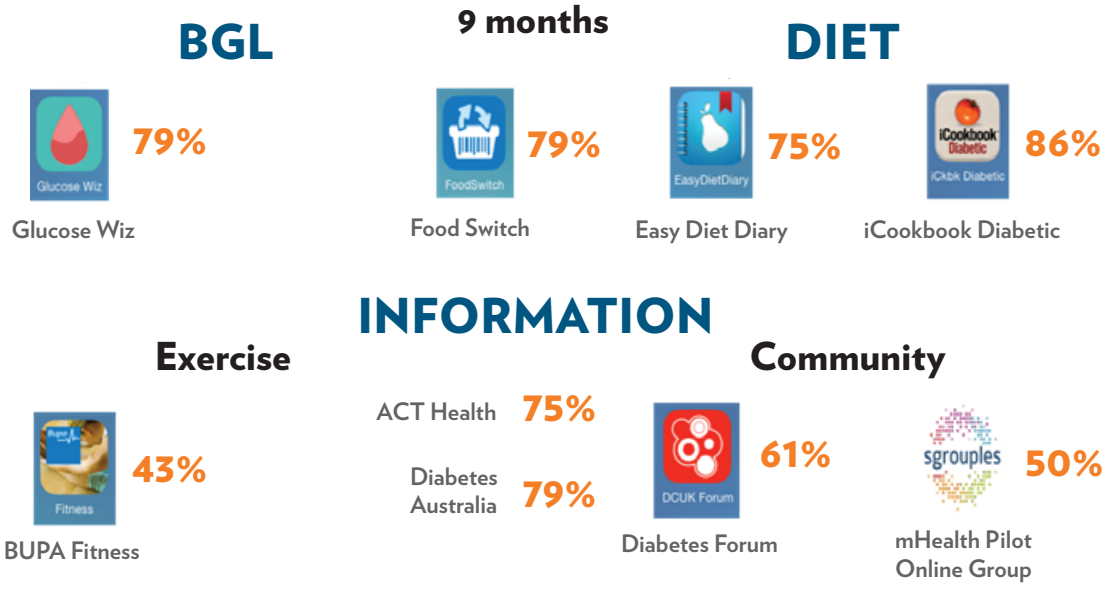


Figure 2: Uses of mHealth apps at 9 months (fourth survey)

In the first two months, the most popular mHealth apps were information and food related. Over time, BGL recording apps were used more widely. Food and diet apps continued to be used by the majority of the participants. The exercise app that was included in the suite of apps was not used as widely as other types of apps. Communication and social apps specifically designed for sharing diabetes information or communicating with participants were also used but to a limited degree.

Most participants downloaded apps on their own, finding apps that were suitable for their needs. The program encouraged participants to engage with their device and use it for non-health related purposes as well. App downloads occurred mostly during the early months of the program. 75% of the participants had downloaded apps in the first two months and by the 9th month, only 40% had downloaded new apps. At the end of the study most participants had more than five apps on their screen. This indicates a certain level of stablisation the participants' use of the device over the period of 9 months.

We asked how often participants used the iPad in seven different areas of self-management, on a five point Likert type scale (1=never, 2=once or twice, 3=occasionally, 4=often, 5=very frequently). The top uses of the iPad for diabetes management were to regularly monitor themselves, acquire knowledge and resources, and to use as an aid to change lifestyles (**Figure 3**).

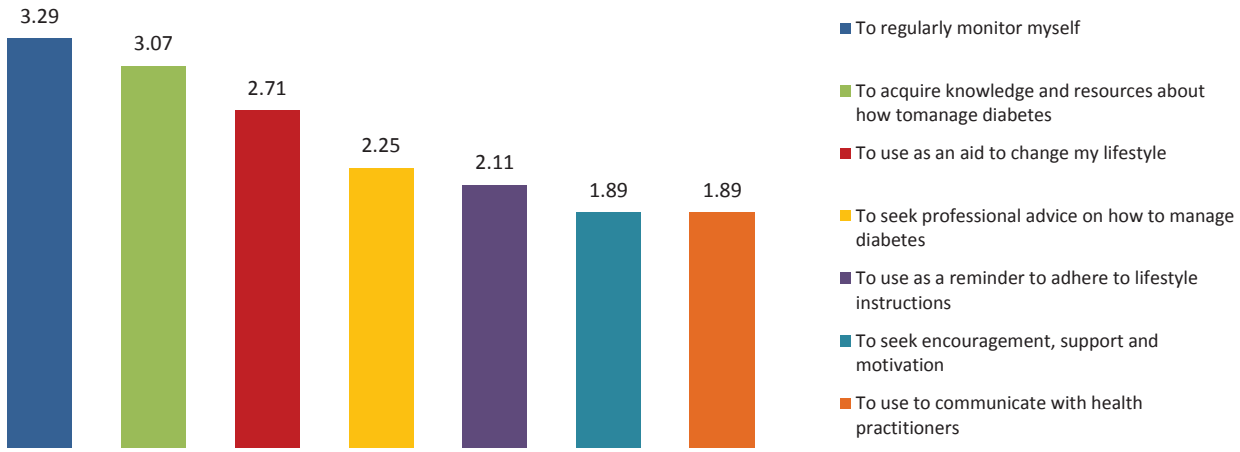


Figure 3: Using iPads to manage diabetes (fourth survey, out of 5)

At five months, about half of the participants were taking their iPads to their regular GP consultations, and this behaviour continued throughout the program. More participants were taking in their iPads to dietitian consultations. At five months, 57% had taken their devices and at the end of the program 83% had shown their data to their dietitians (**Figure 4**).

The perceived benefits of the mHealth program are summarized in **Table 9**. Those who started out with lower digital skills tend to appreciate the training and support. The higher skilled users recognised the opportunity to engage with the device and use the tools to manage their health.

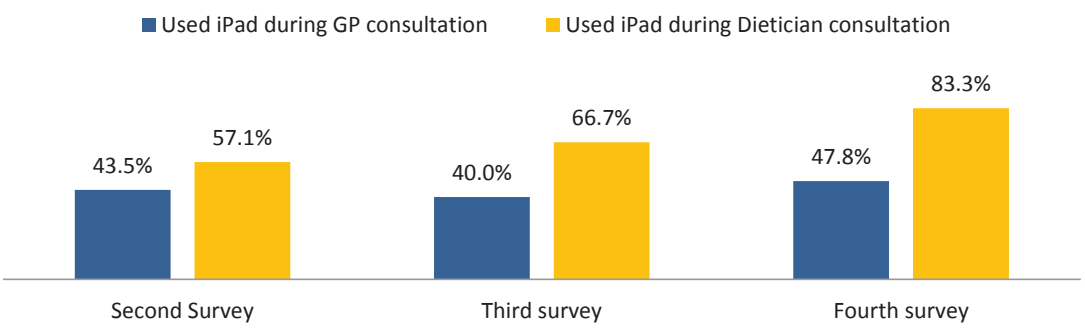


Figure 4: Changes in practitioner consultation

DIGITAL SKILLS BEFORE STUDY (OUT OF 7)	PARTICIPANT	WHAT DID YOU LIKE MOST ABOUT THE mHEALTH STUDY?
LOW (1-2)	**Todd**	The empowerment that came with the iPad to access information when and where I wanted even throw sometimes I had to use my own internet connection.
	Kylie	I was able to gain first-hand knowledge in control and management of diabetic.
	Keith	The contact with the team.
	Kaylee	Getting the opportunity to be in the mHealth study.
	Madelyn	I liked that I made at least one friend. And I really liked the way I could just find scholarly articles without having to sit in the Medical School Library, sifting through journals for information. And I quite liked posting discussion topics, even though no one read them And most of all, I liked the way the iPad made it possible to find a way out of T2D for myself.
	Jasmine	I was lucky to be part of the study and learn to use an iPad. Being kept informed about the usage and 1 to 1 lessons. Group sessions are good as we would be able to learn what other people are struggling with on the iPad.
	Emily	The lecturer [trainer], Andrew was really nice and approachable.
	Ava	The iPad was good also if the study help peoples that's good too.
	Claire	The training in the use of the iPad and how to use the apps. It has shown me some new ways to monitor health issues. The fact that the iPad has given me the ability to access a wide range of recreational activities and Apps that I didn't know existed. I had always assumed that they would be too hard and beyond my capabilities. I have found the study interesting and informative.
AVERAGE (3-5)	**Mitchell**	Being asked questions [through the online surveys] to reflect upon. The people who have been chasing up to complete surveys have shown real commitment to the research.
	Tristan	iPad 1 hour sessions could have been longer, maybe 2hrs. But then you have to take into account the trainer's time away from work.
	Layla	It was a nice easy survey and easy to understand and it's nice to think someone is listening to diabetics in general as there are so many of us and to get new information.
	Ruth	I liked the iPad and the ability to record diet, exercise and blood glucose levels on it. Being able to research information easily. The portability of the iPad to take to health professionals and being able to show them graphs, etc when discussing your diabetes. Learning more about diabetes enabling me to make more informed choices.
	Leah	Everything it was all very help full most of all the iPad. Again I love the iPad.
	Ryder	Freedom to use the iPad in choosing what is applicable to my condition, and easy access to information.
	Lily	Probably not the answer you want to hear, but the chance of a free iPad.
	Rachel	I like that you are motivated to improve the health of diabetics. I like the way it is a technology based program. I also think giving us ownership of the iPad on completion of the study is very generous. Thank you.
	Anna	It helps provide focus on the steps which will assist in diabetic management.

DIGITAL SKILLS BEFORE STUDY (OUT OF 7)	PARTICIPANT	WHAT DID YOU LIKE MOST ABOUT THE mHEALTH STUDY?
HIGH (6-7)	**Parker**	Opportunity to focus on my health.
	Sophia	The fact that apart from the surveys I was left alone.
	Zayne	Access to apps and information and forums, if needed.
	Samuel	Focus on the large list of apps that people with diabetes can access.
	Jackson	The iPad has helped me deal with the condition. Not only has it helped with monitoring sugar levels, it has also been handy to access the web for information. Even getting the emails to do the surveys has kept me on my toes and been a constant reminder to keep up the good work.
	Ryan	I felt that the study was the right thing at the right time for me after being diagnosed with diabetes. It made me focus on the issue at hand and at no stage did I think I was on my own in overcoming or managing the problem. I felt that someone was looking over my shoulder forcing me to adhere and succeed in my endeavours.
	Raymond	That support was always there if needed.
	Ken	Free iPad!
	Preston	The opening of different apps.
	Porter	It opened more avenues of information regarding food choices and food swaps just to mention a few.

Table 9: Merits of the mHealth program (fourth survey)

Improved health outcomes

When asked if their diabetes condition had improved or worsened while participating in the pilot program, the majority of the participants replied that their conditions had improved. After nine months, 60.7% said they experienced an improvement. Only one participant said the condition had worsened during the period (**Figure 5**).

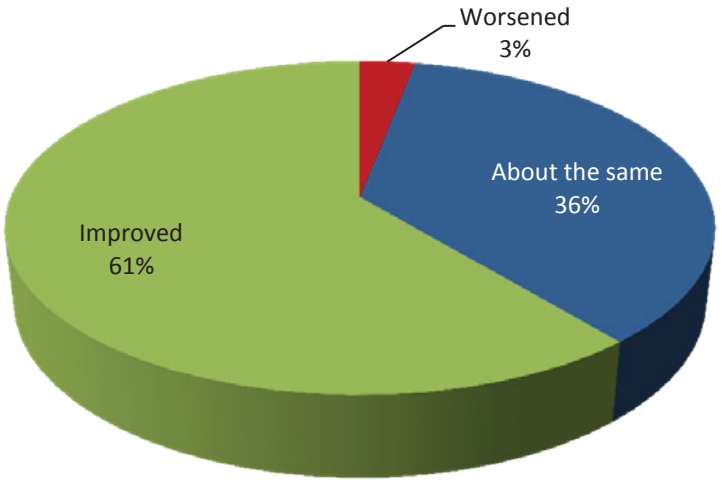


Figure 5: Changes in diabetes conditions (fourth survey)

About 75% of participants (N=21) felt the iPad had helped them manage their diabetes (**Figure 6**). Of those who said iPads helped them, 71% (15 out of the 21 participants) said their diabetes condition had improved since they participated in the program (**Table 10**).

