EXPLORING THE EFFICACY, AVAILABILITY AND PERCEPTIONS TOWARDS USING MOBILE APPLICATIONS FOR DIABETES SELF-MANAGEMENT IN SAUDI ARABIA

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ABSTRACT

Background: Many mobile and web-based applications are used to support diabetes self-management. However, up-to-date evidence of their effectiveness, availability and the attitudes of patients and healthcare professionals (HCPs) towards them is sparse.

Project's Aims and Objectives : The main aim of this project was to explore the efficacy, availability and perceptions towards using mobile applications for diabetes self-management in Saudi Arabia. To accomplish this aim, the following objectives were set: (1) To conduct a systematic review and meta-analysis aiming to explore the nature and effectiveness of mobile and web applications to support diabetes self-management; (2) To conduct a systematic review aiming to explore the knowledge and attitudes of patients and HCPs towards mobile and web applications to support diabetes self-management; (3) To conduct web-based research to explore the availability and features of mobile applications in the Google Play Store® for diabetes self-management; (4) To conduct a survey study to explore patients' beliefs, experiences, attitudes and knowledge of using mobile applications in supporting diabetes self-management; (5) To conduct a survey study to explore HCPs beliefs, experiences, attitudes and knowledge regarding the use of mobile applications in supporting diabetes self-management by patients.

Methods: Based on the aims and objectives, several methods were used in this project: a systematic review, web-based content analysis and surveys. In the systematic reviews, several data synthesis approaches were used: meta-analysis, narrative synthesis and qualitative evidence synthesis. The AADE 7 Self-care Behaviour® model, the Mobile App Rating Scale (MARS) and the Technology Acceptance Model (TAM) were utilised throughout these studies.

Results: In the first study, 13 studies met the inclusion criteria, of which 11 were RCTs and two were observational studies. In the second study, eight studies met the inclusion criteria. There were 402 application results from the search of the third study. Of those, 45 apps met the inclusion criteria.

For the patient survey in the fourth study, there were 277 participants. Of these, only 179 were eligible. In the fifth study, 89 HCPs participated in the survey, but only 71 were eligible.

Conclusion: There is no conclusive evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and QoL. There could be several reasons for the lack of effectiveness. In general, qualitative evidence synthesis shows that patients and HCPs are not users, or limited users, of the currently available mobile diabetes self-management applications. They are looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications. After investigating the Google app store, the number of available applications is high but are limited to supporting only some self-management tasks. Patients are required to install a variety of apps to self-manage their diabetes. The findings also suggest that patients and HCPs may find such a high number of applications overwhelming if there is no guidance or accreditation system in place. In the Saudi Arabian population, most of the study participants used mobile applications and considered them very useful and easy to use, regardless of the issues that some of them faced. However, a limited number of HCPs recommend mobile applications for their patients, despite their belief that diabetes mobile applications are useful. Finally, the general view of the final two studies was that diabetes mobile applications are useful and easy to use. This may affect future adaption positively, according to the TAM model.

DEDICATION

To all people with diabetes all over the world.

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TABLE OF CONTENTS

CHAPTER 1: Introduction 19
1. Motivation and Challenges 20
2. Thesis Structure 21
3. Diabetes & Technology 24
3.1. Diabetes 24
3.1.1. Diabetes In Saudi Arabia 25
3.1.2. The World Health Organization's Action Plan 25
3.1.3. Diabetes Management 25
3.2. Self-Care and Self-Management 27
3.3. Digital Health Technology: Mobile and Web Applications 32
3.4. Theoretical Framework 33
3.4.1. Technology Acceptance Theories 35
3.4.2. Mobile App Rating Scale 37
4. Project's Aims and Objectives 37
CHAPTER 2: Effectiveness of Using Mobile and Web Applications to Support Diabetes Self-management: A Systematic Review & Meta-analysis 39
ABSTRACT 40
1. Introduction 42
2. Aim and Objectives 43
3. Methods 43
3.1. Search Strategy 44
3.2. Study Selection 46
3.2.1. Inclusion and Exclusion Criteria 47
3.2.2. The Screening and Selection Process 47
3.3. Data Extraction 48
3.4. Quality Assessment 48
3.5. Data Synthesis 49
3.5.1. Meta-analysis 49
3.5.2. Narrative Synthesis 50
3.6. Software (Tools) 50
4. Results 51

4.1. Description of Studies 51
4.1.1. Search Results 51
4.1.2. Included Studies 52
4.1.3. The Intervention 52
4.1.4. Excluded Studies 53
4.2. Risk of Bias of Included Studies 58
4.3. Effects of the Intervention 60
4.3.1. Primary Outcome: Glycosylated Haemoglobin A1c (HbA1c) 60
4.3.2. Secondary Outcome: Quality of Life (QoL) 61
5. Discussion 62
5.1. Summary of the Main Results 62
5.2. Quality of the Evidence (certainty of the evidence) 67
5.3. Strength and Limitations 68
5.4. Authors' Conclusions 68
CHAPTER 3: Patients' and Healthcare Professionals' Perspectives on the Use of Mobile and Web Applications in Diabetes Self-Management: A Systematic Review of Qualitative Evidence 70
ABSTRACT 71
1. Introduction 73
2. Aim 74
3. Methods 74
3.1. Search Strategy 74
3.2. Study Selection 74
3.2.1. Inclusion and Exclusion Criteria 75
3.2.2. The Screening and Selection Process 75
3.3. Data Extraction 75
3.4. Quality Assessment 76
3.5. Data Synthesis 76
3.6. Research Tools (Software) 77
4. Results 77
5.1. Description of Studies 77
5.1.1. Search Results 77
5.1.2. Included Studies 78
5.1.3. The Intervention 80
.5.2 Quality Assessment 81

5.3. Synthesis Findings 83
5.3.1. Theme 1: Factors affecting patients' use of mobile applications 83
5.3.2. Theme 2: Factors affecting Healthcare Professionals' use and recommendation of mobile apps 85
5.3.3. Theme 3: Patients' experience and attitude on mobile apps 86
.5.3.4 Theme 4: HCP's experience and attitude on mobile apps 89
5. Discussion 90
5.1. Summary of Main Results 90
5.2. Summary of Integrating the Findings from This Synthesis with the Findings of the Previous Chapter 95
5.3. Quality of the Evidence (Certainty of the Evidence) 95
5.4. Strength and Limitations 95
5.5. Authors' Conclusions 96
CHAPTER 4: Exploring the availability and features of diabetes self-management applications in app stores 97
ABSTRACT 98
1. Introduction 100
1.1. Background 100
1.2. Diabetes Self-Management Applications 101
1.3. What is Already Known and the Gap in the Knowledge 102
2. Aim and Objectives 104
3. Method 104
3.1. Planning & Conduct 104
3.2. Search Strategy and Data Collection 105
3.3. Inclusion and Exclusion Criteria 107
3.4. Data Synthesis 110
3.5. Software (Tools and Equipment) 110
3.6. Ethics 110
4. Results 111
4.1. Included Applications and Self-Care Behaviour 111
4.2. Applications' Specifications & User Interaction 118
4.3. Privacy 123
4.4. Technical Features & Collaboration 125
4.5. Search Update 129
5. Discussion 129

5.1. Implications for Practice 135
5.2. Implications for Research 136
5.3. Strength & Limitations 136
5.4. Conclusion 136
CHAPTER 5: Explore Patients' Beliefs, Experiences, Attitudes and Knowledge of Using Diabetes Mobile Applications in Supporting Diabetes Self-Management 138
ABSTRACT 139
1. Introduction 141
2. Aim and Objectives 145
3. Method 145
3.1 Design, Setting and Recruitment 145
3.2 Survey Development, Validation & Data Collection 148
3.3 Software (tools) 151
3.4 Data Analysis 151
3.5 Ethics & Governance 152
3.6 Development of the Online Survey 154
3.7 Piloting 154
4. Results 156
4.1 Demographic Data & Diabetes Management Habits 157
4.2 Knowledge, Experience and Barriers 158
4.3 Preferred Features and Usefulness 161
4.4 App Design and Ease of Use 164
4.5 General Comments 165
5. Discussion 165
5.1 Implications for Practice 168
5.2 Implications for Research 169
5.3 Strength and Limitations 170
5.4 Conclusion 171
CHAPTER 6: Explore Healthcare Professionals' Beliefs, Experiences, Attitudes And Knowledge of Using Diabetes Mobile Applications in Supporting Diabetes Self-Management. 172
ABSTRACT 173
1. Introduction 175
2. Aim and Objectives 177

3. Method 177
3.1 Design, Setting and Recruitment 178
3.2 Survey Development, Validation & Data collection 180
3.3 Software (Tools) 183
3.4 Data Analysis 183
3.5 Ethics & Governance 184
3.6 Online Survey Developed 185
3.7 Piloting 186
4. Results 188
4.1 Demographic 188
4.2 Healthcare Professionals' Recommendations 189
4.3 Experience 190
4.4 App Features' Usefulness 190
4.5 General Comments 191
5. Discussion 192
5.1 Implication for Practice 194
5.2 Implications for Research 195
5.3 Strength and Limitations 195
5.4 Conclusion 196
CHAPTER 7: General Discussion 197
1. Overview 198
2. A Summary of The Findings and Integration of The Results from All of The Studies 198
3. Implications for Practice 212
4. Recommendations for Applications Developers and Decision Makers 213
5. Implication for Research and Future Research 215
6. Strengths and Limitations 215
7. Lessons Learned 217
8. Conclusion 218
REFERENCES 221
APPENDICES 238
CHAPTER 2 APPENDICES 239
Appendix 2.1: Systematic Reviews in Diabetes Management Technology (scope search) 240

Appendix 2.2: PRISMA-P Checklist (Protocol) for Chapters 2 and 3. 241
Appendix 2.3: Search Strategy 243
Appendix 2.4: PRISMA Checklist 245
Appendix 2.5: PRISMA for Abstracts Checklist 248
Appendix 2.6: Data Extraction Form 249
Appendix 2.7: Comparison Between Systematic Review Software. 250
CHAPTER 3 APPENDICES 251
Appendix 3.1: PRISMA for Abstracts Checklist for the Second Systematic Review 252
Appendix 3.2: PRISMA Checklist for the Second Systematic Review 253
Appendix 3.3: Data Extraction Form for Qualitative data Synthesis 256
CHAPTER 4 APPENDICES 257
Appendix 4.1: Chapter 4 Scoping Search 258
Appendix 4.2: List of Excluded Apps 263
Appendix 4.3: Final Included and Excluded List After Download and Investigation with Reasons 270
CHAPTER 5 APPENDICES 273
Appendix 5.1 Patient Survey – English Version 274
Appendix 5.2 Patient Survey – Arabic Version 285
Appendix 5.3 Patient Survey – Certified Back Translation 296
Appendix 5.4: LimeSurvey Settings 315
CHAPTER 6 APPENDICES 317
Appendix 6.1 Healthcare Professionals Survey – English Version 318
Appendix 6.2 Healthcare Professionals Survey – Arabic Version 324
Appendix 6.3: Healthcare Professionals Survey – Certified Back Translation 330

LIST OF FIGURES

Figure 1.1 The AADE 7 Self-Care Behaviors®. Sources: Association of Diabetes Care & Education Specialists.

Figure 1.2 Diabetes self-management mobile application in relation to diabetes, digital health technology and self-care.

Figure 1.3 The technology acceptance model (TAM).

Figure 2.1 PRISMA flow chart

Figure 2.2 Risk of bias summary: review authors' judgements about each risk of bias item for each included RCT study.

Figure 2.3 Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included RCT studies.

Figure 2.4 Forest plot of comparison: mobile and web app vs usual care, outcome: HbA1c @ 3 months.

Figure 2.5 Forest plot of comparison: mobile and web app vs usual care, outcome: HbA1c @ 6 months.

Figure 3.1 PRISMA flow chart.

Figure 4.1 The Dexcom G6 application does not work without a gadget and patient involvement.

Figure 4.2 Number of apps in each self-management area.

Figure 4.3 Percentage of apps in each self-management area.

Figure 4.4 Frequency of monitoring app's features.

Figure 5.1 Measurement item, contingency question flowchart, and how items are related to theories and other studies in this project.

Figure 5.2 Details of participants and eligibility.

Figure 5.3 participants' engagement in self-management tasks, classified according to AADE 7 Self-Care Behaviours®

Figure 5.4 Number of installed applications by participants.

Figure 5. 5 Source of recommendation to install diabetes mobile applications

Figure 5.6 Participants' behavioural statements regarding mobile apps for self-management of diabetes

Figure 5.7 Participant classifying themselves regarding and mobile apps for self-management of diabetes adaptation Regarding

Figure 5.8 Reasons behind patients of not using diabetes mobile applications.

Figure 5.9 Preferred diabetes mobile application features in 5-Point Likert Scale (mean) among application users

Figure 5.10 Preferred diabetes mobile application's features in 5-Point Likert Scale (mean) among application non-users

Figure 5.11 How accurately/fast do the app features (functions) and components (buttons/menus) work?

Figure 6.1 Measurement item, contingency question flowchart, and how items related to theories and other studies in this project

Figure 6.2 Details of participants and eligibility

Figure 6.3 Healthcare professionals' recommendations based on application group.

Figure 6.4 Preferred diabetes mobile applications' features in 5-Point Likert Scale (mean) among healthcare professionals.

LIST OF TABLES

Table 1.1 Diabetes classifications.

Table 1.2 Summary of guidelines organising diabetes management and its related theories and technologies in UK and USA.

Table 1.3 Aspects of self-care as recommended by AADE 7 Self-Care Behaviors® and The Seven Pillars of Self-Care.

Table 1.4 Summary of technology acceptance theories.

Table 1.5 Measurement scale for technology acceptance model (TAM).

Table 2.1 Organisation of keywords in three different domains to be used for Embase®, Medline® and CINAHL Plus® databases.

Table 2.2 PICOSS of included studies.

Table 2.3 List of inclusion and exclusion criteria.

Table 2.4 Summary of included studies: studies characteristics, outcomes and summary results.

Table 2.5 Intervention's specification and features classification based on AADE7 Self-Care behaviour ®.

Table 3.1 PICo of included studies.

Table 3.2 List of inclusion and exclusion criteria

Table 3.3 Contextual and methodological information of included studies.

Table 3.4 Details of the interventions, targeted group and app design.

Table 3.5 Intervention's Features classified based on AADE 7 Self-Care Behaviours® for Managing Diabetes Effectively.

Table 3.6 Quality assessment of included studies using the Critical Appraisal Skills Programme.

Table 3.7 Summary of factors affecting patients' use of mobile apps

Table 3.8 Summary of factors affecting HCP use and the recommendation of mobile apps

Table 3.9 Summary of patients' experience and attitude on mobile apps use

Table 3.10 Summary of HCPs' experience and attitude on mobile apps use

Table 4.1 App classification based on their end-user group and app features.

Table 4.2 Aspects of self-care as recommended by AADE7 Self-Care Behaviours®

Table 4.3 Application inclusion criteria

Table 4.4 Application exclusion criteria

Table 4.5 Application features of included applications classified based on AADE 7 Self-Care Behaviours®.

Table 4.6 General application specifications

Table 4.7 Summary of applications' specification related to patient privacy.

Table 4.8 Technical features of included applications.

Table 5.1 Studies that explore patients' and healthcare professionals' perspectives of mobile and web applications to support the self-management of type 1 and type 2 diabetes.

Table 5.2 Diabetes App classification based on their end-user group and applications' features.

LIST OF ABBREVIATIONS

ADA: American Diabetes Association

AADE: American Association of Diabetes Educators

ADCES: Association of Diabetes Care & Education Specialists

CGM: Continuous Glucose Monitoring

GDM: Gestational Diabetes Mellitus

HBA1c: Hemoglobin A1C

HCP: Healthcare professional

DIT: Diffusion of Innovation Theory

DHTs: Digital Health Technologies

DSME: Diabetes Self-Management Education

DSMES: Diabetes Self-Management Education and Support

DSMT: Diabetes Self-Management Training

FDA: US Food and Drug Administration

HITAM: health information technology acceptance model

IDF: International Diabetes Federation

NCD: Noncommunicable Diseases

NICE: National Institute for Health and Care Excellence (UK)

QoL: Quality of Life

QISMET: Quality Institute for Self-Management Education and Training

TAM: Technology Acceptance Model

TAM2: Extended Technology Acceptance Model

TRA: Theory of Reasoned Action

TPB: Theory of Planned Behaviour

WHO: World Health Organisation

LIST OF PUBLICATIONS

Several materials were published before submitting this thesis. Also, two abstracts and papers were drafted for submission in conferences and journals related to diabetes technology and diabetes self-management.

Abdulhakem Alhamoudi, Vibhu Paudyal, Zahraa Jalal, Sayeed Haque. Use of mobile and web-based applications to promote self-management of diabetes: a systematic review. PROSPERO 2020 CRD42020140332 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020140332

A. Alhamoudi, V. Paudyal, Z. Jalal. Use of Mobile and Web-Based Applications to Promote Self-Management of Diabetes: A Systematic Review: 48th Symposium of European Society of Clinical Pharmacy; 2019 October 22; Ljubljana, Slovenia. International Journal of Clinical Pharmacy: 2020 42 (1), 275-276.

A. Alhamoudi, V. Paudyal, Z. Jalal. Exploration of the Availability and Features of Diabetes Self-management Applications on the App Stores: Virtual Diabetes Technology Meeting Annual Conference; 2020 November 12; USA, Online. Journal of Diabetes Science and Technology: 2021 15(2) A400.

CHAPTER 1: Introduction

1. Motivation and Challenges

In 1986, when I was six years old, my father bought me my first computer. At this early age, I became passionate about computer technology. My first PC processor was 8 MHz and had 4 MB RAM. I have witnessed every step of the development of technology during the last 35 years, including the first Wi-Fi system, internet modem, USB, graphics operating system, and pocket PC. I also witnessed the launch of the first social media platform, YouTube. I enjoy every aspect of computing. I worked for several years as an IT support technician and software developer. When I compare my PC now to the one I owned 35 years ago, the rapid and incomparable growth in this field is clear. I look at technology from the perspective of someone who has watched, in detail, technology development during recent decades. I also view technology through the eyes of a pharmacist. After I graduated as a pharmacist and had worked in a hospital, I decided that I needed to advance my skills, and took a master's in clinical pharmacology at the University of Aberdeen. I then returned to work in a hospital as a senior pharmacist. I then took on two separate roles as a senior pharmacist and lecturer at the Albaha University for several years. After that, I decided that I needed to develop my academic skills further. My passion for computer technology, pharmacy, academia, and learning new skills led me to embark on a PhD with a view to working in the digital therapeutics field. As well as my passion for digital therapeutics, I have four family members with diabetes and live in a country where diabetes prevalence has reached almost 25%. Thus, I worked on a multidisciplinary project that aimed to utilise technology to advance therapeutic and disease management.

Any large project needs management and risk assessment, and my PhD project was no exception. During my PhD, in addition to the multidisciplinary project, I came across

several obstacles, including COVID-19, medical isolation, working from different locations and the English language. My determination enabled me to overcome all of these challenges. The language barrier was a specific extra challenge as, although my English level is advanced, it is not my native language. However, I minimised its impact by ensuring that I spent time planning and working at a suitable pace. If a native speaker spent 10 minutes reading an article, I knew that I would need double that amount of time to complete the same. Thus, my solution was to spend more time reading and sacrifice my weekends when necessary. Writing is another issue. Despite the fact that English grammar is similar to Arabic grammar, the writing style is different. My aim was not only to write grammatically correct sentences, but also to write with an English reader in mind. Above all, it had to be written in an academic style. Thus, to write my thesis, I needed triple the amount of time required by a native speaker.

Through my PhD, and the obstacles that I have faced, I have learned a lot. Doing a PhD was very different to anything that I had done previously. The PhD impacted not only my academic skills, but also my personality and life. I attended several courses related to methodologies and academic skills and a two-week course on systematic review methodology was my PhD starting point. I attended several conferences with my published abstracts, and completed various courses. Finally, the PhD and its circumstances taught me more than I expected. I am grateful to every person I met or interacted with during this four-year, full-time journey.

2. Thesis Structure

When I started my PhD in 2018, there were no textbooks about diabetes technology or diabetes digital therapeutics. The first textbook on diabetes digital health was published

in 2020. To the best of my knowledge, no written book or thesis has organised diabetes technology and its related theories the same way this thesis has. This thesis is multidisciplinary, so it begins with a literature review of three domains – diabetes, self-management and technology – and how they can be linked. These domains, which are presented in the literature review, guided the research and thesis in their entirety. The reader will notice that, throughout the thesis chapters, the three domains theme was consistent. For example, the systematic reviews in the 2nd and 3rd chapter search strategies were organised on the same theme.

Conducting an intensive systematic review, which covered 4,000 articles on diabetes mobile applications (Chapters 2 and 3), was a good way to begin the thesis. However, to put the thesis into the context of diabetes technology, an introductory chapter (Chapter 1) was required. The literature section in Chapter 1, did not only focus on the mobile application, but was also expanded to cover diabetes digital health technologies and its related theories. The aim of this was to put the diabetes mobile applications and the thesis into context, link it to the literature and make it easier for the reader to follow.

This thesis flows logically from one idea to another, and each chapter leads to the next; however, it can also be read in any order as the introduction section of each chapter summarises previous chapters to provide context for the reader without the need to read them in full. More importantly, this thesis is written according to the University of Birmingham guidelines(1), an alternative formatting style(2) and other UK PhD guidance (3). As this thesis is presented in an alternative format, each chapter comprises of one unit with its own introduction, methods, results and conclusion. However, the final general discussion chapter considers all of the results and their implications. When preparing this thesis, reader

comfort was considered for both the printed and digital versions. All figures are provided at the sharpest HD quality (>330dpi) and are ready for printing. The digital version is provided with headings linked to the table of contents, so the reader can easily navigate through the document using any PDF reader.

Chapter 1 will set the ground for this thesis, starting with my personal motivation to how the thesis was organised and written and ending with a literature review on diabetes, self-care and technology. In Chapter 2, the effectiveness of using mobile and web applications to promote diabetes self-management is explored using a systematic review and meta-analysis methodologies. Through a systematic review of qualitative methodology, Chapter 3 explores the perspectives of patients and healthcare professionals on the use of mobile and web-based applications in diabetes self-management. As there was a need to look at mobile applications from medical and information technology points of view, the availability and features of diabetes self-management applications on app stores are investigated in Chapter 4. Chapter 5 explores patients' beliefs, experiences, attitudes towards and knowledge of using diabetes mobile applications in supporting diabetes self-management in Saudi Arabia. In Chapter 6, the beliefs, experiences, attitudes and knowledge of healthcare professionals on mobile applications in supporting diabetes self-management of patients in Saudi Arabia are explored. Chapter 7 provides an overall discussion for the whole thesis, with a combination of all of the studies and disciplines. Finally, this four-year, full-time project resulted in more than 2,700 documents, files, images and other formats. However, the appendices were chosen based on the thesis relevance and its style's norm.