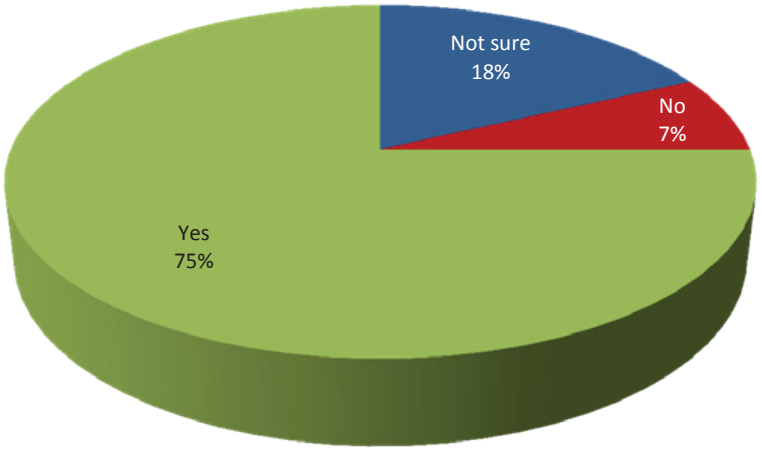


Figure 6: iPad helped manage diabetes

		IPAD HELPED MANAGE DIABETES			
		Yes	No	Not sure	Total
DIABETES IMPROVED OR WORSENED SINCE PARTICIPATION	**It has improved**	15 (71.4%)	1 (50%)	1 (20%)	17 (60.7%)
	It is about the same	5 (23.8%)	1 (50%)	4 (80%)	10 (35.7%)
	It has worsened	1 (4.8%)	-	-	1 (3.6%)
	Total	21 (100%)	2 (100%)	5 (100%)	28 (100%)

Table 10: Improvement after study (fourth survey)

We asked at the fourth survey which among the self-management activities participants found to be most challenging. The biggest challenge for the majority of participants was modifying eating habits (50%). Exercising (18%) and checking BGLs (7%) were the second and third most challenging issues. However, there were 14.3% who said none of the activities were challenging (**Figure 7**). The mHealth program clearly addressed these issues and was used to that effect.

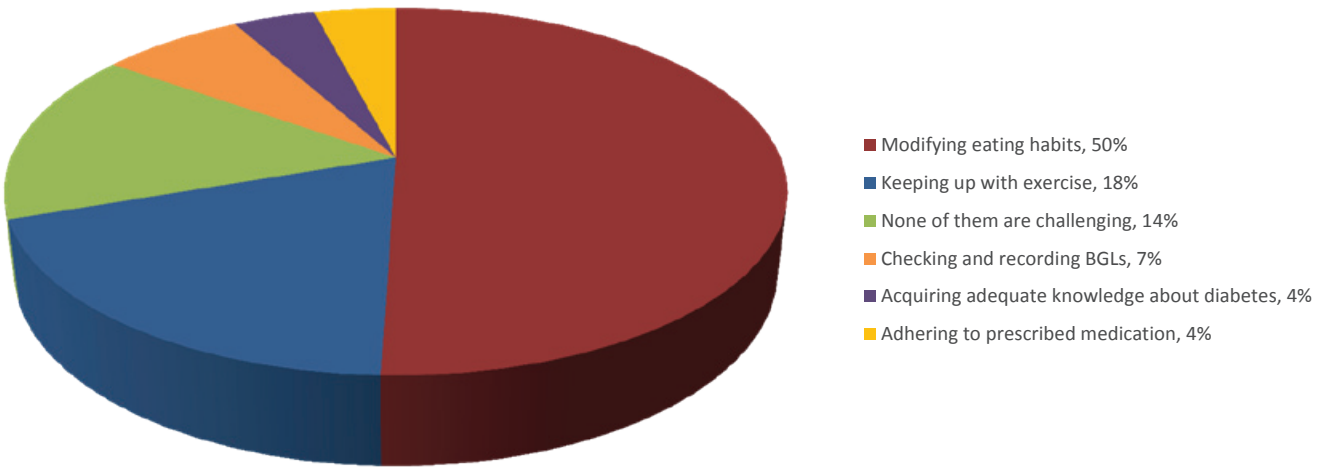


Figure 7: Most challenging self-management activities

After the study 75% of the participants said that they gained more confidence in food choices because of the mHealth program. Satisfaction with the exercise plan improved somewhat: 32.1% of the participants said their satisfaction had increased due to the mHealth program. Only 21% thought the program had helped them in their medication. About 46.4% did not think the program had improved their satisfaction with the prescribed medication. The mHealth tools were mainly beneficial to self-management activities, in particular, in making food choices and diet (**Figure 8**).

The areas that the participants experienced changes the most were in obtaining information about diabetes (82.1%), making decisions regarding food intake (64.3%), and recording data (53.6%). It should be noted that 39.3% of the participants said that their weight management did not improve (**Figure 9**).

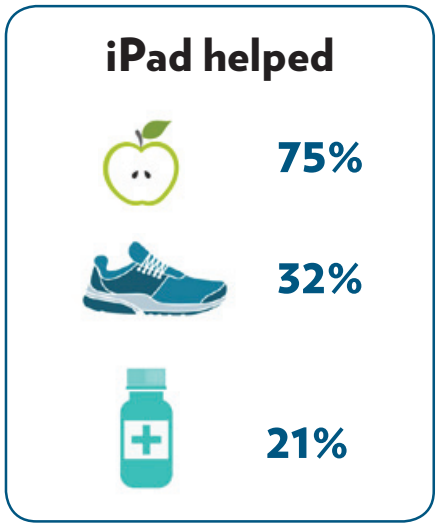


Figure 8: Perceived changes in diet, exercise and medication (fourth survey)

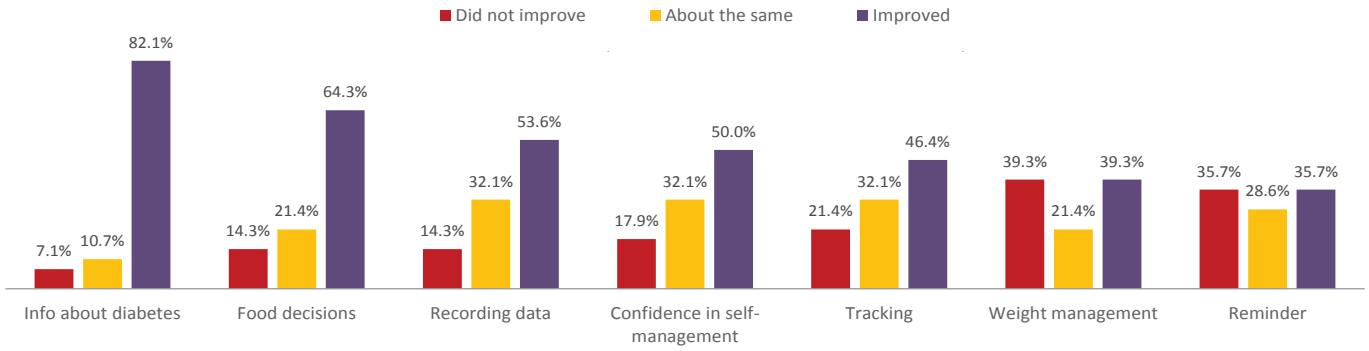


Figure 9: Areas of improvement (%, fourth survey)

Participants were asked where they usually get information about managing diabetes before and during the program. The source of information was more diversified. The majority acquired information from their GPs and this trend does not change much during the program. Before participating in the pilot program, 85.7% replied that they would consult their GPs. At the fourth survey, 78.6% cited their GPs as source of information. However, there was an increase in internet uses for information. At the time of sign-up, only 46.4% searched online for information but at the end of the study, 82.1% used the internet to obtain information about diabetes management (**Figure 10**).

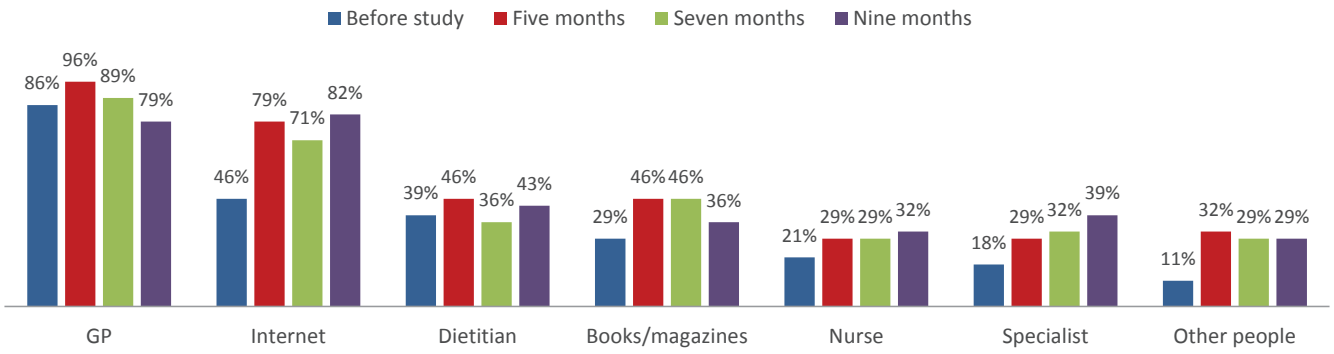


Figure 10: Information channeld for diabetes management (%)

Overall, participants thought that their knowledge about diabetes had improved over time during the study. Figure 11 shows the distribution of how many participants rated themselves on a scale that ranged from 1 (poor) to 7 (excellent). The mean score out of 7 increased from 4.7 (pre-study survey) to 5.3 (third survey), and 5.6 (fourth survey). Before enrolling in the program, only 8 participants rated themselves 6 or above. After 9 months, 15 participants rated themselves as 6 or above. Participants experienced an improvement in their knowledge about their condition (**Figure 11**).

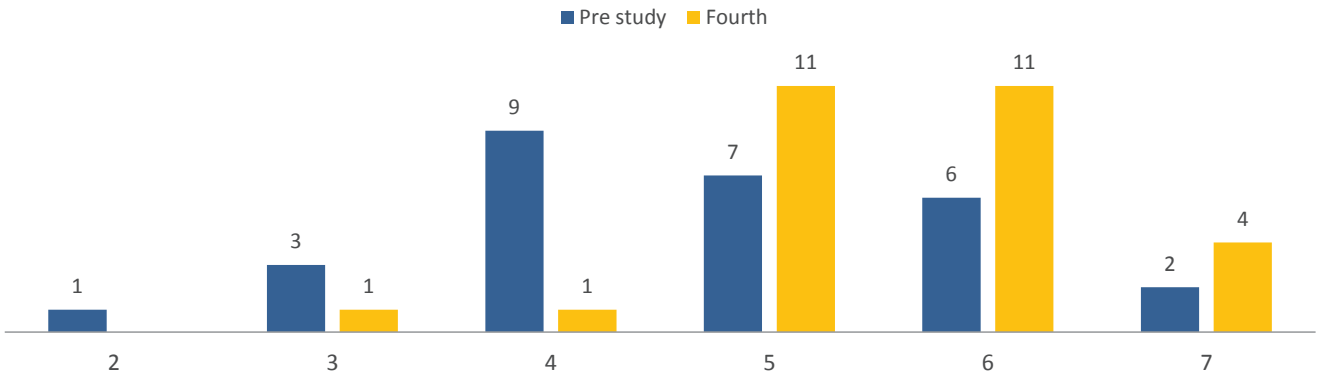


Figure 11: Knowledge before and after the program (number of responses)

We asked participants to rate their ability on a 5 point Likert type scale how they perceive of their own capability to manage their diabetes: How well they handle themselves with respect, compared to others how well they managed, how successful they were in implementing management projects, whether they had support and whether they were able to find solutions when they encounter problems. The overall rating for all items improved after the program. At the end of the program participants felt more competent in managing their diabetes. The scale that improved the most was the relative capability to manage their condition. Participant's confidence in managing their condition in comparison to others had improved (**Figure 12**).