English is not my native language. However, every effort has been made to write using an academic style. I have considered every detail, such as idioms in academic English.

I have used a passive voice throughout the thesis, apart from when writing this section and my motivation section, in which, for both, I have used an active voice. Moreover, I have thought deeply about my writing, and have tried hard to retain the English style, e.g. paragraph structure, and have attempted to prevent any influence from my native language. Language is very important, not only in grammar and style, but also in effective word choices. The language used related to diabetes follows the recommendations by the American Association of Diabetes Educators and the American Diabetes Association(4). In Chapters 2 and 3 (systematic review reports) the language and terms used followed the Cochran style.

To summarise, every effort has been made to present this thesis to the highest possible academic PhD and research standards while paying utmost respect to people with diabetes.

3. Diabetes & Technology

3.1. Diabetes

Diabetes is a serious global issue. It was the seventh most common cause of death worldwide in 2016, the ninth in 2019 and was accountable for around two million deaths(5,6). Global expenditure on diabetes is estimated to be around 309 billion per year(7). Globally, approximately 425 million patients have diabetes, which is equal to 8.8% of the world's population. Moreover, an estimated 212,400,000 people with diabetes remain undiagnosed, accounting for approximately 50% of the current prevalence(7). The prevalence of diabetes varies across the globe. For example, 5.9% of the UK population have diabetes, while the figure stands at 18.6% in Saudi Arabia. More importantly, diabetes prevalence is increasing. According to the WHO, diabetes was not in the top ten leading causes of death in 2000, but it became the seventh highest in 2016(5). These figures are

consistent with International Diabetes Federation (IDF) estimates, which suggest that, in 28 years, worldwide diabetes prevalence will increase by 1.1%, which is equal to a 48% difference from today's prevalence.

3.1.1. Diabetes In Saudi Arabia

The current prevalence in diabetes in Saudi Arabia is 18.6%, which is about 3,852,000 people(7). This is more than double the global prevalence (8.8%). More importantly, the IDF estimates that the prevalence of diabetes in Saudi Arabia will be doubled (99.66%) and expected to reach 7,691,000 people by 2045. When comparing these figures with the predicted global prevalence increase in 2045, which is about 48%, it is clear that Saudi Arabia is facing a real issue. The expenditure per person is 1661.4$(7). Because prevalence will be doubled, the country's expenditure could also doubled.

3.1.2. The World Health Organization's Action Plan

The high increasing prevalence of diabetes is a global concern; in response to this situation, the World Health Organization (WHO) included diabetes in the 2013–2020 action plan(8). The plan's goal is to reduce preventable morbidity and mortality due to non-communicable diseases (NCDs). One of the aim is to halt the rise in diabetes cases. Because NCD deaths are preventable, management and self-management play an essential role in preventing long-term complications and death(9).

3.1.3. Diabetes Management

The American Diabetes Association defines diabetes as *'a group of metabolic diseases characterised by hyperglycemia resulting from defects in insulin secretion, insulin action, or*

both.'(10) Based on the aetiology, diabetes is classified into type1, type2, gestational diabetes mellitus (GDM) and others(10) – see Table 1.1. A recent study has classified diabetes differently. Based on the severity and the need for medical attention, diabetes is classified into five categories(11).

Table 1.1 Diabetes classifications.

ADA Classification	Cause
Type 1 diabetes	Autoimmune β-cell destruction
Type 2 diabetes	Progressive loss of β-cell insulin secretion
Gestational diabetes mellitus	Hormonal changes lead to the elevation of blood sugar levels during pregnancy
Specific types of diabetes	Other causes such as monogenic diabetes syndromes, drug or disease-induced diabetes

Unmanaged hyperglycaemia results in long-term complications for various organs, including blood vessels, nerves, kidneys and the heart(12). Diabetes management is a complicated process. To support diabetes management, there are several guidelines on the subject of diabetes management and its related theories and technologies – see Table 1.2. Regardless of diabetes type, self-management skills are imperative to improving quality of life and preventing long-term complications.

Table 1.2 Summary of guidelines organising diabetes management and its related theories and technologies in UK and USA.

Domain	Subject	Guidelines, Standards or Recommendations	Organisation	Country
Diabetes	Diabetes diagnosis and management	* Type 1 diabetes in adults: diagnosis and management (13) * Type 2 diabetes in adults: management (14) * Diabetes (type 1 and type 2) in children and young people: diagnosis and management (15)	NICE	UK
		Standards of medical care in diabetes 2019 (10)	ADA	USA

Self-management	Self-care	The Seven Pillars of Self-Care (16)	ISF	UK
		AADE7 Self-Care Behaviors® for managing diabetes effectively (17–20)	AADE	USA
	DSMES	NICE diabetes guidelines (13–15)	NICE	UK
		The diabetes self-management education quality standard 2016 (21)	QISMET	UK
		National standards for diabetes self-management, education and support (22)	AADE & ADA	USA
Technology	Evidence quality	Evidence standards framework for digital health technologies (23)	NICE & NHS England	UK
	Mobile and web applications	Guidance: medical device standalone software including apps (24)	MHRA	UK
		Mobile medical applications: guidance for industry and drug administration staff(25)	FDA	USA

Glycosylated hemoglobin A1c (% HbA1c)

Glycosylated Hemoglobin (HbA1c) is a used measurement to monitor glycemic control. Also, starting in 2010, it has been used for diabetes diagnosis if the reading ≥ 6.5 %. The percentage indicates the average plasma glucose concentration over time. It has several drawbacks as it is affected by some clinical conditions where CGMs overcome some issues (26–28).

3.2. Self-Care and Self-Management

On average, a patient spends three hours in contact with professional healthcare providers and 8,757 hours taking care of him/herself (self-care) per year(29). This may explain why self-management is such an important concept.

Self-care, self-management and self-monitoring terms are used interchangeably in the literature. A study by Richard et al. aimed to define and distinguish between these concepts. This study described the relationship between these different terms in a model. Richard et al. defined self-care as '*The ability to care for oneself and the performance of*

activities necessary to achieve, maintain, or promote optimal health'. The self-care concept has evolved over the years(30) and has been defined by different organisations. Furthermore, a most recent definition by WHO described self-care in 2013 as: '*The ability of individuals, families and communities to promote health, prevent disease, maintain health, and to cope with illness and disability with or without the support of a healthcare provider*'(31). Moreover, the UK Department of Health's definition is the most comprehensive and recent. It refers to self-care as '*the actions people take for themselves, their children and their families to stay fit and maintain good physical and mental health; meet social and psychological needs; prevent illness or accidents; care for minor ailments and long-term conditions; and maintain health and wellbeing after an acute illness or discharge from hospital'*(29).

According to Richard et al.(32), self-care is a concept that includes self-management and self-monitoring. Also, The Department of Health in the UK considers self-management as a subset of self-care. According to the Department of Health, there are several types of self-care support, such as care plans, self-diagnostic tools, self-monitoring devices, multi-media and multi-lingual self-care facilities, and information materials. The study by Richard et al. study chose Wilkinson and Whitehead's definition of self-management as '*The ability of the individual, in conjunction with family, community, and healthcare professionals, to manage symptoms, treatments, lifestyle changes, and psychosocial, cultural, and spiritual consequences of health conditions.*' Moreover, self-monitoring is part of self-management and is defined as the '*Awareness and measurement of specific physiologic parameters or symptoms of a health condition that are indicators of the need to take action or consult with a healthcare provider*'(32). Regardless of the interchangeability in the use of the terms 'self-

care' and 'self-management' in the literature, in definitions, they are considered to be different. Thus, the definition of self-management by Wilkinson and Whitehead will be used in this project when self-management referred to.

Several organisations set recommendations and measurable actions for self-care. The International Self-Care Foundation (ISF) proposes The Seven Pillars of Self-Care framework.(16)In the context of diabetes, the Association of Diabetes Care & Education Specialists (ADCES), formally known as the American Association of Diabetes Educators (AADE)(33), has developed AADE 7 self-care behaviour as a model to guide patients and healthcare professionals in effective diabetes self-management – see Table. 1.3.

Table 1.3: Aspects of self-care as recommended by AADE 7 Self-Care Behaviors® and The Seven Pillars of Self-Care

AADE7 Self-Care Behaviors® for managing diabetes effectively	**The Seven Pillars of Self-Care** for preventing lifestyle diseases
Healthy eating	Healthy eating
Being active	Physical activity
Monitoring	----
Taking medication	Rational and responsible use of products, services, diagnostics and medicines
Problem solving	Knowledge & health literacy
Reducing risks	Risk avoidance or mitigation
Healthy coping	Mental wellbeing, self-awareness & agency
----	Good hygiene

AADE defines AADE 7 self-care behaviour as: *'a framework for patient centred diabetes self-management education (DSME) and care'* and includes seven domains: healthy eating, being

active, monitoring, taking medications, problem solving, healthy coping and reducing risks(18) (see Figure 1.1).

Figure 1.1: The AADE 7 Self-Care Behaviors®. Sources: Association of Diabetes Care & Education Specialists.



In 2020, AADE suggested that this framework could guide the self-management of other chronic diseases; it is described as 'The Framework for Optimal Self-Management'(20). However, because AADE 7 is the only behaviour designed specifically for diabetes self-care, it used as a guide for exploring self-management in this project(34). For example, mobile app features organised into seven domains, according to this model. Also, this classification was used in this project during the survey and in analysing and presenting the data.

The role of diabetes self-management in good diabetes outcomes has been extensively researched. Several studies have found that diabetes self-management lowers haemoglobin HbA_{1c} by 1% in patients with type 2 diabetes(35–37). For example, a systemic review and meta-analysis assessed diabetes self-management education (DSME) on clinical, lifestyle and psychosocial outcomes in patients with type 2 diabetes

compared to normal treatment and found that HbA1c was significantly reduced at different time points (6, 12 and 24 months).(35) This study also determined that fasting blood glucose levels were significantly reduced. Another systematic review by Norris et al. (2002) also showed that DSME decreased HbA1c by 0.76% (95% CI 0.34 –1.18) at the 1–3 months follow up. However, they also found that the effect decreased overtime; 0.26% (0.05–0.48) at four months or after, due to factors such as short contact time with an educator.(36) The benefits of self-management are not limited to HbA1c; other health benefits include an improvement in the quality of life,(38) increased physical activity(39) and reduced depression.(40,41) For example, a study investigated the effects of diabetes education involving the Dose Adjustment For Normal Eating (DAFNE) programme for patients with type 1 diabetes and found a significant improvement in HbA1c and quality of life.(38) Another RCT study investigated the impact of a behavioural programme involving diet, physical activity, problem solving, and stress management and found a significant improvement in psychosocial and clinical outcomes among patients with type 2 diabetes.(39) The stated benefits will not only help the patient, but will also have the potential to help healthcare systems by minimising care costs and hospital admissions.(42) The last few years have seen an increased interest in mobile health technology (mHealth) research. Mobile applications are platforms used to deliver mHealth.(43) The use of mobile applications in supporting diabetes self-management have the potential to assist patients because they can set reminders, record data, contact healthcare professionals and provide patients with helpful advice.(44–49)

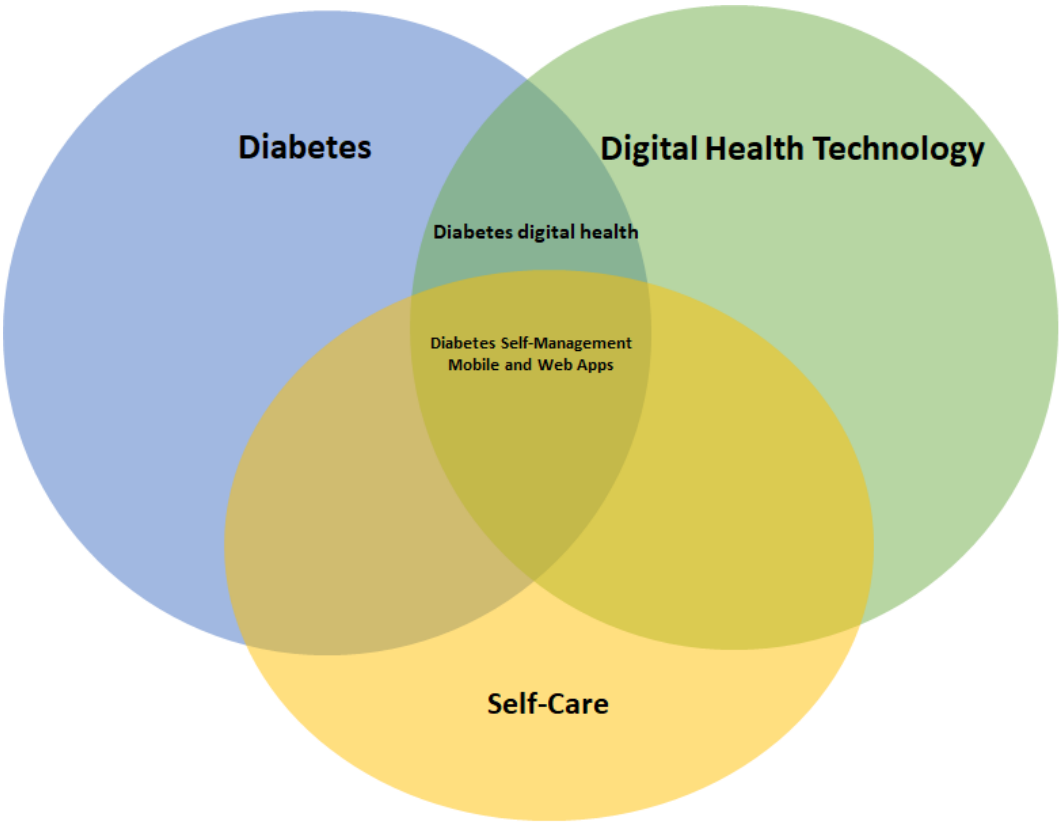
3.3. Digital Health Technology: Mobile and Web Applications

Various terms have been used to describe technology in health care. Throughout this thesis, the term 'digital health technology' (DHT) was used and its defined by the National Institute for Health and Care Excellence (Nice) as the following: *'Digital health technologies comprise a wide range of products used in the health and care system including apps, software and online platforms that are intended to benefit people or the wider health and care system. They may be standalone or combined with other products such as medical devices or diagnostic tests.'*(50) In the UK, in December 2018, the National Institute for Health and Care Excellence (NICE) and NHS England introduced a draft of an evidence standards framework to organise the evidence of digital health technologies.(50) Regarding diabetes, the American Diabetes Association (ADA) has introduced a new section in its 2019 edition guidelines of standards of care in diabetes about diabetes technology, which was not available in the 2018 edition.(10) These new guidelines not only reflect the importance of digital technology, but also show a motivation towards organising the care and evidence of digital technology. Mobile health – sometimes referred to as mHealth – is defined by the WHO as '*Medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices*.'(9) If we consider that most websites are now mobile ready, or in technical terms, 'responsive', web-based technologies accessible by desktop or mobile can fit the WHO's definition of mobile health.

The scope of this project is mobile digital health technology only, specifically mobile or web applications tailored to a mobile platform that is designed to support diabetes self-management – see Figure 1.2. Thus, the definition of the mobile application by the US Food

and Drug Administration (FDA) is used throughout this thesis in general. However, for each chapter, the definition is more specific for the relevant sub-study. The FDA definition of a mobile application is *'A software application that can be executed on a mobile platform or a web-based software application that is tailored to a mobile platform but is executed on a server.'* (25)

Figure 1.2: Diabetes self-management mobile application in relation to diabetes, digital health technology and self-care.



3.4. Theoretical Framework

The Cambridge Dictionary defines theory as *'a formal statement of the rules on which a subject of study is based or of ideas that are suggested to explain a fact or event or, more generally, an opinion or explanation.'*(51) Theories are used to maximise the

robustness and rigour of research and help enhance the quality of research by supporting research processes, starting from justifying the research through to the data analysis. All research processes, including aim construction, methodology selection, data collection tool development, and data analysis, can benefit from using a theory.(52) For example, using the ADDE 7 self-care behaviour® helped in organising app features in various self-care domains. It also helped identify which domain most apps support, and which domain receives no support. A previous systematic review investigated the use of theory in guideline implementation research from 1966 until 1998, and found that the number of theories used in each research varied between one and three.(53) This project has been informed by AADE 7 self-care behaviour® (18,20), Technology Acceptance Model (TAM)(54) and Mobile App Rating Scale (MARS),(55,56) which was used to guide different studies in this project, such as aims construction, questionnaire development and data presentation and analysis. The use of these theories and tools together has been an approach used in several studies(57,58). A systematic review investigated the impact of technology on outcomes of people with diabetes and utilised AADE 7 Self-Care Behaviors® to map the self-management area addressed by these studies.(34) TAM was also used in a study, which aimed to explore how patients use mobile health apps and their perceived benefits to inform interview guide questions.(58) TAM and MARS were used to develop an interview guide in a qualitative study aiming to evaluate experiences, barriers and facilitators to app usage among people with type 2 diabetes.(57) The AADE 7 Self-Care behaviours® were discussed earlier in section 3.2, while TAM and MARS will be discussed in the following sections.

3.4.1. Technology Acceptance Theories

Several theories and models have been developed in computer science to explain reasons behind acceptance or reluctance in using a new technology. These theories aim to explain how end users accept, understand and use a new technology. The technology acceptance model (TAM) was developed in computer science by Davis (1986) and was derived from the theory of reasoned action (TRA) relevant to the field of social psychology(59) (see Table 1.4). TAM consists of two constructs; perceived usefulness and perceived ease of use. Davis et al. defines perceived usefulness as '*The degree to which a person believes that using a particular system would enhance his or her job performance*' and perceived ease of use as '*the degree to which a person believes that using a particular system would be free of effort*.' (54) Each construct consists of six items (see Figure 1.3 and Table 1.5). In this project, TAM has been chosen for two main reasons. The model was developed in computer science, which makes it more specific to mobile applications than theories developed in other fields. Second, TAM aligns with the aim of studies in Chapters 5 and 6.

Figure 1.3: The technology acceptance model (TAM) – adapted from Alwahaishi and Snasel.(60)

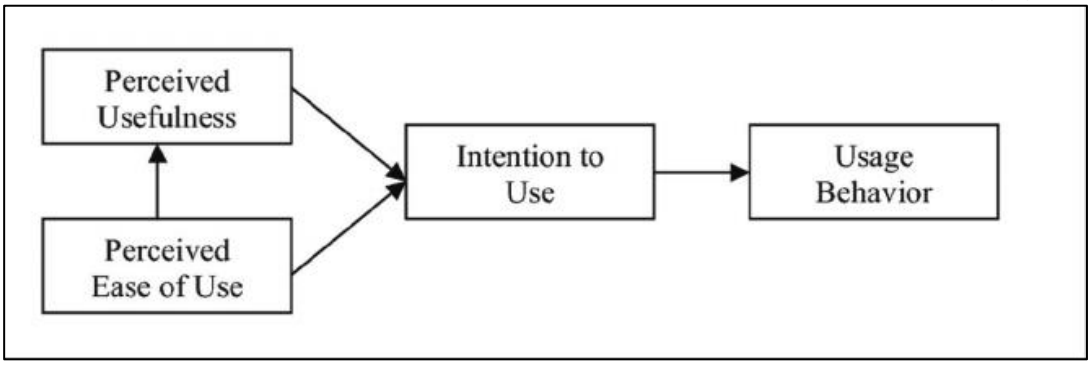


Table 1.4: Summary of technology acceptance theories. (59,61)

Theory/Model	Scientific field	Author	Based on	Aim
Theory of Reasoned Action (TRA)	Social Psychology	Ajzen and Fishbein 1967	--	Explain human behaviour
Theory of Planned Behaviour (TPB)	Social Psychology	Ajzen 1985	TRA	Explain human behaviour
Diffusion of Innovation Theory (DIT)	Social Science	Rogers 1962	--	Study innovations adaptation
Technology Acceptance Model (TAM)	Information Technology	Davis 1986	TRA	Explain acceptance and attitude toward using technology
Extended Technology Acceptance Model (TAM2)	Information Technology	Venkatesh and Davis 2000	TAM	Explain perceived usefulness and perceived ease of use from the social influence
The health information technology acceptance model (HITAM)	Information Technology	Kim and Park 2012	TAM	Describing behavioural intention of using health information technology

Table 1.5: Measurement scale for technology acceptance model (TAM).(54)

Construct	Items	Scale
Perceived Usefulness	1. Using *CHART-MASTER* in my job would enable me to accomplish tasks more quickly. 2. Using *CHART-MASTER* would improve my job performance. 3. Using *CHART-MASTER* in my job would increase my productivity. 4. Using *CHART-MASTER* would enhance my effectiveness on the job. 5. Using *CHART-MASTER* would make it easier to do my job. 6. I would find *CHART-MASTER* useful in my job.	**Likely** ❑ Extremely ❑ Quite ❑ Slightly ❑ Neither ❑ Slightly ❑ Quite ❑ Extremely **Unlikely**
Perceived Ease of Use	1. Learning to operate *CHART-MASTER* would be easy for me. 2. I would find it easy to get *CHART-MASTER* to do what I want it to do. 3. My interaction with *CHART-MASTER* would be clear and understandable. 4. I would find *CHART-MASTER* to be flexible to interact with. 5. It would be easy for me to become skilful at using *CHART-MASTER*. 6. I would find *CHART-MASTER* easy to use.	

3.4.2. Mobile App Rating Scale

The mobile app rating scale (MARS) was developed and tested to assess the quality of mobile health apps.(55,56) The tool consists of 23 items divided into five categories: engagement, functionality, aesthetics, information quality and subjective quality scale. It is a reliable and widely used tool on similar studies.(57,62) Some MARS items are around usefulness and ease of use – the two main constructs of TAM. Thus, using this tool will support using the TAM model.

4. Project's Aims and Objectives

The main aim of this project is to explore the efficacy, availability and perception towards using mobile applications in diabetes self-management in Saudi Arabia. To accomplish this aim, the following objectives have been set:

Objective one: To conduct a systematic review and meta-analysis aiming to explore the nature and effectiveness of mobile and web applications to support self-management for adults with type 1 and type 2 diabetes.

Objective two: To conduct a systematic review aiming to explore the knowledge and attitudes of patients and healthcare professionals towards mobile and web applications to support self-management for adults with type 1 and type 2 diabetes.

Objective three: To conduct web-based research to explore the availability and features of mobile applications in the Google Play Store® (Android™) for diabetes self-management for adults with type 1 and type 2 diabetes.