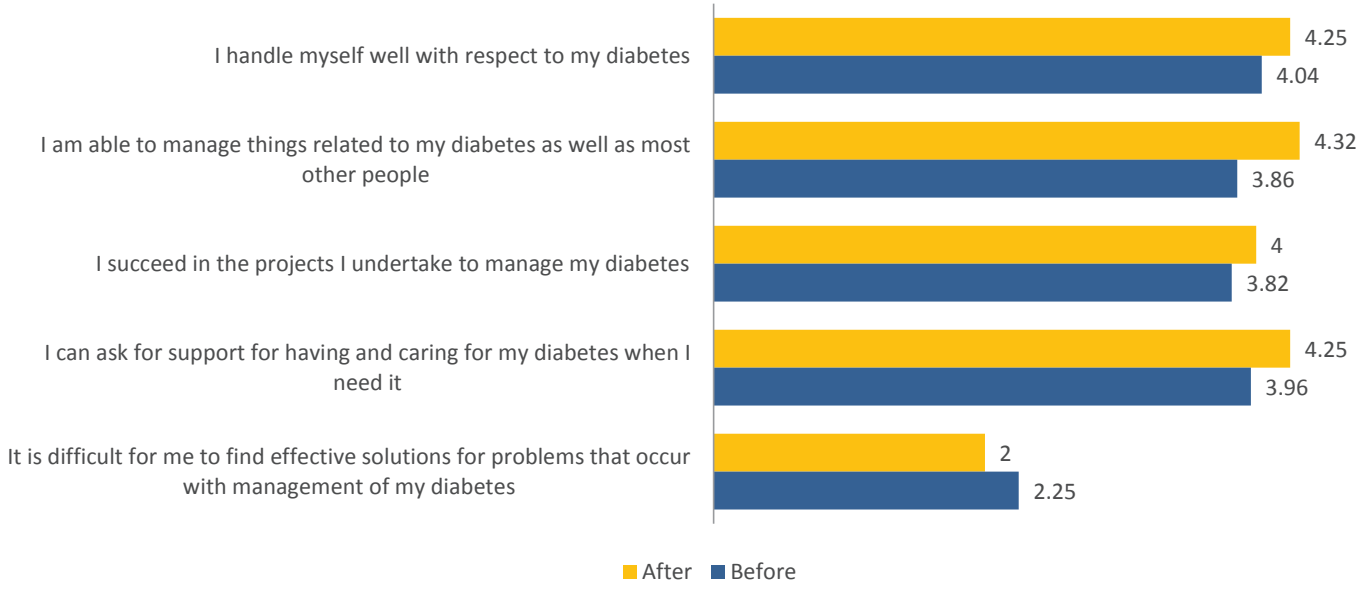


Figure 12: Changes in self-management (out of 5)

Digital training and support

Before the pilot program, digital literacy among participants varied. At sign-up 28.6%% (N=8) of the participants had never used a mobile tablet device before, and 39.3% (N=11) used it very well. Among the non-users of mobile tablet devices, two had smartphones. Four did not use a computer or a mobile phone. Three did not use the internet at the time of sign-up.

Overall, patients experienced an increase in their internet use after participating in the pilot program: 66.7% of participants reported using the internet more than once a day in the pre-study, after 9 months 96.4% of participants were using the internet daily. The proportion of frequent internet users – those who use the internet several times a day – increased from 59% to 75% during the same period. There were no non-users at the end of the program (**Figure 13**).

The main uses of the internet were to search for information and email. Information uses, finding diabetes information, shopping, and social networking site (SNS) uses increased over time. The question included all internet use across all devices. It is notable that communicative uses such as email, instant messenger (IM) and social networking (SNS) uses increased after participating in the program.

	Before	After
Do not use	11%	0% ↓
Use several times a day	59%	75% ↑

Figure 13: Changes in internet use

When asked specifically about iPads, most participants reported an increase in use. In the first survey (two months), 75% of the participants reported using their iPads more than once a day. This increased steadily and after 7 months (third survey): 90% of the participants were using their iPads more than once a day. Frequent users of the device – those who use their iPads several times a day – increased from 42.9% at two months, to 60.7% after 9 months of use. Using their iPads, participants preferred information searching activities and email. The most increased activities on iPads were messaging and social media use. The percentage of participants using messaging and chat on iPads increased from 7% to 25%. Social media use increased from 18% to 32% (**Figure 14**).

	2 months	9 months
Messaging	7%	25%
Social media	18%	32%

Figure 14: Frequent users of messaging and social media on iPad

We investigated the diverse levels of digital engagement with technologies that patients bring with their health condition. Providing a digital literacy support system was a unique element of this study. At the onset, we deliberately recruited patients with a variety in their levels of digital literacy. In addition to the initial training session, participants had the option to request individual training sessions or to attend group sessions organized by the trainer throughout the study.

Forty-two individual and thirteen group sessions were held within four months of the study. Nineteen participants attended training sessions in the first two months, 15 were still participating at five months into the program, and six continued at nine months. Throughout the 10 month pilot program, a total of 17 group training sessions (including the information sessions) and 96 individual sessions were provided. The range of individual training participation was from 0 to 28. There were 9 participants who chose not to come to training. Among the 19 who signed up for training, 4 participants attended 5 or more individual sessions.

Contrary to the anticipation of the research team, it was not just the novice users that signed up for training sessions. In fact, some of the novice users did not participate in the training, whereas some of the skilled users took up the opportunity. Among the 11 who said they knew how to use the iPad very well at the time of sign-up, 6 of them had attended training at two months and four were still participating in the training at five months.

Digital literacy was improved over the course of the mHealth program. When asked on a scale of 1 to 7, how participants felt about their digital literacy compared to others, the mean score increased from 4.3 before the program to 4.9 at nine months (**Figure 15**).

Before	After
4.3	4.9 ↑

Figure 15: Relative digital literacy (out of 7)

By the third and fourth survey (7 and 9 months into the program), participants felt that their digital skills had improved considerably (66.7% and 60.7% respectively). At nine months, 92.85 of participants felt that their digital skills had improved (**Figure 16**).

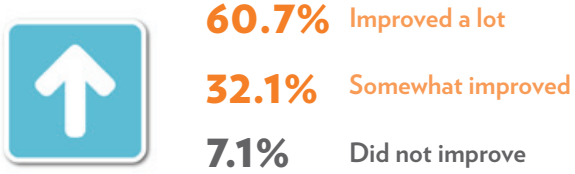


Figure 16: Improvement in digital skills (fourth survey)

After the program, 13 out of 17 reported wanting to learn more about using various functions and apps and to improve their skills. Among those who are eager to learn, 7 (25%) wanted to learn from professional trainer or someone else, and 6 were happy to learn by themselves. After 9 months, some of the participants still felt the need to learn more from someone else – a professional trainer – rather than acquiring further skills on their own (**Figure 17**).

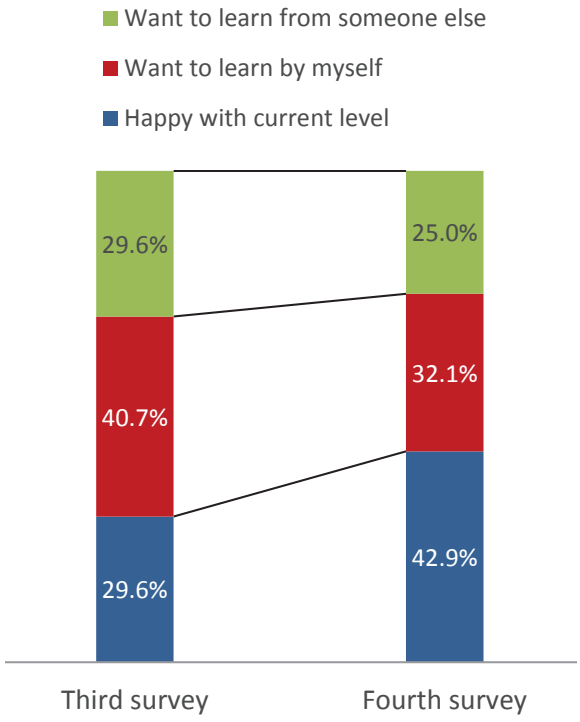


Figure 17: Demand for further training

When experiencing difficulties with the device, about half of the participants turned to their children for help. They also asked the mHealth digital trainer, and their partner or friends (**Figure 18**).

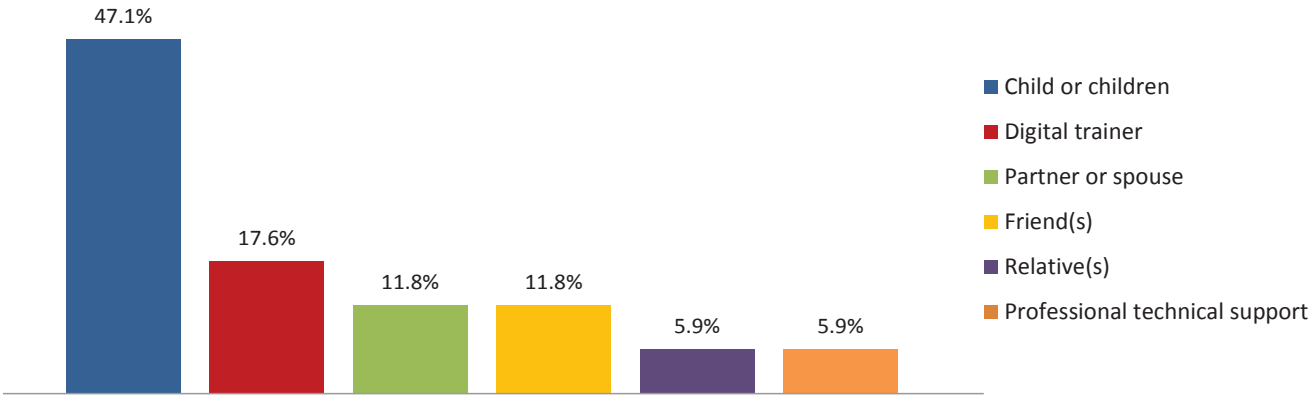


Figure 18: Help with iPad (fourth survey)

A strong need for a mHealth program that integrates digital literacy training was identified through the pilot study, not only in the skills training but also in the form of ongoing support. Many self-management programs that utilise digital technologies often lack the provision of technical support and assume participants will be able to figure out the best uses of the technology. Providing adequate training and support was found to be essential to the pilot program participants. For a sustainable engagement with mHealth tools, continuous digital literacy programs and technical support are both crucial elements.

For mHealth training programs to be effective, customised and individualised programs are needed. This is because different types of users need different attention. They learn at different paces and also have different needs. Another important factor in embedding digital technologies into health management is that they must be embraced into the users' everyday lives, rather than used solely as health tools.

The 10 month pilot program reveals that users acquire digital literacy at different paces and they are motived through a diverse range of needs. The gradual process

of learning technical skills to utilising the skills to manage their health requires customised and continuous training. Once participants acquired the confidence to use the devices on their own, most of them could use the mHealth tools to better manage diabetes.

Engaging with digital technologies for effective uses is a slow and gradual process. There was a strong need for training among those who did not have adequate skills or confidence to learn on their own. Within the context of health management, two types of training were required: technical skills and ongoing support. First, users need to acquire basic technical skills to access the devices and effectively use the tools. However, when they practice the new skills they often encounter difficulties, which can usually be solved by additional support sessions and customised training. The process of acquiring the knowledge and skills was gradual because many of the skills that they apply in diabetes management required changes in behaviour and lifestyles. To link the skills to the behaviour additional support from the trainer was needed. The additional training involved gaining confidence in order to become autonomous users of the device. Digital confidence is the key to learning and practice. Those who chose to participate in training at the beginning became repeat trainees. They returned for further training, knowing that continuous training is essential.

Digital confidence

Gaining confidence is an important start to digital competency as well as self-management of chronic conditions. The pilot program primarily focused on building confidence in digital skills through providing access to digital tools, training and support.

When asked if they were confident enough to use the iPad at the end of the pilot program every participant answered yes. More than half (60.7%) replied that they gained confidence through the mHealth study (**Figure 19**).

The factors that helped build their confidence were practicing and using the iPad daily, getting on-demand help when needed, and to be reassured that they can also become competent users (**Table 11**).

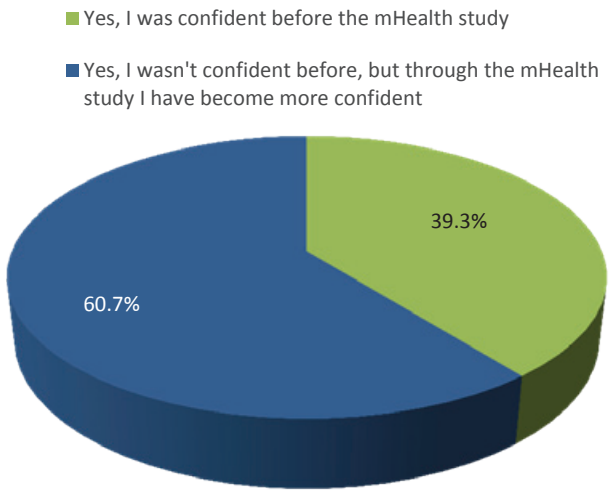


Figure 19: Confidence in using iPad after study (%, fourth survey)

MAIN FACTORS THAT HELPED PARTICIPANTS BUILD THEIR CONFIDENCE LEVEL		NUMBER OF RESPONSES
Constant use and familiarity		11
Training and support	Learning the functions of the iPad/the information sessions	5
	Support/encouragement	5
	Not being frightened to touch buttons	4
Interaction with family members		1

Table 11: Main factors that helped participants build their confidence level (fourth survey)

A more detailed example of how participants were able to gain confidence is listed in **Table 12**.

PARTICIPANT	HOW THEY GAINED CONFIDENCE
Anna	What else! Practice.
Ava	Just using it all the time
Claire	The single main factor that has helped increase my confidence has been Andrew*. He has taught me how to use the iPad, how it works and the possibilities it offers. He has encouraged me to try and find new things on it and explained in the next session and answered many questions or guided me to discover for myself. The other main factor has been the repeated use or practice of a particular function or app.
Emily	Trial and error and practicing.
Jasmine	Not being frightened to touch buttons as I often thought I would lose information. Finding my way around the iPad and using the Internet since the survey started has given me great confidence.
Kaylee	That my grandchildren they can do more than me.
Keith	Being able to use at my own time and having someone to ask for help
Kylie	Daily use of the iPad. Use of the iPad through understanding it with my trainer and also interacting with other members of my family, who also have their iPads.
Layla	Just getting in and trying things pressing buttons and seeing how things work but mostly be able to find information for myself and on my own I feel quite good about myself and my capabilities.
Leah	I was able to ask questions. I received emails of support and offers of help if I needed. Constant use the more I use it the more I learn. Having that apps to assist me in the management of my diabetes. All the help I need is on my iPad or I can get an app that will help me.
Madelyn	The first training sessions with Andrew* were a good start. Then practice using some of the apps. Then finding links to interesting information and research. Then a few more sessions with Adrian to learn particular manipulations. After that, it was finding stuff that I could apply to my own situation that actually worked. After that, I was unstoppable!
Porter	My knowledge of my laptop which I have used for the past fifteen years and my smart phone as the processes are very similar.
Rachel	Constant use and familiarity with the device. Using it many times a day builds confidence and encourages you to explore different functions, uses and apps.
Ruth	Attending the information sessions and learning the functions of the iPad. Continued use of the apps and functions of the iPad and becoming more familiar with them.
Ryan	I have found the only way to build confidence is to use the device as much as possible and to download and delete apps, turn on and off Wi-Fi and carrier settings and practice with emails and attachments.
Todd	The one-on-one workshops with Andrew*.
Tristan	I am still very basic at using the iPad but it is better than before I started as then I had never used one. I still have a hell of a long way to go to be able to use the iPad competently.

* Pseudonym of the digital trainer

Table 12: Building confidence (qualitative responses, fourth survey)

Through the pilot program, the majority of participants experienced an increase in their confidence level in using digital media, such as mobile devices and computers. They were also more confident when using apps and the internet. At five months, 71.4% of the participants felt an increase in their confidence in managing diabetes, 64.3% said they felt more confident about their life in general. At the end of the program, the confidence levels increased to 78.6% and 67.9% respectively (**Figure 20**).

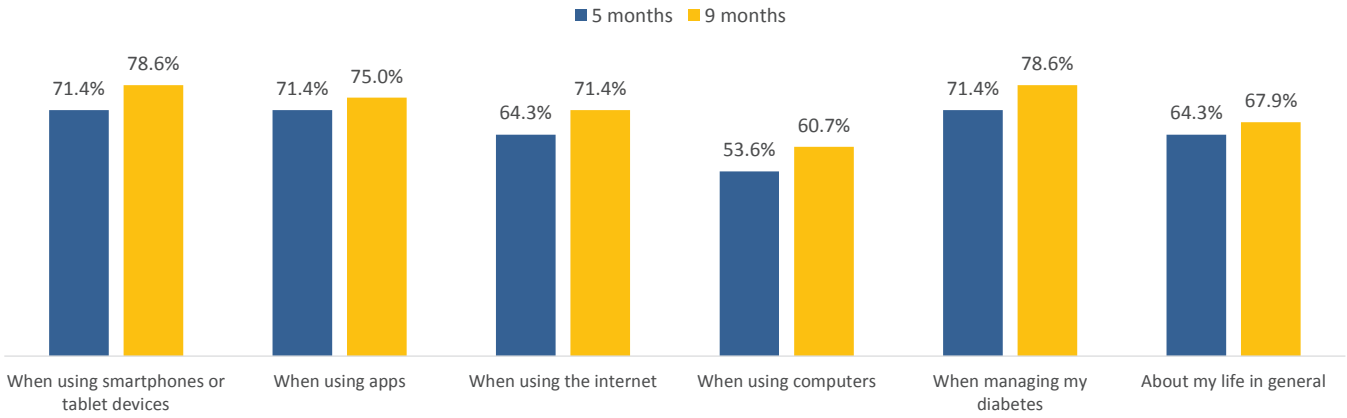


Figure 20: Increased confidence after participating in the program (%)

Among those who attended one or more training sessions, 89.5% (N=17) of the participants reported that the iPad helped them manage diabetes since participating in this study. In contrast, only 44.4% of those who did not participate in the training felt that the iPad helped them and 44.4% was unsure of the effect. With customised training, users can benefit from targeted and effective uses of the device (**Table 13**).

		TRAINING*		TOTAL
		YES	NO	
iPad helped manage diabetes	Yes	17 (89.5%)	4 (44.4%)	21 (75.0%)
	No	1 (5.3%)	1 (11.1%)	2 (7.1%)
	Not sure	1 (5.3%)	4 (44.4%)	5 (17.9%)
Total		19 (100.0%)	9 (100.0%)	28 (100.0%)

*participants who attended at least one training session

Table 13: Trainees and non-trainees' perception of iPad benefits

The scope of digital training was broad and customised for each individual. The training program was not always focused on mHealth. Many participants chose to learn email, social media, reading, and watching videos. Need-based training equipped the participants with digital confidence and eventually they were able to explore and use various tools independently.

Those who participated in the training perceived of the iPad to be helpful in managing diabetes more than those who did not participate. The differences between trainees and non-trainees were larger in recording, gaining confidence, and reminder activities (**Figure 21**).

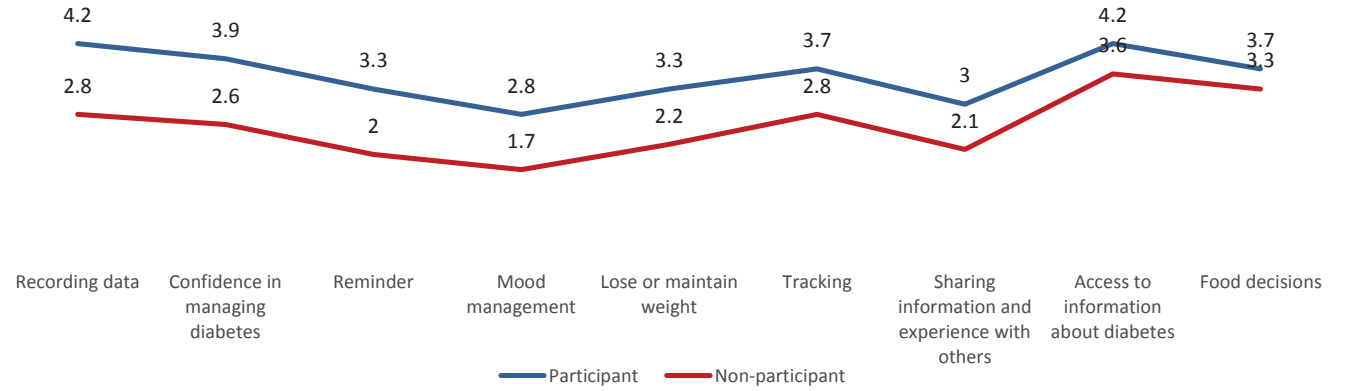


Figure 21: The training effect: 1 = Strongly disagree to 5 = Strongly agree

Differences in confidence levels between trainees and non-trainees were also found at the end of the program. Those who participated in the training felt a lot more confident in various aspects of diabetes management, as well as using digital devices.

This is an important finding, since trainees were mostly those who had lower digital skills at the time of sign-up. Training not only increases digital skills but also confidence in managing diabetes and life in general (**Figure 22**).

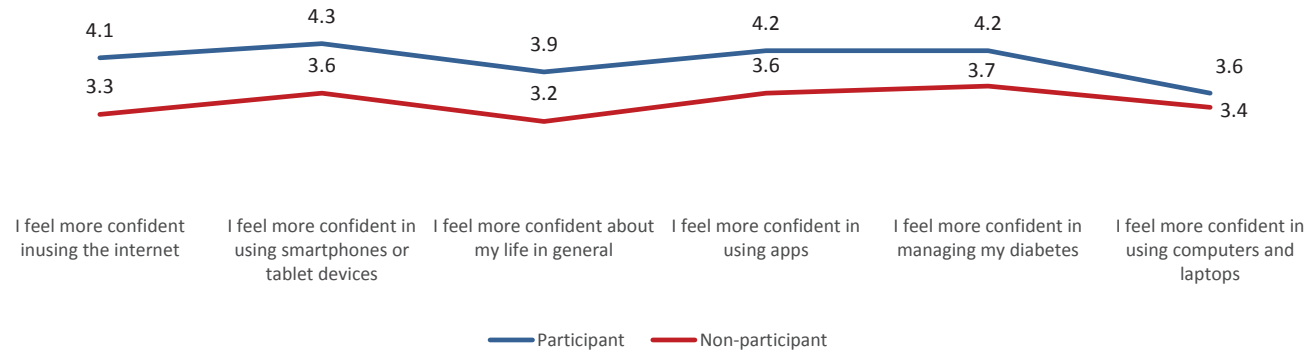
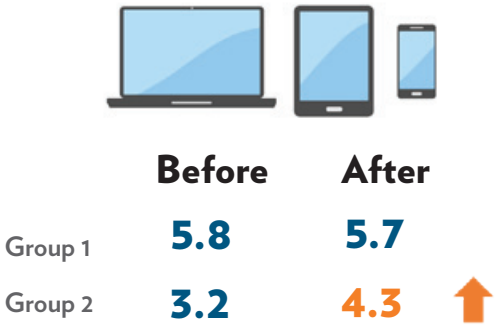


Figure 22: Confidence of trainees and non-trainees: 1 = Strongly disagree to 5 = Strongly agree

To see the impact of increased confidence in using mobile tablet devices, we asked participants at the fourth survey, if their confidence levels had changed over the course of the program. Participants who remained more or less the same in their confidence in using iPads, and those who experienced an increase and were divided into Group 1 (N=11, 39.3%) and Group 2 (N=17, 60.7%).

Figure 23 presents the differences in the changes in the relative digital skills between the two groups. A noticeable increase in the relative digital skills was observed among Group 2 participants at the end of the pilot program (Mean = 4.29), whereas the skills did not change among Group 1 participants. This is partly because their skills were relatively high to begin with. The improvement in the skills among Group 2 is indicative of how the training can improve users' digital engagement (**Figure 23**).

Everyone in Group 2 (17 out of 17) felt their user skills had improved after participating in the mHealth program: 14 felt that they improved a lot, and 3 said that they had improved somewhat (**Table 14**).