Objective four: To conduct a survey study to explore patients' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications in supporting diabetes self-management for adults with type 1 and type 2 diabetes among the Saudi Arabian population.

Objective five: To conduct a survey study to explore healthcare professionals' beliefs, experiences, attitudes and knowledge in regard to the use of mobile applications in supporting diabetes self-management by patients in Saudi Arabian population.

CHAPTER 2:

Effectiveness of Using Mobile and Web Applications to Support Diabetes Self-management: A Systematic Review & Meta-analysis

ABSTRACT

Background: Diabetes is a serious global issue. Around 425 million patients have diabetes. Self-management is an important factor in the control of diabetes, as patients are known to spend, on average, three hours in contact with professional healthcare providers and over 8,000 hours taking care of themselves each year. Many mobile and web-based applications have been used to support diabetes self-management. However, a systematic review focusing on the effects of mobile and web applications for the self-management of diabetes is necessary, as recent systematic reviews specific to mobile and web applications are lacking.

Objective: The objective is to systematically review the nature and effectiveness of mobile and web applications to support the self-management of diabetes in adults.

Search Methods: Embase®, Medline®, CINHAL PLUS® and Google scholar databases were searched on May 2019 for literature published between May 2010 and May 2019.

Selection criteria: The studies selected were Randomised Controlled Trials (RCTs) and quasi-experimental and observational studies (cohort), evaluating the effectiveness of mobile and web applications on diabetes self-management compared to the usual care of adults with type 1 or type 2 diabetes.

Data collection and analysis: Meta-analysis for HbA1c of RCT was carried out. Quality of life(QoL) outcome and other study designs are narratively summarised in tables. The nature of the interventions was explored by extracting and classifying the apps' features, according to the AADE 7 Self-care Behaviours™.

Main results: Thirteen studies met the inclusion criteria, of which 11 were RCTs and two were observational studies. Ten trials reported HbA1c, and results were mixed over time. The mobile and web applications had a small effect on HbA1c, but not all trials were statistically significant. The pooled results of HbA1c for three and six months were also in favour of the intervention, but it was not statistically significant at -0.11 [95% CI -.026 - 0.01] and -0.26 [95% CI -0.59 - 0.07]. Five studies provided quality-of-life results, but only one study was statistically significant. In all the included studies, no intervention supported all self-care activities based on the AADE 7 self-care domains.

Authors' conclusions: Conclusive evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and quality of life (QoL) is lacking. This may not be because they are ineffective, but could be due to the limited number of studies conducted on a small number of mobile and web apps. Thus, we believe that more research needs to be done to explore the availability of mobile applications in app stores, their features, and how they are designed and tested. Also, it is important that healthcare professionals' and patients' knowledge and attitudes towards mobile and web apps is investigated. More research then needs to be done to explore the efficacy of well-designed and accepted mobile apps.

Funding and registration: This research is a PhD scholarship; it has been funded by Albaha University and the Ministry of Education in Saudi Arabia.

1. Introduction

Diabetes is a serious global issue. Around 425 million patients have diabetes globally (7). Self-management is an important factor in the control of diabetes as patients are known to spend, on average, three hours in contact with professional healthcare providers and over 8,000 hours taking care of themselves each year(29). Many mobile and web-based applications have been used to support diabetes self-management. In the last 10 years, several systematic reviews have explored the impact of digital health technologies on diabetes management. Alanzi (2018) conducted a systematic review on the impact of social media on diabetes management outcomes within a middle eastern population. Only five studies were included. The authors found that the acceptance rate for using social media in diabetes is relatively high in this region, which helps in lowering haemoglobin A1c. However, this study was limited to a specific population. Tao D *et al.*(63) conducted a systematic review to examine the effect of consumer-oriented technology on diabetes management outcomes. This review found that the use of technology is more effective than normal care. However, this systematic review was not specific to mobile and web applications, but included all technologies used by patients. Heitkemper *et al.* (64) examined the effects of diabetes self-management education in which technology was used for glycemic control. They found the result to be similar to diabetes education, but without the technology. However, this review was limited to a medically underserved population. Greenwood *et al.* (34) examined the same, but with no limitations on the population. They found that technology significantly improved HbA_{1c}. However, the study focused on many types of technologies, including SMS, the web and apps. McMillan KA *et al.* (46) examined the effectiveness, acceptability and feasibility of mobile technology on patients with type 2 diabetes. The review was limited to

one outcome – active lifestyles – and concluded that very few studies had examined this outcome. Bonoto BC *et al.* (65) evaluated the efficacy of mobile apps on supporting patients with diabetes. They concluded that mobile applications could improve the control of HbA_{1c}. A systematic review investigating the effects of mobile and web applications for the self-management of diabetes is necessary. Moreover, there have been no recent systematic reviews specific for mobile and web applications. In addition, technology in mobile and web applications is rapidly evolving, so evidence needs to be updated. This systematic review will benefit stakeholders, including patients, healthcare providers, policymakers, researchers and the software development industry. Patients and healthcare providers will have up-to-date evidence regarding the use of mobile and web applications in managing their diabetes. This will help patients to make an informed decisions about whether or not to use a particular technology to support their diabetes self-care. Policy makers will be able to obtain the most recent evidence of the technology in use and identify gaps and requirements for more research or actions within software development. Researchers will identify gaps in the literature, which will help to direct future research and build existing knowledge.

2. Aim and Objectives

The aim of this systematic review is to explore the nature and effectiveness of mobile and web applications to support the self-management of type 1 and type 2 diabetes. To achieve this aim, the following objective was set: To systematically review the nature and effectiveness of mobile and web applications to support the self-management of diabetes.

3. Methods

This systematic review has been conducted, written and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)(66) – see

Appendix 2.4. The proposal of this systematic review has been registered and published through PROSPERO. The registration No. is: CRD42020140332. Also, PRISMA-P Checklist for Protocol (67) and PRISMA for Abstracts Checklist used to guide proposal and abstract writing (68) – please see appendices 2.2 and 2.5.

Based on the FDA definition of 'health mobile app' (25) and AADE 7 Self-care Behaviours®, and for the purpose of this systematic review, mobile application intervention is defined as *'Any application that can be executed on a mobile platform either by direct installation or through a web browser tailored to a mobile platform (Mobile Ready), used by patients to provide any self-management features in accordance with AADE7 self-management behaviour or education*.'

3.1. Search Strategy

Source:

The Embase®, Medline®, CINHAL PLUS® and Google scholar databases were searched during May 2019 for literature published between May 2010 until May 2019. The Embase® and Medline® databases were searched through the Ovid® Platform. The CINHAL PLUS® database was searched through the EBSCOhost® platform. Each database was searched separately to maximise the sensitivity, specificity and benefit from indexing tools specific for each database, such as MeSH terms and Emtree terms – see Table 2.1.

Key words:

The key words were selected based on a scoping search that had been done prior to conducting the systematic review. There were scoping search results in 42 published

systematic reviews in relation to diabetes, self-care and technology. These studies were used to extract the key words(34,44,46,63–65,69–104) – see Appendix 2.1.

MeSH terms or Emtree terms were used wherever possible; if no term was found, natural language was used in the search. The key words were divided to three domains – diabetes, self-care and technology. The results of all these domains were combined using the operator "OR". Key words within a domain were combined using the operator "AND". This was done to ensure a good balance between sensitivity and specificity – see Table 2.1 and the search strategy in Appendix 2.3.

Table 2.1 Organisation of keywords in three different domains used for Embase®, Medline® and CINAHL Plus® databases.

Domain	Embase® Keywords	Medline® Keywords	CINAHL Plus® Keywords	Google Scholar Keywords
Diabetes	Diabetes, diabetes mellitus[#]	Diabetes, DIABETES MELLITUS[&], Diabetes Mellitus Type 2[&], Diabetes Mellitus Type 1[&]	Diabetes, diabetes mellitus[%]	Diabetes
AND				
Self-care	self-care[#], self-management, self-monitoring[#]	Self care[&], self-management[&], blood glucose self-monitoring[&], self-monitoring	Self care[%], self-management[%], self-monitoring, Blood Glucose Self-Monitoring[%]	self-care, self-management
AND				

Technology	Internet[#], web, web-based, mobile application[#], mobile app*, mobile software, phone app*, computer program, software[#], computer-based, mHealth, medical informatics, medical informatics[#], digital health, mobile technology, mobile-based technology, mobile health	Internet[&], web, web-based, mobile application[&], mobile app*, mobile software, phone app*, computer program, software[&], computer-based, mHealth, medical informatics[&], digital health, mobile technology, mobile-based technology, mobile health	Internet[%], world wide web[%], world wide web applications[%], web, web-based, mobile application[%], mobile app*, mobile software, phone app*, computer program, software[%], computer-based, mHealth, telehealth[%], medical informatics[%], digital health, mobile technology, mobile-based technology, mobile health, technology[%]	Internet, web, web-based, mobile app*, mHealth

Emtree term. & MeSH term. % CINAHL Plus subject heading.

3.2. Study Selection

The studies selected were RCTs, quasi-experimental or observational studies and evaluated the effectiveness of mobile and web applications on diabetes self-management compared to usual care on adults with type 1 or type 2 diabetes, and reporting HbA1c and QoL as either primary or secondary outcomes – see Tables 2.2 and 2.3.

Table 2.2 PICOSS of included studies. Adapted from Boland et. al, (105)

Population	Adult patient with T1 or T2 diabetes
Intervention	Mobile and web applications
Comparator	Usual care or any other self-management support
Outcome	HbA1c and QoL
Settings	Any settings of self-management, such as home or work etc.
Study Design	Randomised control trials, quasi-experimental studies and observational studies (Cohort)

3.2.1. Inclusion and Exclusion Criteria

Table 2.3 List of inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Time frame	2010 and after	
Study design	Randomised control trials, quasi-experimental studies and observational studies (cohort)	
Population	Adults (18 years or more) with type 1 or type 2 diabetes	Children or adolescent and gestational diabetes
Intervention	Mobile and Web applications	Any other application type such as clinical decision support systems or any mobile or web applications used by healthcare providers and not the patient
Comparator	Usual care with or without other self-management support	Any other comparators
Outcome	HbA1c and QoL	
Language	English	Any language other than English
Publication type	Peer reviewed journal articles	Abstracts, conference proceedings, editorials, letters, reviews, opinions

3.2.2. The Screening and Selection Process

The first review author (AA) executed the search on each database separately. Identified records were collected and duplications were removed automatically using RefWorks™; the remaining duplications that were not detected by RefWorks™ were removed manually before the screening. The first review author (AA) assessed the titles and abstracts for their inclusion eligibility. Potential inclusion eligibility studies were obtained and read in full by the first review author (AA) to confirm their inclusion based on the inclusion criteria – see Table 2.3.

The other review authors, (VP and ZJ), independently and randomly sampled and double-checked the screening and selection process. VP and ZJ reviewed the eligibility of the included studies. Any disagreement regarding the selection was resolved through discussion over several meetings.

3.3. Data Extraction

AA independently developed an initial version of data extraction based on data collected by the Cochrane collaboration. The second review author (VP) independently reviewed the data extraction form. Over several meetings, the final pilot version was ready for pilot data collection. AA and VP independently piloted data extraction from, and changes made to, the form prior to the start of the actual data collection. The third review author (ZJ) reviewed the form independently during the data collection and some changes were made to the form. Data extraction was done through Excel® and used several pages – a cover page, coding, study eligibility, study characteristics, interventions, and results – see Appendix 2.6. AA independently extracted the data from the included studies. VP and ZJ sampled, reviewed, and cross-checked the extracted data. Any disagreements were solved through discussion.