*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

Figure 23: Improvement in relative digital skills (out of 7)

	GROUP 1	GROUP 2	TOTAL
No not at all	2 (18.2%)	0 (0%)	2 (7.1%)
Somewhat improved	6 (54.5%)	3 (17.6%)	9 (32.1%)
Improved a lot	3 (27.3%)	14 (82.4%)	17 (60.7%)
Total	11 (100%)	17 (100%)	28 (100%)

*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

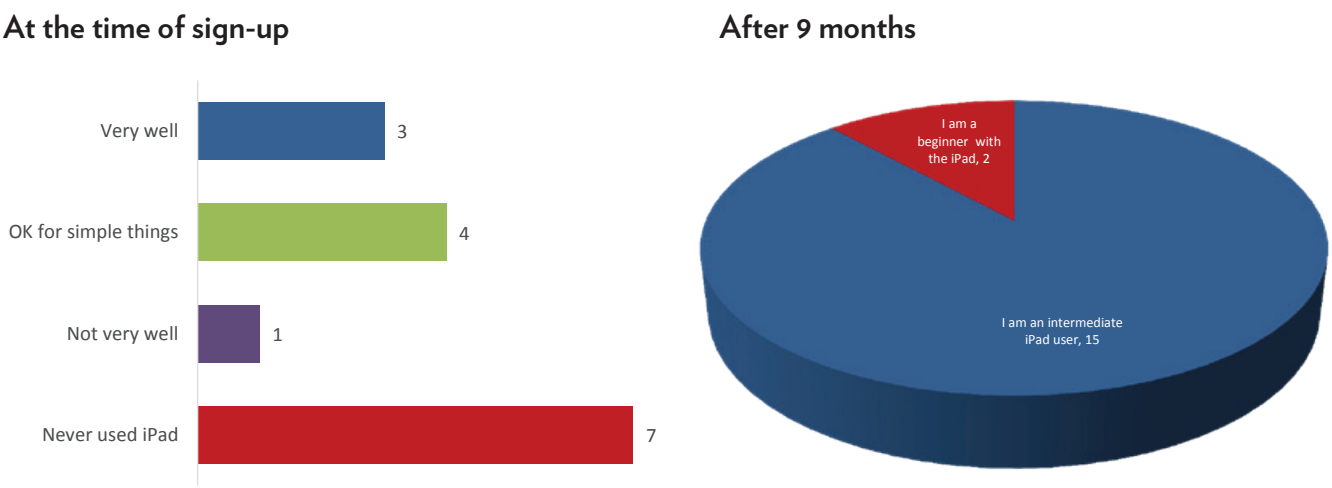
Table 14: iPad skills improvement by group

	GROUP 1	GROUP 2	TOTAL
No I am happy with my current skill level	8 (72.7%)	4 (23.5%)	12 (42.9%)
Yes I would like to learn by myself	3 (27.3%)	6 (35.3%)	9 (32.1%)
Yes, I would like to learn from someone else to improve my skills	-	7 (41.2%)	7 (25%)
Total	11 (100%)	17 (100%)	28 (100%)

*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

Table 15: Participation in training sessions by skill level during the mHealth program

Those who gained confidence through the mHealth program were eager to learn more from a professional trainer, while those who were already confident before the program were happy at their current skill level (**Table 15**). Among Group 2 participants, 15 out of 17 regarded themselves as an intermediate iPad user (88%) after the program (9 month). Among those who regarded themselves an intermediate iPad user at month 9, almost half of them (41%, 7 out of 15) had never used iPad before participating in the study (**Figure 24**).



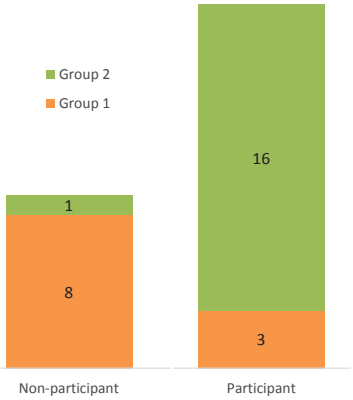
*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

Figure 24: Confidence changes of trainees and non-trainees (number of responses)

Training was a significant factor in improving the confidence levels among participants. Among Group 2 members, 15 out of 17 (88.2 %) participated in the training during the study, while 54.5% of Group 1 members participated (6 out of 11). Among Group 2 members, 14 out of 17 (82%) attended two or more training sessions. Four members continued to participate in the training sessions for the entire period of the program.

In other words, Group 2 members participated more in the training. At two months, 16 of Group 2 members participated in the training whereas only 3 from Group 1 participated. At five months, 12 of Group 2 members and 3 of Group 1 were still coming to training sessions. At 9 months, 6 from Group 2 were still in training and none from Group 1 (**Figure 25**).

Score	Pre		Fourth	
	G1	G2	G1	G2
7	2			
6	5		7	
5	1		1	
4				1
3				
2		1		
1				
Mean	6.13	2	5.88	4



Score	Pre		Fourth	
	G1	G2	G1	G2
7	1	1		
6		1	2	4
5	1	2		3
4		2	1	4
3	1	2		4
2		3		1
1		3		
Mean	5	3.29	5.33	4.31

*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

Figure 25: Participation in training and digital skills by group (number of responses)

The health outcomes were different between the two groups as well. Among Group 2 participants, 70.6% said their diabetes had improved since they participated in the study, 23.5% replied that it was about the same, and 5.9% felt it had worsened. In contrast, 45.5% of Group 1 participants said that their health had improved during the program (**Table 16**).

	GROUP 1	GROUP 2	TOTAL
It has improved	5 (45.5%)	12 (70.6%)	17 (60.7%)
It is about the same	6 (54.5%)	4 (23.5%)	10 (35.7%)
It has worsened	0 (0%)	1 (5.9%)	1 (3.6%)
Total	11 (100%)	17 (100%)	28 (100%)

*Group1: I was confident before the mHealth study
Group2: I wasn't confident before, but through the mHealth study I have become more confident

Table 16: Improvement in health by group

We asked the question, "Do you think you will continue to use the iPad to manage your health?" The majority of the participant replied that they will continue to do so. We also asked, "Do you think that you will continue to use the iPad for purposes other than diabetes management?" The majority replied that they would be using their iPads.

One participant who said he wouldn't be using the iPad as he had a health condition that made it hard for him to hold and carry the iPad. He was adept in using the computer and smartphones and would continue to use these technologies to maintain his health. However, the iPad was too heavy for him to use (**Table 17**).

	USE IPAD FOR DIABETES MANAGEMENT	USE IPAD FOR OTHER PURPOSES
Yes	23 (82.1%)	26 (92.9%)
No	1 (3.6%)	1 (3.6%)
Not sure	4 (14.3%)	1 (3.6%)
Total	28 (100%)	28 (100%)

Table 17: Intention to use the iPad after the study (fourth survey)

The process of engaging with mHealth

Regardless of the skills level before participating in the program, participants commonly reported that engaging with digital technologies was a slow and gradual process in this mHealth intervention. Among those who did not have the skills or the confidence to learn by themselves, there was a strong need for training support. Within the context of health management, the type of training that is required consists of technical training and continued support. First, users need to acquire basic technical skills to access the devices, and use the tools.

However, when they practice the new skills they often encounter difficulties, which can be solved by customised training and support sessions. The process of acquiring the knowledge and skills was gradual because many of the skills that they apply in diabetes management required a change in behaviour and lifestyles. Linking the obtained skills to the health context required additional support from the trainer. This often involved gaining confidence in becoming autonomous users of the device.

The progress of the unskilled users who became confident after the program shows that support is necessary not only for the technical learning but also to build confidence. Digital confidence is the key to learning and practice. Those who chose to participate in training at the beginning became repeat trainees. They returned for further training, knowing that continuous training is essential.

Digital engagement – being able to use digital technologies effectively – requires longer term learning and repeated exposure to new tools. Participants had a diverse range of digital skills at the onset of the program. They also had different styles of learning and using digital tools. Typologies of patients were identified depending on the different levels of digital engagement and health behavior.

- Active uses: Some of the participants were actively engaged in recording, tracking and observing aggregate data. Through visualised and integrated data, they were able to appreciate the value of their 'small data'. These were typically those who wanted to learn more about technologies and become more sophisticated users of digital devices.
- Functional uses: Learning new technologies were not a major motivation to participate in the program. Some users either already had sufficient skills or acquired the ability to use the apps for effective self-management. The ease of access to mobile devices was a crucial element in functional uses.
- Limited uses: Many users struggle to adapt to new technologies. Those who were not adept users of technologies still did not want to be left behind and wished to be able to use the tools without frustration. They acquired a certain level of skill and used the device minimally for specific purposes.

Whether a user becomes an active user or a functional user is an individual's choice. However, the loop between disengaged to effective users largely depends on the training and support that users are provided with. The typologies identified through the pilot program are not by any measure an inclusive list of uses. People's uses of technologies are diverse and within the limited number of participants, we were able to showcase patterns of uses. It should also be noted that a user's typology is not static. Uses of technology changes over time, and users engage differently with the tools depending on the context. Identifying different types of uses was the purpose of profiling the users into different typologies but it is not always the case that one user fits neatly into one category.

This is why in order to be effective, mHealth training must be customised and individualised. Different users need different attention in various contexts. Users have varied needs and learn at different paces. Another important factor in embedding digital technologies into health management is that they must be embraced into the users' everyday lives, rather than used solely as health tools.

Some examples of how participants engaged with mHealth apps and the devices are provided in **Table 18**.

PSEUDONYM	BRIEF SUMMARY
Anna	Experiencing benefits of checking facts and finding cause and effect, weight loss led to lowering BGL
Mitchell	Did not use the iPad because it was too heavy for him to manage with Parkinson's disease, very good user of smartphone, computer, stereo, and other digital devices
Jasmine	Non-user of mHealth apps, use iPad for email and communication, relinked with friend via iPad
Ruth	High awareness of health management, liked to confirm facts, used authoritative sources, not a social user
Tristan	Overly cautious user of technologies, especially the internet, use iPad as a reminder to take medication
Parker	Use iPad for information, seamless fit between computers and phones
Rachel	Newly diagnosed as type 1 diabetes, active user, like learning new things and figuring out how things work, use iPad for information
Madelyn	Information seeker but cautious about digital technologies
Ryder	Very positive and active user
Ryan	Not active mHealth user but health conscious
Claire	Not active mHealth user but engaged with the iPad and continues to learn with a strong sense of empowerment
Leah	Very active user, benefited from Glucose Wiz to diagnose her as a rare type of diabetes

Table 18: Examples of mHealth uses

Participant experiences

Improved knowledge

When people are diagnosed with diabetes, they learn about the condition, set up a daily management plan with health practitioners, and continuously monitor the outcomes. It is not an easy task to absorb the knowledge, keep a routine of food intake and exercise, as well as record biometrics.

The mHealth apps are designed to aid with one or more aspects if self-management. Participants found that integrating information was especially empowering. They were able to find relevant knowledge to their conditions and grow an understanding of how to manage the illness.

> *"I have been able to access some research on diabetes. I find the actual research more useful than the "pop culture" advice offered by others"* (Samuel)

This was the main source of behavioural changes and what kept them maintaining their routine. The easy access to information enabled them to make informed decisions.

- Broader and deeper knowledge about diabetes
- Acceptance of the disease through improved knowledge
- Motivation to change behaviour

> *"It has opened a whole new world to me that I didn't think was possible." "It's like a whole new world of information has opened up for me, my knowledge of the world and of technology was very narrow before I got the iPad, but that has changed now."* (Emily)

"The apps apart [from] providing actual information of your management, helps maintain good management.....Knowing the calorie intake level that should see gradual loss of weight, it has assisted me to reduce my calorie intake and as consequence I have found that my meal sizes have reduced, without feeling hungry." (Anna)

"The ease of access to nutritional information, food alternatives and recipes has made this much easier than having to locate books and locate the information I needed by trawling through pages of irrelevant information" (Zayne)

"It has helped me come to grips with my diabetes by helping me to understand more about the disease" (Emily)

The feedback loop

Between appointments with GPs and specialists, patients experience ups and downs while monitoring their condition. GP consultation usually are in 2 to 3 months interval. During this time, participants were able to benefit from the ongoing monitoring, tracking, and getting feedback on the mHealth apps, which helped them better understand their conditions.

"The iPad has helped me deal with the condition. Not only has it helped with monitoring sugar levels, it has also been handy to access the web for information. Even getting the emails to do the surveys has kept me on my toes and been a constant reminder to keep up the good work..". "Using this app [Glucose Wiz] frequently not only helps maintain [BGL] levels, but over time will educate you on what you eat." (Jackson)

"The iPad is like someone looking over your shoulder and checking your progress. Someone to answer to...I find that I can get answers to all my questions by visiting the appropriate internet sites...".."I reach for the iPad first thing in the morning and last thing at night to monitor my glucose levels. My weight is monitored first thing in the morning and during the day my activity levels are also monitored. These major functions are key aspects of my health program." (Ryan)

The act of recording and tracking constantly reminded them of their daily habits, which enabled them to change their lifestyles. This was because they could link the cause and effect of their daily activities.

- Interactive experience as empowerment tools
- Ability to link BGL, diet, and weight through different apps
- Observing the link between their actions and outcomes

"I like the Glucose Wiz because it gives me visual feedback on how my blood sugars are progressing, and I am able to send results to my GP. I like the Food Switch App to check on my purchases and how wise (or not) they are." (Raymond)

"Obtaining true nutritional values of food" "having a bank of previously selected food to choose from". "Using the apps to record my blood glucose level has been useful to see the results in graph form pointing out high recordings. These graphs were beneficial to show my doctor as she could see a broader picture of my levels rather than look through my book or rely on one blood test." (Ruth)

The social aspect

The potential to engage in discussion with other patients, the feeling of connectedness, and being in touch with family and friends were important aspects of social support that the participants were able to moblise through the devices.