3.4. Quality Assessment

The bias risk assessment of RCTs was performed by AA using the Cochrane Collaboration Risk of Bias Assessment Tool(106). VP and ZJ double-checked the data. Each RCT study assessed the following: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and other biases. Another study design was assessed by one review

author (AA) using Critical Appraisal Skills Programme (CASP) tools(107) and it was randomly cross-checked by VP and ZJ. Each study was assessed on three domains: study validity, results and generalisability.

3.5. Data Synthesis

Based on the nature of the aim, the different study designs and outcomes, a different synthesis approach was used to summarise the evidence. Meta-analysis for HbA1c and the quality-of-life outcome of RCTs has been carried out whenever possible following guidance of Cochrane and others(108,109). Only HbA1c induced meta-analysis. Other study designs and outcomes have been narratively summarised in tables. AA synthesised the data and VP and ZJ double-checked the data. The meta-analysis synthesis was checked and reviewed by a statistician, Sayeed Haque (SH).

3.5.1. Meta-analysis

Clinical heterogeneity, intervention features (study design heterogeneity) and the statistical heterogeneity of available data were checked before performing the meta-analysis of the RCTs of any clinical outcome. The intervention's features were standardised using AADE 7 Self-care Behaviours®; if there were more than three studies sharing at least one feature, statistical heterogeneity was performed, given that they were already clinically homogenous and measured using the same scale. Only HbA1c led to meta-analysis. As most studies reported HbA1c at three and six months, meta-analysis was performed at these time points. The size of the effect was summarised using the unstandardised mean of HbA1c reduction for individual studies at three and six months.

Statistical heterogeneity was checked for HbA1c visually using a forest plot produced using RevMan 5.3 software. It also used to calculate the chi-squared test for heterogeneity. Significance was determined using a p-value of 0.05. Heterogeneity was found and measured using I^2 Statistic. There was a moderate heterogeneity and, thus, a random effects model was used for both the three- and six-month time points. A statistician (SH) checked the meta-analysis performance process and made changes when necessary. No sub-group analysis was conducted.

3.5.2. Narrative Synthesis

Other study designs and outcomes are narratively synthesised. The study characteristics, interventions and results are summarised in tables. To standardise the features of the applications, and make them comparable, a method published elsewhere was followed (110) to match the features to AADE 7 Self-care Behaviours® for Managing Diabetes Effectively. The data is presented in the tables.

3.6. Software (Tools)

Mendeley™ and RefWorks™ were used for the management of documents and for maintaining a list of the included and excluded studies. Microsoft Word® and Excel® were used for recording and synthesising the evidence. RevMan 5 (V.5.3) was used for meta-analysis and the RCT risk of bias assessment and graph production. Several applications are available to facilitate work and calibration in doing systematic review. A comparison between Systematic review software was made, but none of these software was used in conducting this systematic review – please see appendix 2.7-

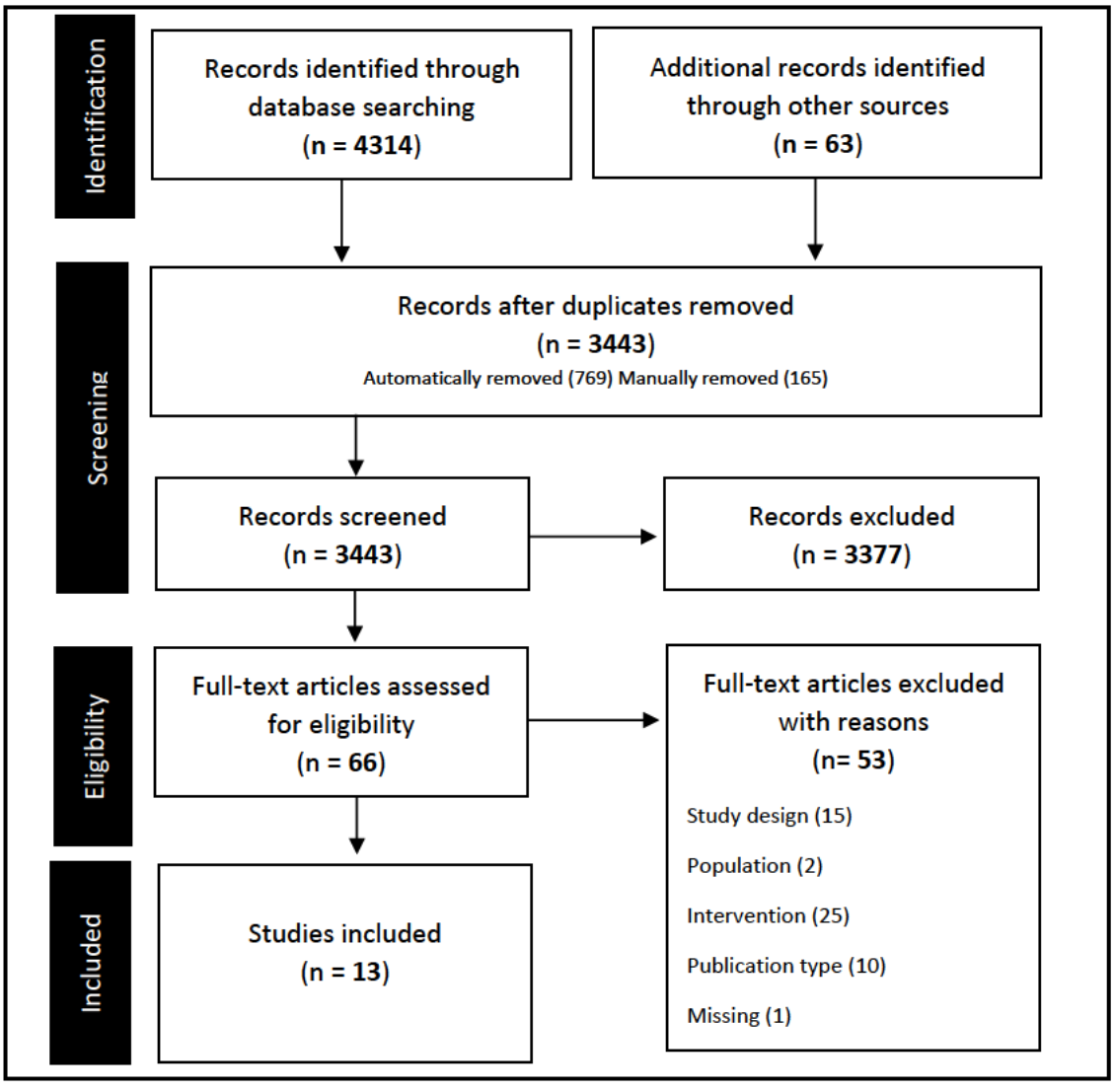
4. Results

4.1. Description of Studies

4.1.1. Search Results

In total, 4,377 records were identified: 4,314 from searching databases and 63 from Google or screening references of the included studies. Google Scholar search was for ten pages and added no new results. A total of 934 duplicates were removed; 769 automatically used the RefWorks™ exact method and 165 were removed manually. Based on the screening of 3,439 titles and abstracts, 66 articles were potentially relevant to mobile technology in support of the self-management of type 1 and type 2 diabetes and underwent the full text screen. Details of the search results are presented on the PRISMA chart, shown in Figure 2.1.

Figure 2.1 PRISMA flow chart. Adapted from The PRISMA Group (2009)



4.1.2. Included Studies

Thirteen studies(111–123) met the inclusion criteria. A summary of the characteristics of the included studies are exhibited in Table 2.4. Five studies were based in the USA(114,115,120,122,123), one in Canada(111), one in China(117), one in Malaysia(119), one in India(116), one in the UK(118), one in the Netherlands(112), one in Norway(113), and one in Australia(121).

Study design

Most of the included studies were randomised clinical trials (RCTs); there were 11 RCTs(111–121), and two observational studies(122,123). The duration of the RCT studies ranged from 3 to 20 months: one study lasted for three months(112), six studies lasted for six months(111,114,116,117,119,120), one study took nine months(121), two studies took 12 months(113,118) and one study lasted for 20 months(115).

4.1.3. The Intervention

Interventions varied in type; seven interventions were mobile applications(111,113,116,120–123), five were web applications(114,115,117–119) and one was a mobile and web application(112). In eight of the studies(111,112,117,118,120–123), the interventions were available for the public to download from an app store or to access online, while in two studies(114,119), the interventions were developed for a research purpose. Three studies(113,115,116) showed no information. The intervention's target population were seven apps for type 2 diabetes, five apps for type 1 and one for both types. Only three interventions were developed based on guidelines(111,118,119). A full summary of the intervention is presented in Table 2.5.

The interventions' features

The interventions' features varied. By matching app features to AADE 7 Self-care Behaviour® areas, 10 apps supported healthy eating, eight supported being active, 10 supported monitoring, five supported taking medications, four supported reducing risks, and three supported healthy coping. No apps supported problem solving – see Table 2. 5.

4.1.4. Excluded Studies

After reading the full texts, 53 studies were excluded(124–161). Of these, 15 studies were excluded based on study design, two on population, 25 on intervention, 10 on publication type and one study could not be obtained.

Table 2.4: Summary of included studies: studies characteristics, outcomes and summary results.

Study	Study Duration (Months)	Design	Study Setting (Country)	Outcome	Measurement Tools	Measurement point	Summary Results
Agarwal 2019	6	RCT	Canada	HbA1c		3 months	The results had no impact on HbA1c levels at 3 months (mean difference −0.42, 95% CI −1.05 to 0.21; P = 0.19).
				QoL	EuroQol-5D (EQ-5D)		No significant differences between groups. (P > 0.05)
Yu 2019	6	RCT	China	HbA1c		3 months 6 months	No significant differences between groups.
Ramadas 2018	6	RCT	Malaysia	HbA1c		6 months 12 months	The mean HbA1c of the intervention decreased significantly by 0.5% at post-intervention (F = 8.334, p = 0.004, η2 = 0.114). No significant difference between groups and within the control group. The mean HbA1c of the intervention decreased significantly by 1.5% at 12th month (F = 10.934, p = 0.001, η2 = 0.152). No significant difference between groups and within the control group.
Garg 2017	6	RCT	USA	HbA1c		3 months 6 months	Decrease in HbA1c among both the control and intervention (iBGStar) at 3 months. However, the amount of change in HbA1c was not different between (-0.21 vs. -0.4, p = 0.20).