> *"I feel I have more knowledge around diabetes than I ordinarily would have had along with knowing there is a support network available should I require it."* (Zayne)

> *"It has helped me to not feel as isolated from the family as we can now keep in contact and see how everyone is going on a daily basis."* (Kaylee)

In other words, the iPad provided participants the opportunity to connect with others and to seek support at various levels.

- Social support in form of online communities and forums specific to diabetes
- Support network from family and friends enabled by online communication tools and social media
- Connectedness through a wider online network

> *"My expectations have been met to a large degree, the interaction with other diabetes sufferers is not usually available in normal daily life as where there is a forum on line you learn different approaches for all sorts of problems and how they solved them."* (Porter)

Embedding iPads into everyday context

From the onset, the pilot program recognized that digital devices and tools cannot be separated from the user's daily routine. Participants were encouraged to use the iPads for daily activities and not only for health management. Training was provided on-demand to accommodate the needs of the individual.

> *"The iPad has become like another part of me. I use it in the morning, noon, evening and before bed."* (Sophia)

> *"Learning to use the iPad has been so much more valuable to me than I can express adequately. Meeting people and learning how others cope with their diabetes, taking part in discussions sometimes, playing games and sharing humour has been very good."* (Madelyn)

> *"Even when I am by myself, having the iPad always makes me feel connected to people who are in similar situation."* (Ryder)

As a result, participants were able to place the device into their daily context. By embedding the device into their daily lives, participants could benefit from immediate and continuous use of the tools. Participants found the iPad to be portable compared to laptops and computers. Compared to mobile phones, the iPad was easy to use when searching and looking up information.

> *"The iPad has educated me on modern technology. In addition to using the iPad for the mHealth study (recording, reading, using the apps) I find I now use the iPad on a daily basis to read the papers, do the crosswords, read emails, check the weather and use the internet. I find myself sitting reading more, the time can pass very quickly using the iPad."* (Ruth)

> *"The iPad is a big part of my life and when at home it goes with me everywhere."* (Preston)

> *"The iPad has changed my life, it is my best friend."* (Leah)

The value of training and support

Digital training is not just about learning technical skills. The user must reach a certain skills level in order to be able to maneuver the device. However, further engagement is necessary to realise effective uses. This level of active engagement requires a support system that is continuous, immediate and personalised. When a novice user with low digital skills learn to use the device, it takes time and repetitive learning to become confident enough to use the device on their own.

> *"I have found the individual training sessions extremely valuable as Andrew was able to answer all of my questions, patiently show me how the various features of the iPad worked as I needed them or wanted to know about them. He was also able to reassure me about my usage and reinforce things I may have forgotten from previous sessions, He also encouraged me to try various features and reassure me that I probably wouldn't erase everything on there. He has given me confidence to do things on the iPad. He has been my greatest resource."* (Claire)

> *"Being a novice to the iPad the training sessions have taught how to get to know the iPad. I would not know how to use the iPad without the training sessions. The training brings confidence to understand you can't "lose" information. The sessions empowered me knowledge I did not have before."* (Jasmine)

The participants were able to build digital confidence through training sessions that were paced at the learner's progress. The process is not linear and the ways to reach digital competency are varied. Each individual has different needs and learning styles that need to be considered when providing the training.

> *"I guess in a way they were only prepared to learn what they only wanted to know rather than wanting to learn the true capabilities of the device...We then put the ball into their court to say okay, can you think of anything that you would like to do with it? But then they come back and say well, how do I know what I want to use it for if I don't know what I can do with it? It's just okay, we can give you examples of how you can use it and then there comes a time when we then pass it back to them. We're okay, now you know a little bit of what it can do have another think about that same question."* (Digital trainer)

GP Survey

GPs use of digital media and the internet

The majority of respondents had internet access in their consultation rooms (99.2%) and in most cases, broadband connection (76.3%). This reflects the state of connectivity across primary care facilities in Australia.

The use of electronic methods to store administrative and patient medical records was reported to be pervasive. A total of 84.8% of GPs responded that the records they keep are all or mostly electronic, while 13.9% of GPs reported using combined electronic and paper records (**Figure 26**).

However, there were variances in the uses of different types of electronic methods. The most popular activity in clinical practice was to receive laboratory reports from other professionals or practices; 94.8% of GPs replied that they routinely receive reports electronically. The least common activity was to send prescriptions to pharmacists electronically. The majority (71.1%) had never used this method before (**Table 19**).

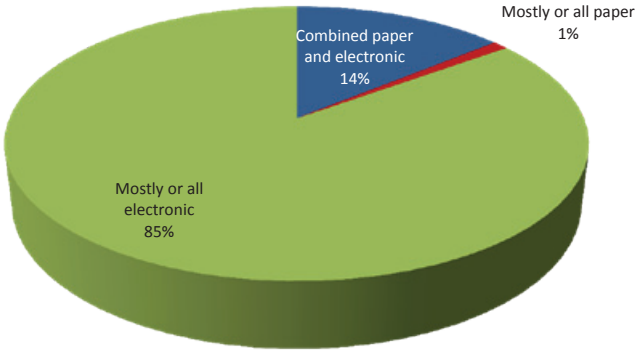


Figure 26: Participation in training and digital skills by group

Receive laboratory reports	98.2
Use the computer/mobile device as a patient education tool/give information during consultation	93.0
Send/receive referral and discharge letters	88.7
Receive/send laboratory reports and share with healthcare professionals/providers	88.4
Order supplies for your practice	83.8
Exchange radiology reports with healthcare professionals/providers	80.9
Exchange medical patient data with other healthcare providers/professionals	79.4
Update information in the electronic health record system	75.5
Exchange patient medication lists with other healthcare professionals/providers	65.2
Patient appointment requests	61.3
Send SMS to patients	61.1
Interact with patients by email about health-related issues	54.9
Certify sick leaves	50.5
Online booking	42.3
Make appointments at other care providers on your patients behalf	36.1
Exchange medical patient data with any healthcare provider in other countries	30.7
Transfer prescriptions to pharmacists	28.9

Table 19: Use of digital media and the internet at work (%)

While the majority of GPs use desktop computers (92.3%) for work, 64.9% also reported using their smart phone, 41.5% their laptop and 39.2% their tablet device. There was a difference in the uses of varying types of digital devices for personal use. The most common device for personal use was a smart phone (83.8%), followed by a tablet device (69.1%), laptop (68.6%) and desktop computer (49.7%).

There was no gender difference but age differences were observed in the uses of smartphones, laptops and desktop computers for work. GPs in the under 50 age group tended to use smartphones more than those in the 50 or above age group. Similarly, in the case of laptops, there was a relatively lower usage among in the 60 or above age group (**Figure 27**).

		UNDER 40	40s	50s	60+	ALL
	Work	72%	72%	59%	51%	**65%**
	Personal	85%	89%	80%	78%	**84%**
	Work	42%	43%	50%	27%	**42%**
	Personal	77%	64%	76%	54%	**69%**

Figure 27: GPs use of digital devices

Digital literacy and attitude towards technology

Digital literacy of GPs was a significant factor that influences the perception of how mHealth can be utilised to benefit type 2 diabetes patients. This was across all age groups. Those who do have higher digital literacy tend to have a more optimistic view of introducing mobile technologies into patients' self-care. Exposure to and use of electronic systems in health delivery were also important factors. There were no regional differences but male doctors were more positive towards the benefits of mHealth.

The activity that GPs were most confident with when using digital devices was effectively deciding which information would be most useful online (69%), taking photos with digital devices (64%), and operating buttons or menus (63%). More than half (62%) of GPs rated themselves to be above average in their ability to identify prejudice and bias online. About 60% said they were above average in finding out different functions of digital devices. Posting on social networking sites or managing blogs or websites were rated lower. Overall, GPs tended to have higher functional skills, such as taking photos and operating buttons or menus, as well as higher content-related literacy, such as the ability to identify useful or biased information. However, GPs tended to have lower network-related literacy, such as use of social networking sites, managing websites or blogs (**Figure 28**).

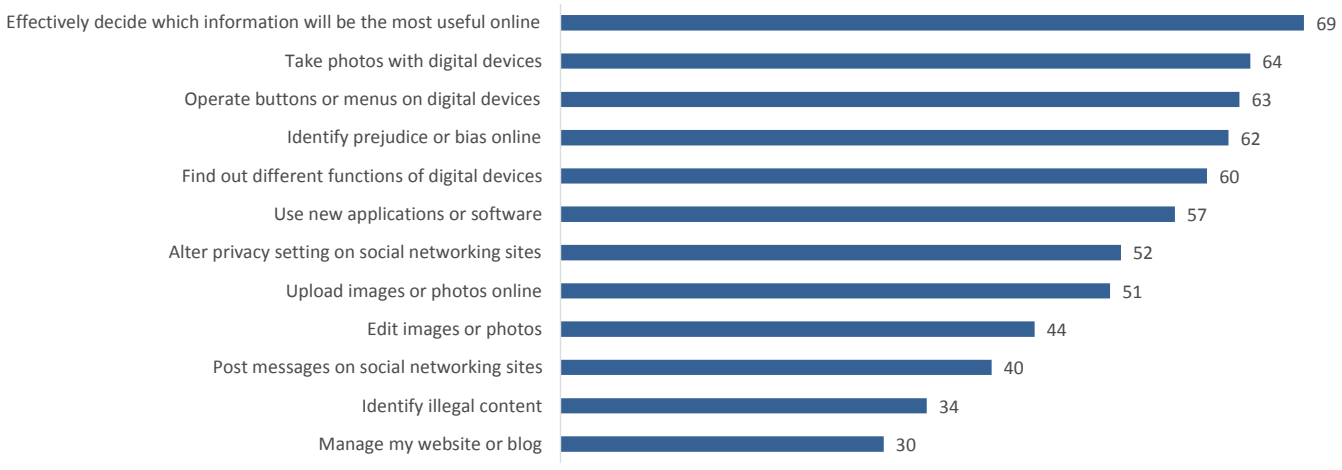


Figure 28: Percentage of GPs who rated themselves as above average (%)

In general, male GPs have a higher digital literacy than female GPs. There were significant gender differences in functional skills, such as taking photos and finding out different functions of digital devices, using new applications or software, uploading images or photos online, and editing images or photos.

However, there were no significant differences in content-related activities, such as identifying useful or bias information, were found. There were significant age differences in digital literacy – the older GPs have lower digital literacy (**Figure 29**).

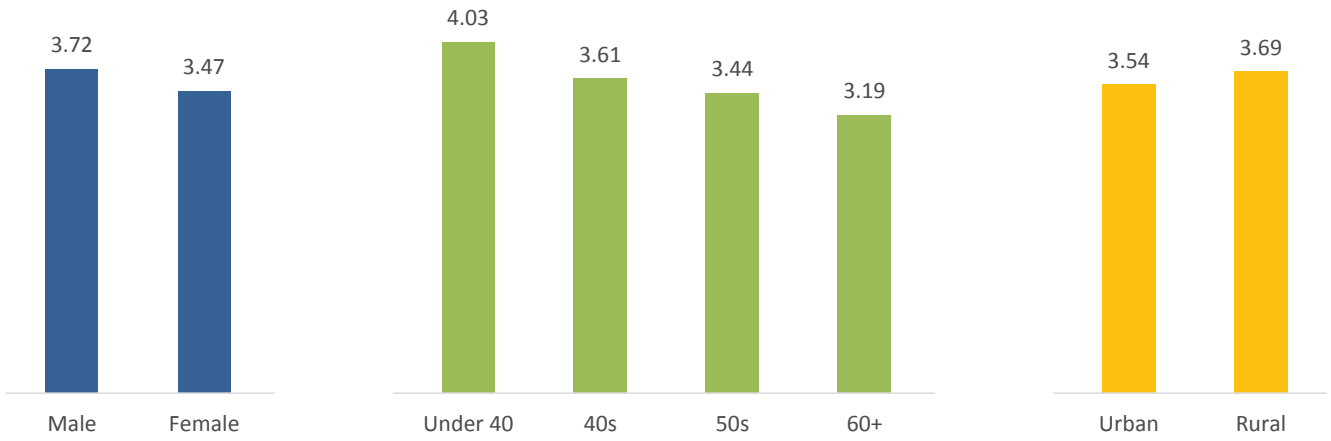


Figure 29: GPs digital literacy by gender, age and region (out of 5)

The majority of GPs (94.4%) like to find out about new technology ('always' 42.3% and 'sometimes' 52.1%), but only half of GPs (54.1%) like to try out new technology ('always' 11.3% and 'sometimes' 42.8%). More than half of GPs talk to others about new technology (65.4%) and are asked by others about their opinions on new gadgets (65.8%).

At the same time, 68.1% of the GPs reported that they experience confusion in relation to the new technology. Gender differences were found in the attitude towards technology. Male GPs tend to be more positive and apt in using technologies. Female GPs were more confused with technologies compared to male GPs (**Figure 30**).

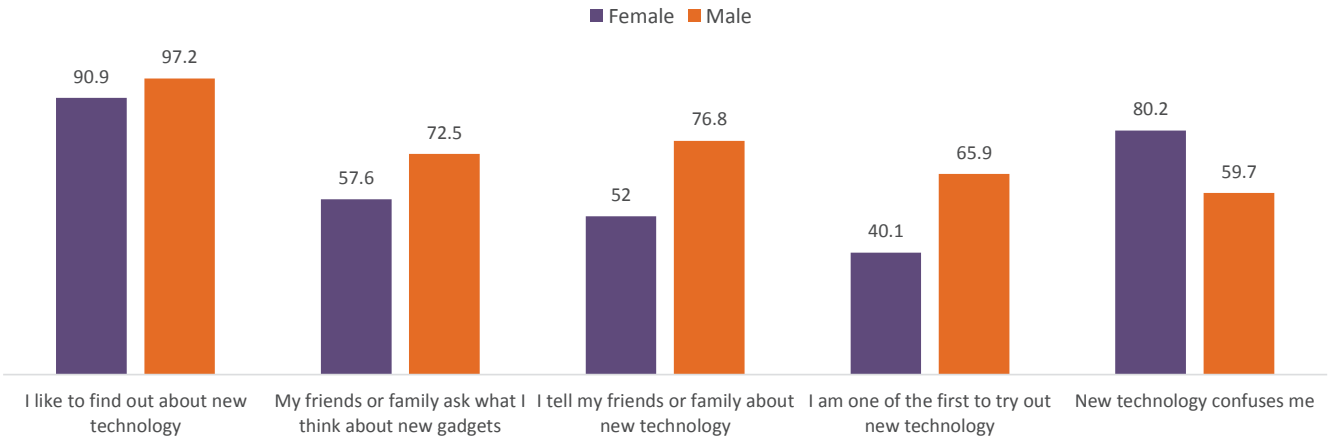


Figure 30: Gender differences in attitude towards technology (%)

What do GPs think about mHealth?

Ease of use (70.6%) was ranked the highest in the perceived usefulness of mobile tablet devices in practice. More than half of the GPs believed that the use of mobile tablet devices could increase the quality of care (63.7%). However, 68.0% of the GPs were also concerned about privacy and security issues, and 49.2% of GPs believed the use of mobile tablet devices would result in a greater workload. More than half of GPs had technical support at their practices (61.1%) (**Figure 31**).

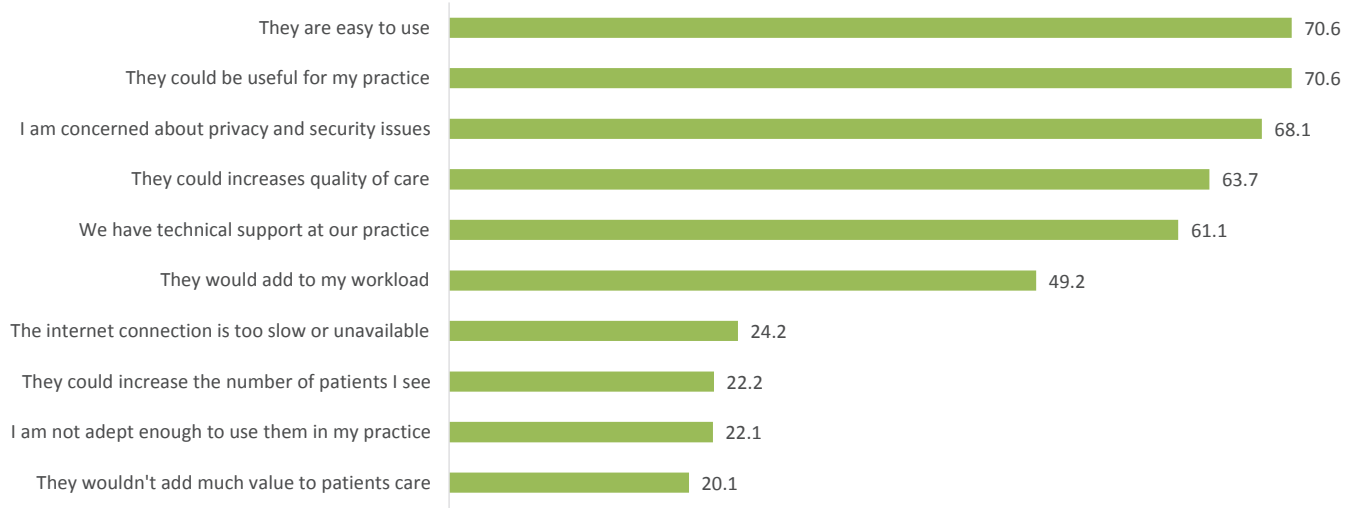


Figure 31: Perceived usefulness of mobile devices in practice (%)

The majority of GPs appreciated the value of mobile tablet devices in diabetes management for patients. In particular, the greatest perceived value was in information searching for dietitians and health educators (85.1%). However, the lowest perceived value related to technology's use for communicating with practitioners (59.0%). Overall, mobile tablet devices were perceived as better self-management tools for reminding, monitoring and checking. However, for communication and seeking professional advice, mobile tablet devices were less valued (**Figure 32**).

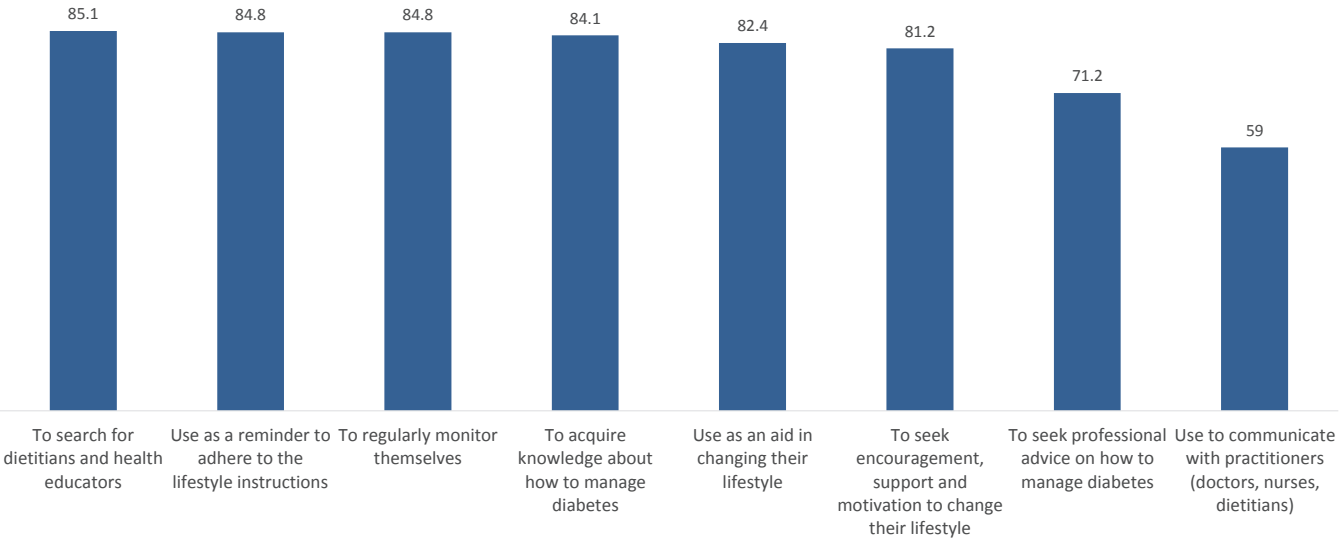


Figure 32: How mobile devices can help with day-to-day management (%)

The experience with mHealth was prevalent among GPs. More than half of GPs reported knowing their patients use apps to self-manage their health (63.7%), or have looked up mobile health apps (53.9%). However, the experience of administration staff and nurses in using mobile devices was low; only 10.6% of GPs had ever seen the nurses at their practice use mobile devices when attending to patients, and only 13.9% of GPs reported that the administration staff at their practice use them when interacting with patients (**Figure 33**).

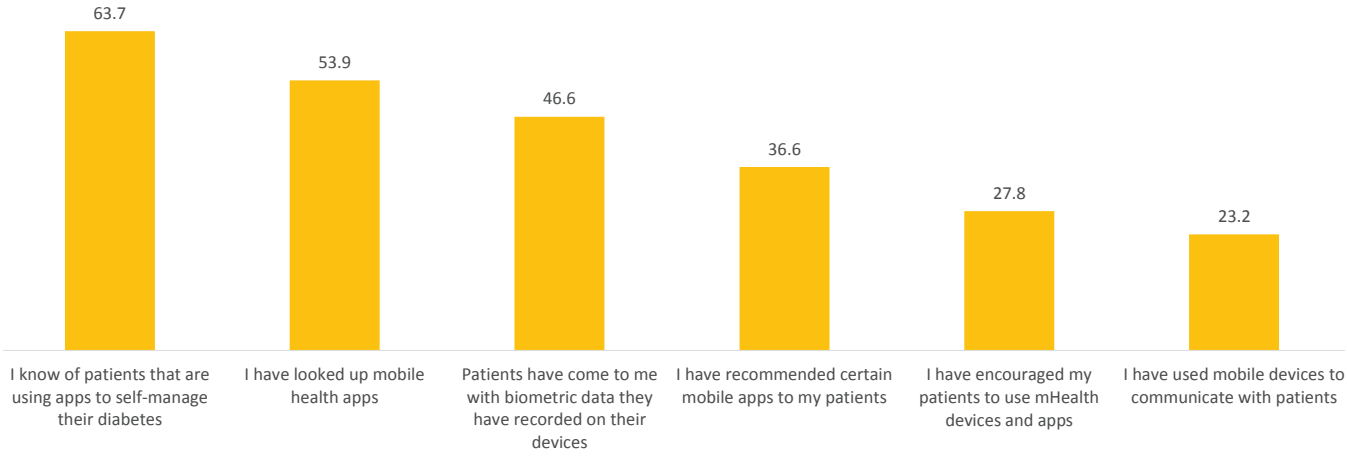


Figure 33: Experience with mHealth (%)

There was a distinct difference in the perception of whether tablets or mobile phones are better devices for mHealth practices. GPs chose tablets as better devices to acquire knowledge and resources about how to manage diabetes (63.4%), whereas mobile phones were perceived as better devices for monitoring or communicating with practitioners (**Figure 34**).

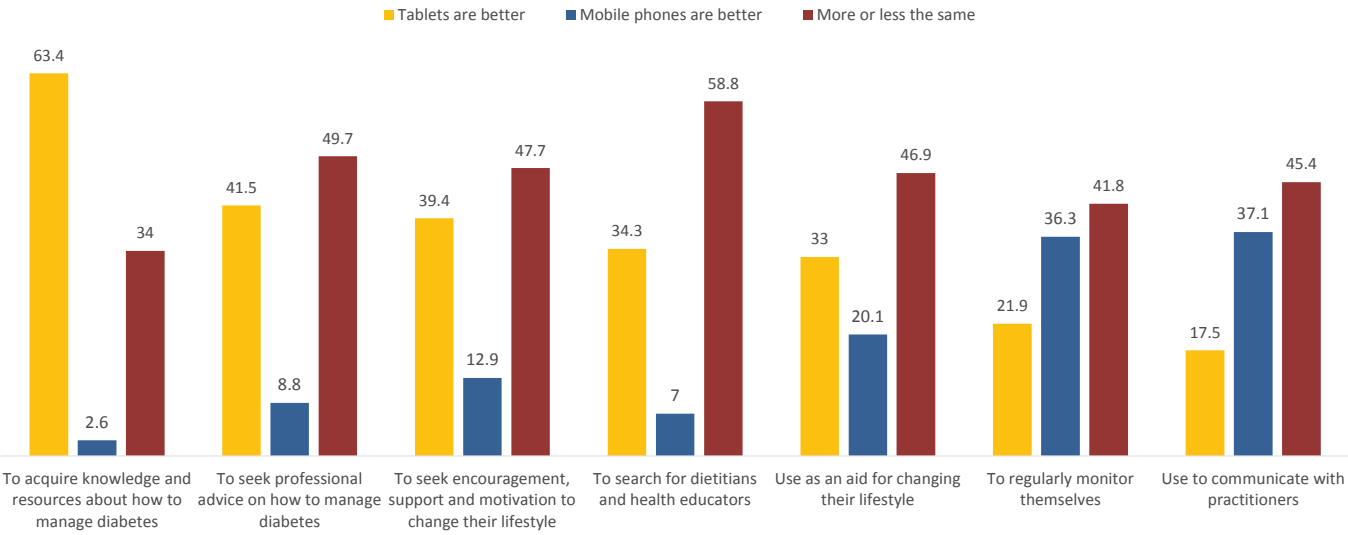


Figure 34: Phone vs. tablets (%)

GPs were asked to what extent they agree or disagree that there are barriers to the introduction and usage of mHealth programs in primary care. All items were answered on a 5-point scale (1= strongly disagree, 2= somewhat disagree, 3=neither agree nor disagree, 4= somewhat agree, 5= strongly agree). Financial barriers were the highest (M=3.99), followed by system barriers (M=3.82), technology barriers (M=3.52) and lack of needs (M=3.37).