							At 6 months, there was a significant decrease in HbA1c in the intervention (iBGStar). The amount of change was significantly higher in the intervention than in the control (-0.16 vs. -0.51, p = 0.04).
Kleinman 2017	6	RCT	India	HbA1c		3 months 6 months	Overall baseline mean HbA1c was 9.3% (SD–1.2). At 6 months, the mean HbA1c decrease by 1.5% in the intervention and 0.8% in the usual care which was a statistically significant (p = 0.02; 95% CI mean difference: 0.10–1.37).
Murray 2017	12	RCT	UK	HbA1c		12 months	At 12 months, a significant difference in HbA1c between groups. The participants in the intervention (HeLP-Diabetes) had a lower HbA1c. (mean difference = −0.24%; 95% CIs −0.44 to −0.049, p = 0.014)
Drion 2015	3	RCT	Netherlands	HbA1c		3 months	Glycaemic control remained unchanged in both groups.
				QoL	RAND-36 questionnaire		There were no significant differences in the RAND-36 scores.
Holmen 2014	12	RCT	Norway	HbA1c		12 months	Level of HbA1c did not differ significantly between the groups.
				QoL	Short-Form 36v2 Health Survey (SF-36)	12 months	No significant differences in any of the subscales or in the summary component scores between the 3 groups.
Kirwan 2013	9	RCT	Australia	HbA1c		3 months 6 months 9 months	In the linear mixed model, there was a significant effect between groups (F1,246=20.07, P < 0.001). The intervention group had a significant

							decrease in HbA1c (mean −1.10, SD 0.74, P< 0.001) over the 9-month.
				QoL	Diabetes Quality of Life (DQOL)		No significant differences.
Bond 2010	6	RCT	USA	QoL	The Problem Areas in Diabetes Scale (PAID)		The univariate ANCOVA F tests for the showed a significant (P < .05) difference QoL.
Glasgow 2010	20	RCT	USA	HbA1c		4 months	Not significant (Baseline 7.86 ± 1.59 7.76 ± 1.50, @4 Months 7.76 ± 1.50 (P 0.763)
Osborn 2017	NA	Observational study	USA	HbA1c		4 months	There was a significant 1.36% HbA1c reduction (unadjusted and adjusted F = 62.60, P < 0.001) (Unadjusted: 8.26% to 6.90%; adjusted 8.72% to 7.36%)
Osborn 2017	NA	Observational study	USA	HbA1c	Self-reported HbA1c	3 months	Mean blood glucose and second self-reported HbA1c was significant (P < 0.001)

Table 2.5 Intervention's specification and features classification based on AADE7 Self-Care behaviour ®.

Study	Intervention	App Name	App Purpose	Diabetes Type	Intervention's Features							
	(Mobile, Web or Both)			T1 or T2	Healthy Eating	Being Active	Monitoring	Taking Medication	Problem Solving	Reducing Risks	Healthy Coping	Other
Agarwal 2019	Mobile Application	BlueStar	Available to public	T2	☑	☑	☑					
Yu 2019	Web Application	Diabetes-Carer	Available to public	T2	☑	☑	☑			☑	☑	☑
Ramadas 2018	Web Application	myDIDeA	Developed for research	T2	☑							
Garg 2017	Mobile Application	iBGStar + the Diabetes Manager App	Available to public	T1			☑			☑		
Kleinman 2017	Mobile Application	Gather Health	NI	T2			☑			☑		☑
Murray 2017	Web Application	HeLP-Diabetes	Available to public	T2								☑
Drion 2015	Mobile & Web Application	DBEES	Available to public	T1	☑	☑	☑	☑				
Holmen 2014	Mobile Application	Few Touch Application	NI	T2	☑	☑	☑					☑
Kirwan 2013	Mobile Application	Glucose Buddy	Available to public	T1	☑	☑	☑	☑				
Bond 2010	Web Application	NI	Developed for research	T1 & T2	☑		☑			☑		
Glasgow 2010	Web Application	NI	NI	T2	☑	☑		☑				
Osborn 2017	Mobile Application	One Drop	Available to public	T1	☑	☑	☑	☑			☑	☑
Osborn 2017	Mobile Application	One Drop	Available to public	T1	☑	☑	☑	☑			☑	☑

Available to public: *Available to download from an app store OR Access online.* ***Developed for a research:*** *Developed for a research purpose and not available to public* ***T1****: Diabetes Type 1* ***T2****: Diabetes Type 2* ***NI****: No information*

4.2. Risk of Bias of Included Studies

The review authors' judgements on the risk of bias assessments, for the included RCT studies, are summarised in Figures 2.2 and 2.3.

Allocation

Ten trials(111–113,115–121) were judged to be of low bias risk as they described the randomisation. One trial(114) was rated as high risk because they randomised participants using a stratified 2-tier format based on glycosylated haemoglobin and gender; there is no information about the concealment.

Blinding

All trials, except one, were judged to be of high risk in terms of blinding participants. It is not always possible to perform a study blind, which is inherently the nature of the intervention. However, one trial(118) managed to overcome this issue by introducing another simple application; participants in either of the groups knew which application they were using, so it was judged to be low risk.

Incomplete outcome data

One trial(111) was judged as high risk because of its high attrition rate (35%); nine trials(112–119,121) were judged as low risk and the risk of one trial(120) was unclear.

Selective reporting

All trials except one were judged to be low risk(112–121). One trial(111) was judged as high risk as the outcome was not reported as described in the method.

Other potential sources of bias

One trial(112) was judged as high risk because only patients who were familiar with smartphones were asked to participate. Other trials were judged as low risk as there was no clear source of bias risk.

Figure 2.2 Risk of bias summary: review authors' judgements about each risk of bias item for each included RCT study.

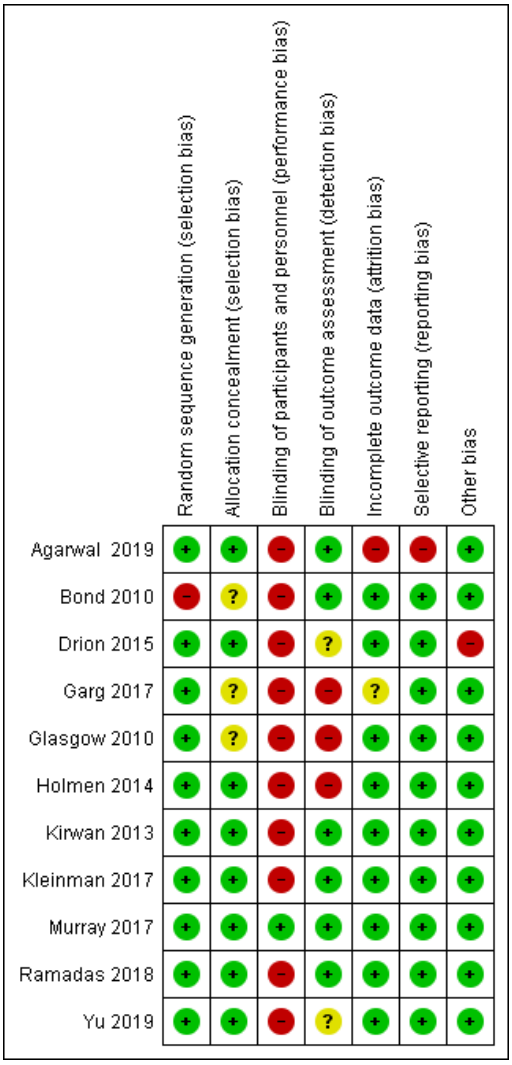
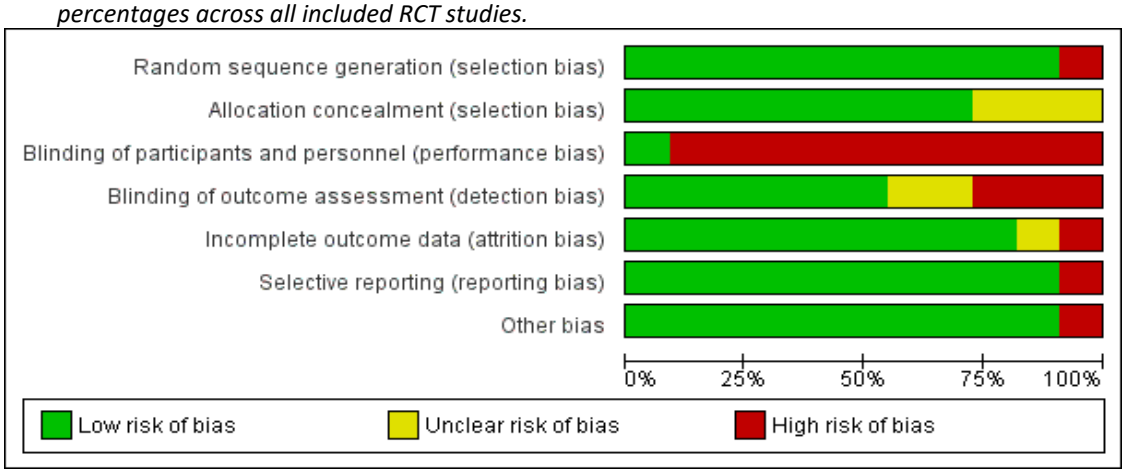


Figure 2.3 Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included RCT studies.



4.3. Effects of the Intervention

4.3.1. Primary Outcome: Glycosylated Haemoglobin A1c (HbA1c)

Ten trials reported HbA1c as an outcome(111–113,115–121). Five trials(111,112,116,117,121) contained enough data to be included in the meta-analysis at the three-month measure point and four trials(116,117,119,121) for the six-month measure point – see Table 2.4. The pooled result included 466 participants at the three-month and 385 at the six-month meta-analyses. The remaining trials did not report enough data to be included in the meta-analysis. Of the included observational studies, only two were reported HbA1c (122,123).

The individual results of the six trials, which reported the difference in HbA1c at three-month time point, were not significant in most trials(111,112,117,120,121) except one(116). For the six-month time point, three trials reported an insignificant difference(117,119,121) and two reported a significant change in favour of the intervention(116,120). For the 12-month time point, two trials(113,119) reported an insignificant difference and one reported a significance change in favour of the intervention group(118). Only one trial(115) reported results at four months and was not significant. Another trial(121) reported results at nine months and showed a significant reduction in the HbA1c of the intervention group compared to the control group – see Table 2.4.

The pooled results of the three-month data indicate there is small, statistically insignificant change in the mean difference between the intervention and control groups in favour of the intervention of -0.11 [95% CI -.026 - 0.01] – Figure 2.4. The pooled results

of the six-month data also indicated a small change in favour of the intervention; however, it was statistically insignificant -0.26 [95% CI -0.59 - 0.07] – Figure 2.5.

Figure 2.4: Forest plot of comparison: mobile and web app vs usual care, outcome: HbA1c @ 3 months.

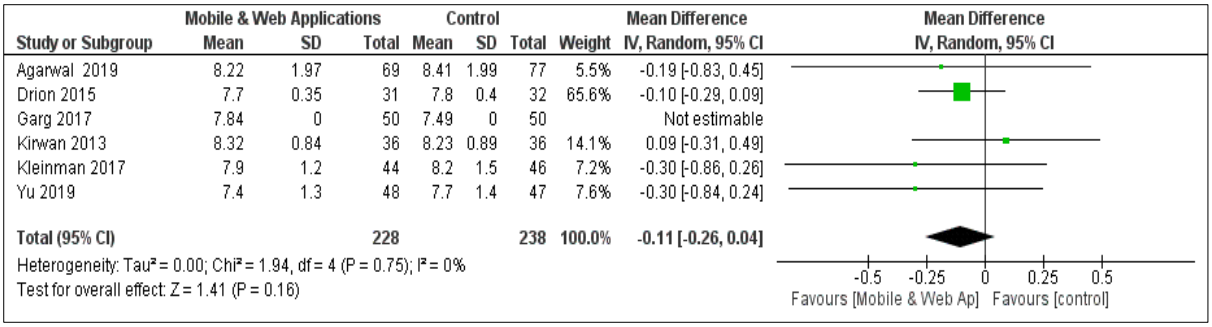
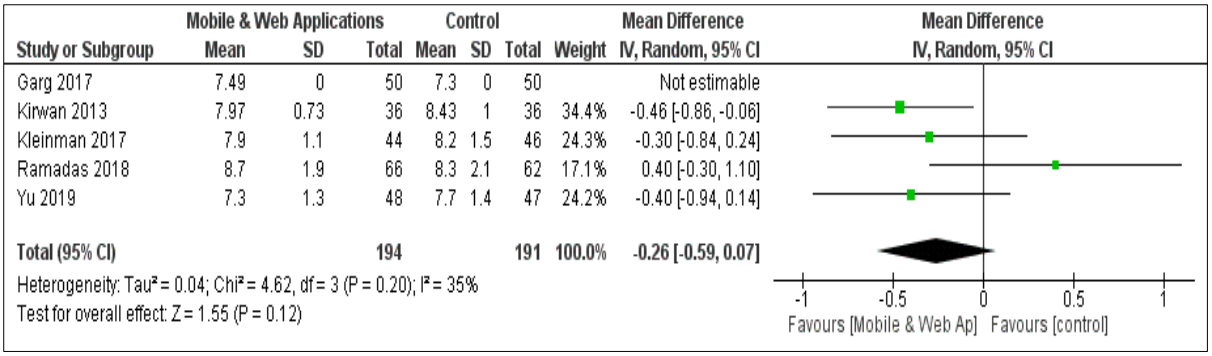


Figure 2.5: Forest plot of comparison: mobile and web app vs usual care, outcome: HbA1c @ 6 months.