The top ranked barriers were, 'lack of remuneration for additional work', 'lack of financial resources', 'lack of financial incentives', and 'lack of time' (**Figure 35**).

Among the financial barriers, 'lack of remuneration for additional work' was the highest (M=4.09). In case of technology barriers, 'lack of technical support' (M=3.85) and 'lack of sufficient digital training for healthcare professionals' (M=3.81) were highly rated to be barriers. For system barriers, 'issues of confidentiality and privacy' was higher (M=3.86) than other items. The lack of clear motivation to use mobile devices in primary care was also one of the main barriers to mHealth adoption (M=3.77).

There were gender, age and regional differences. Female GPs (M=4.05) rated higher on lack of time compared to male GPs (M=3.82). Gender differences in system barriers were also evident: female GPs rated the lack of sufficient security, regulatory frameworks and policy as well as issues of confidentiality and privacy, higher than male GPs. GPs in major cities (M=4.05) rated the barriers to be higher compared to rural GPs (M=3.76). GPs in major cities rated the 'lack of remuneration for additional work' (M=4.17) higher, compared to rural GPs (M=3.98). There was a higher need for sufficient digital skills on the side of healthcare professionals among GPs in major cities (M=3.70) than GPs in non-major cities (M=3.44). This is partly due to the sample characteristics of rural GPs being younger.

1. Lack of remuneration for additional work
2. Lack of financial resources
3. Lack of financial incentives
4. Lack of time
5. Issues of confidentiality and privacy
6. Lack of technical support
7. Lack of inter-operability and standards
8. Lack of sufficient digital training for healthcare professionals
9. Lack of regulatory framework and policy
10. Lack of sufficient security

Figure 35: Top 10 barriers to mHealth adoption in primary care

Perception of GPs' role in diabetes care

GPs were asked to what extent they agree or disagree with the role of GPs in diabetes care and all items were answered on a 5-point scale (1= strongly disagree, 2= somewhat disagree, 3=neither agree nor disagree, 4= somewhat agree, 5= strongly agree). The most highly perceived role of GPs for diabetes patients was to communicate effectively with patients (M=4.83), followed by the role to encourage, support and motivate diabetes patients to change their lifestyle (M=4.76), and to regularly monitor and follow-up with patients (M=4.74). GPs in non-urban areas had a significantly higher perception than GPs in major cities in most aspects of GP roles (**Figure 36**).

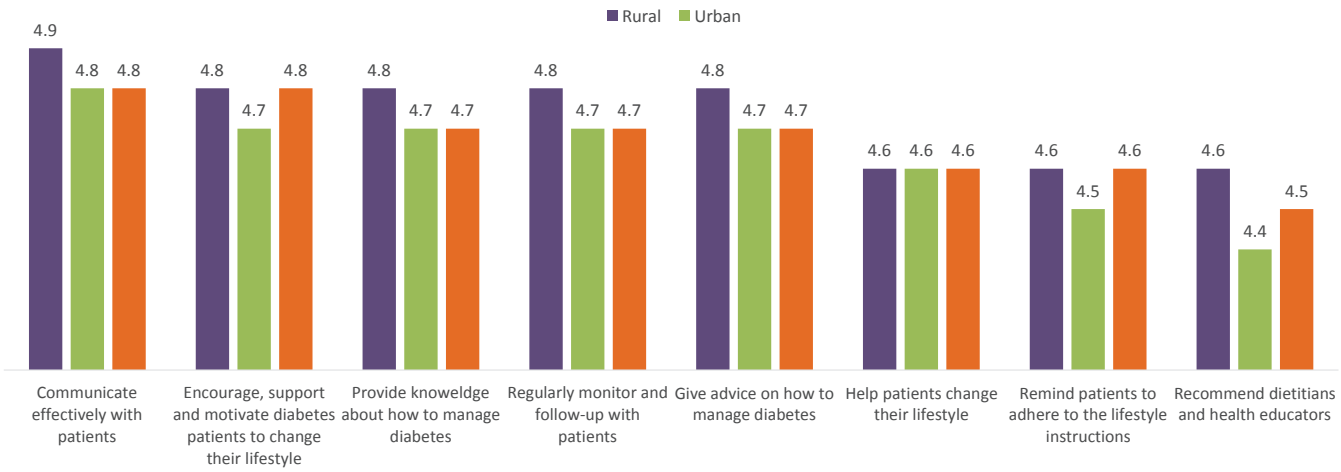


Figure 36: GPs' role in diabetes management (out of 5)

When asked about the challenges of diabetes management, 52% of GPs said 'modifying eating habits' was the most challenging, followed by 'keeping up with exercise'(32%) (Figure 38). Considering that participants in the pilot program indicated that they benefited the most from the mHealth program in their food choices, an effective mHealth program can be devised to include self-management in food intake in particular.

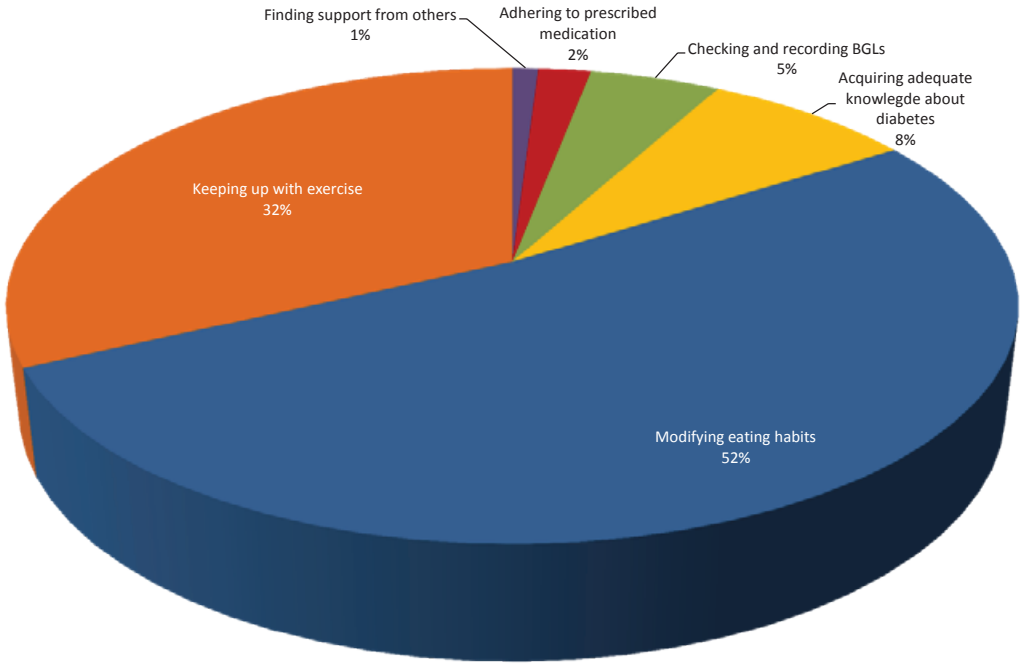


Figure 37: Difficulties in patients' self-management

CONCLUSION

The mHealth pilot program reported here was co-designed with health practitioners. Type 2 diabetes patients were supplied with mobile tablet devices installed with apps. On-demand digital training and support was provided throughout the 10 month program. Participants were encouraged to use the digital tools in their everyday settings, and at their own pace. The pilot program model was based on the recognition that ongoing lifestyle modification is an on-going effort that goes beyond a consultation with medical professionals. It is about everyday choices and a sense of control in making decisions that can improve health outcomes.

The findings of the study demonstrate that equipping diabetes patients with digital skills generate health benefits. Digital training improves not only digital skills, but the ability to use digital tools for health management. Many participants experienced improvement in their diabetes conditions and the majority felt that the iPad helped manage their health. The digital feedback loop provided by the mHealth apps empowered participants to develop a sense of responsibility for their own healthcare.

We explored how a mHealth program, when accompanied by digital training support can enable patients to better manage their health. Many self-management programs that utilise digital technologies lack the provision of digital training based on the assumption that people figure out the best uses of technologies. However, for those who are not experienced in digital technologies, this is not always the case. Digital support in the form of both technical skills training and continued assistance was found to be an effective way to engage patients to sustain engagement with mHealth tools. Digital engagement requires long term learning, repeated exposure and practice. Adapting to new devices is not a uniform process and different types of users need different approaches in learning.

The need for digital training was also identified in a national survey of GPs in Australia. The overall perception of mHealth was positive, the highest perceived value being the uses in diabetes self-management. GPs' digital literacy was found to be a significant factor in their perception of mHealth benefits. Furthermore, GPs that view themselves as playing a major role in the management of diabetes patients perceived mHealth technology to be more beneficial. There is an educational need among practitioners both in form of retraining as well as embedding digital tools and their use in the curriculum of the emerging workforce.

The results suggest that investing in upskilling digital literacy of those who are at risk of chronic illness or already are living with the condition should be viewed by policymakers as an investment rather than a cost. Providing a mechanism which 'extends' the advice and motivating role a GP plays into an everyday setting can equip people to better self-manage their disease. Ultimately this can improve health outcomes, while reducing the cost to the health system, through either reduced complications or avoidable hospital admissions, not to mention the better coordination of primary care across GPs, dieticians, excise and lifestyle modification experts. Furthermore, the cost of the training is relatively low compared to the cost to the health system of addressing chronic disease complications, should they occur.

A strategy to provide digital skills to newly diagnosed diabetes patients may hold substantial synergies with other government initiatives to narrow the digital divide in the wider population. It may also familiarize patients with future eHealth initiatives, improve digital recordkeeping, increase access to government resources and create better understanding between the patient and the GP.

For individuals, acquiring digital literacy can lead to a whole range of potential life-changing benefits including the possibility of maintaining good health and being able to continue with normal daily activities. A positive health impact may extend to the social wellbeing of the nation, as well as an individuals improved psychological health and a renewed sense of being part of a 'community'.

The next phase of the project is to move toward mainstreaming the mHealth program; to include a wider population in primary care sites across Australia. Considering the near ubiquity of mobile devices, the potential for scaling up is significant. The program can also be applied to other types of chronic conditions, where constant self-management activities are beneficial.

APPENDICES

List of academic publications as of May 2016

Park, S., Burford, S., Nolan, C. & Hanlen, L. (2016). The role of digital engagement in the self-management of type 2 diabetes, Health Communication, DOI: 10.1080/10410236.2015.1089468

Burford, S., Park, S., Dawda, P. & Burns, J. (in press). Participatory research design in mobile health: tablet devices for diabetes self-management, Communication & Medicine

Park, S., Burford, S., Hanlen, L., Dawda, P., Dugdale, P., Nolan, C. & Burns, J. (in press). An integrated mHealth model for type 2 diabetes patients using mobile tablet devices, Journal of Mobile Technology in Medicine

Park, S., Dawda, P., Burford, S. & Lee, J. (under review). Mobile devices in healthcare: Australian General Practitioners' perspective

Burford, S., Park, S., Carpenter, M., Dawda, P. & Burns, J. (2016). Digital engagement, self-management, and shifting the locus of control: An mHealth program for people with type 2 diabetes. 49th Annual Hawaii International Conference on System Sciences, (Jan 5-8, 2016, Kauai), Computer Society Press.

Further information and updates

Webpage on News & Media Research Centre website

www.canberra.edu.au/research/faculty-research-centres/nmrc/research/mobile-digital-communication-and-health-management

Summary Report

www.canberra.edu.au/research/faculty-research-centres/nmrc/research/mobile-digital-communication-and-health-management/Mobile-Health-Empowering-people-with-type-2-diabetes-using-digital-tools-updated-v2.pdf

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