Only two observational study(122,123) reported HBbA1c and the results showed a significant reduction favouring the intervention – see Table 2.4.

4.3.2. Secondary Outcome: Quality of Life (QoL)

Five trials reported the QoL (111–114,121). They used five different scales; EuroQol-5D (EQ-5D)(111), RAND-36 questionnaire(112), Short-Form 36v2 Health Survey (SF-36)(113), Diabetes Quality of Life (DQOL)(121) and The Problem Areas in Diabetes Scale (PAID)(114). None of the

trials used the same measuring unit to warrant meta-analysis. Only one trial(114) showed a statistically significant difference – see Table 2.4.

5. Discussion

5.1. Summary of the Main Results

This systematic review aimed to explore the nature and evaluate the effectiveness of mobile and web applications in supporting diabetes self-management in adults with types 1 and 2. The search resulted in 4377 records; however, 66 articles underwent full-text screening, and only 13 studies were included. The search strategy used to balance sensitivity and specificity returned a very high number of records. Keywords, databases, and platforms were broadened to make the results as sensitive as possible, leading to many irrelevant (low specificity) results. For example, in the Medline database, not only keywords' diabetes type 1' and 'diabetes type 2' were used, but 'diabetes' was also used. So, there were results related to children, gestational diabetes and others. This approach was used to increase sensitivity as may be some studies relevant to both 'diabetes Type 1' and 'diabetes type 2' and used only 'diabetes' as a keyword. Another example, the term 'technology' was used, which could be any technology related to diabetes, such as smart pens, drug delivery systems or CGMs. This general term is used to benefit from databases' predefined terms; Emtree, MeSH and subject heading. Even though this approach took a considerable amount of time, it may lead to not missing any relevant study. If there is a missed study, it could be due to chance rather than a systematic error. This high number of records combined with the low number of included studies is seen in other studies on diabetes mobile technology. A systematic review by McMillan et al.,(46) retrieved 7662 records and included only nine studies. This approach increased the confidence in achieving the study's aims by not missing relevant studies.

As this study aims to explore the nature of diabetes mobile applications, The general picture emerging from this study is that mobile and web applications that support diabetes self-management have various features. Classification of the intervention's features, according to the AADE 7 Self-care Behaviour® domains, showed that most of these applications support some diabetes self-care activities: healthy eating (77%), physical activity (61.5%), monitoring (77%), taking medications (38%), reducing risks (30%), and healthy coping (23%). None of the applications supported problem solving. More importantly, no application supports all self-care activities. In General, most applications support three to four domains only. It is worth highlighting that there may be various features within a domain itself. For example, monitoring could be blood glucose, lab results or clinical outcome monitoring. Thus if two applications support monitoring does not mean they support the same self-care tasks. This may lead to a question of how these applications were developed.

It is out of the scope of this systematic review to assess the quality of the used applications. However, design guidelines and application availability data were extracted. Only three applications were designed based on guidelines, theory or model (111,118,119). This may lead to a concern about the quality of the software used. In the same context, two studies developed applications for the research, and three gave no information, which not only led to concern about the quality but also to a question: are there any applications available to diabetes self-management? This question is not raised only from this fact but also from the low number of included studies. As mentioned previously regarding the search approach, high sensitivity approach was used, which increased the confidence that there no relevant study was missed, so the low number of studies included may show us there is no application to conduct research on this area or show us how research is limited in this area.

Regarding the effect of the intervention, in 10 trials, these applications minimally affected or did not affect HbA1c. The pooled HbA1c results for the three and six-month periods favoured the intervention, but they were statistically insignificant, with a mean difference of -0.11 [95% CI: -0.026–0.01] and -0.26 [95% CI: -0.59–0.07]. Most of the individual results from the trials favoured the intervention. However, not all the results were statistically significant. Six trials that reported results at the three-month time point were insignificant, except for one. Three trials reported an insignificant difference at the six-month time point, and two reported a significant change, favouring the intervention. For the 12-month time point, two trials reported an insignificant difference, and one reported a significant change. The overall image of these results may suggest that the diabetes mobile application has a limited positive effect on HbA1c.

The intervention effect on the quality of life outcome is no different from HbA1c. Only five studies provided QoL data, but only one was statistically significant ($P < 0.05$). As these used different measurement tools, meta-analysis was not possible. In line with HbA1c, the data may suggest a limited effect on patients' quality of life.

Several reasons could explain why the effectiveness in improving HbA1c and QoL was small, as most of the included studies showed statistically insignificant effectiveness in favour of the mobile application. This may not be because the results are ineffective; instead, it could be due to several factors, such as the number of studies, the availability of applications, application design, and patient acceptance. First, the findings of this review show that only a few studies have been conducted on a limited number of mobile and web applications. Thus, it may not be enough to detect the difference. Second, some studies were conducted using apps designed specifically for research purposes that were unavailable to the public, so their

quality could not be investigated. Third, our results showed that not all self-care activities were available within applications, which could reduce their efficacy and patient acceptance, as a patient needs to install several applications to cover all aspects of self-management. Finally, this review also showed that most applications were not designed based on any theory or model, such as AADE 7 Self-care Behaviour®. If all of these factors were considered, we could see more promising results and higher efficacy.

As mentioned in the introduction, systematic reviews in mobile technology are limited. There is no recent study specific to diabetes self-management mobile applications as this systematic review. Thus, it is not feasible to compare the results with previous literature. However, in a bigger image and comparing these results with systematic reviews in diabetes mobile technology in general, this systematic review is different. First, this systematic review concentrated only on diabetes mobile and web applications. Additionally, within the diabetes mobile applications, this study explored the nature of these applications and standardised these applications using AADE 7 self-care behaviour prior to conducting a meta-analysis to minimise study design heterogeneity and perform a sub-analysis if possible. Moreover, two studies conducted by Tao D et al., (84) and Greenwood et al., (34) explored all technologies used by patients, including SMS. Both of these studies show that mobile technology, in general, is effective, which is different from this systematic review finding. Another study by Heitkemper et al., (64) found that educational diabetes mobile application has no effect different from education without technology. Another study by McMillan et al. found that very few studies examined the active lifestyle outcome. This systematic review aligns with this study that found that a limited number of studies examined HbA1c and Quality of life. This may suggest that, in general, a limited number of studies have been conducted on diabetes mobile applications.

Comparing the study with mobile technologies for other diseases may help to put diabetes mobile applications in context. Several systematic reviews were conducted to explore the effectiveness of mobile technology on other diseases. This study is in line with the finding of these studies. A study conducted by Belisario et al., concluded that there is no positive evidence to support the use of mobile applications in the self-management of Asthma(162). Similarly, a study conducted by McCabe et.al, concluded that there is limited evidence supporting the use of mobile technology to support self-management of chronic obstructive pulmonary disease (COPD)(163).

IMPLICATION FOR CLINICAL PRACTICE

Evidence is insufficient to advise clinical practitioners, patients or policymakers regarding the adaptation of diabetes mobile applications. In general, these findings suggest a limited impact on clinical practice due to applications' availability and effects. For example, if an application was designed for research, is not commercially available, or is no longer available, it could not be adopted in clinical practice, regardless of its effectiveness. However, this systematic review provides a healthcare professional with a general image of the nature of diabetes mobile applications and what to expect from these applications. A healthcare professional may choose to adapt several applications that cover several self-care domains to increase the overall benefit of these applications. Also, a healthcare professional may choose not to rely on these applications only but to use these applications for data collection and patient progress tracking. For example, a HCP may choose to monitor patients' hypo episodes and link them to sports activities to make an informed decision and not rely on the application's problem-solving features.

IMPLICATION FOR RESEARCH

As highlighted previously, there is a limited number of studies conducted to investigate the effectiveness of diabetes mobile applications. Further research should be done to investigate these applications. Also, there was a concern about these applications' quality; further research is needed in this direction. Other research questions raised in this discussion are worth investigating. It was unclear why some studies developed applications for the research. More research needs to be done to explore the availability of mobile applications in app stores and their features. The definition of the intervention and the standardisation of it using AADE 7 self-care behaviour would be beneficial in supporting future research and facilitating conducting meta-analysis with low study design heterogeneity. More importantly, as the quality of diabetes mobile applications is unclear, the negative consequences of using mobile applications should also be investigated.

5.2. Quality of the Evidence (certainty of the evidence)

We believe that we did not introduce a bias to the study as Cochrane methodology has been followed. However, it was inevitable that we would encounter limitations that could affect the strength of the evidence. We have moderate confidence in the evidence as most of the included trials were of moderate risk of bias due to the non-blinding trials. Also, due to the relatively small number of participants and a limited number of trials, we also downgraded our confidence in the evidence. Given that most of the interventions were not designed based on guidelines or theory, we only had moderate confidence in our estimates of effectiveness.

5.3. Strength and Limitations

The main strength of this systematic review is that it concentrated on mobile and web applications. Additionally, it explored the nature of the intervention before conducting a meta-analysis. Moreover, it used a research strategy approach to ensure there is no study was missed. Above all, it used the Cochrane methodology and followed a transparent process that started with publishing the proposal prior to conducting the systematic review. However, there is a limitation to this study. Besides the issues that affected the quality of the evidence, other limitations were faced. We only included studies written in English, which could lead to publication bias and affect the strength of the evidence.

5.4. Authors' Conclusions

Classification of the intervention's features, according to the AADE 7 Self-care Behaviour® domains, showed that most of these applications support some diabetes self-care activities None of the applications supported problem solving and no application supports all self-care activities. Moreover, there is no conclusive evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and QoL. So, there is no advice that could be made from these results to clinical practice. The lack of positive effect may not be due to their lack of effectiveness; it could be due to the limited number of studies conducted on a limited number of mobile apps. Also, some of the studies had been carried out using apps designed specifically for research purposes and were not available to the public; this could have led to further concern regarding how the apps were designed and tested. Thus, we believe that more research needs to be done to explore the availability of mobile applications in app stores, their features, and how they are designed and tested. Also, it is imperative to explore healthcare professionals' and patients' knowledge

and attitudes toward them. Then, more RCTs need to be done to explore the efficacy of well-designed and accepted mobile apps.

CHAPTER 3:

Patients' and Healthcare Professionals' Perspectives on the Use of Mobile and Web Applications in Diabetes Self-Management: A Systematic Review of Qualitative Evidence

"*In the future, we might not prescribe drugs all the time. We might prescribe apps.*"

Daniel Kraft

ABSTRACT

Background: Many mobile and web-based applications have been used to promote diabetes self-management. Patient and healthcare professionals (HCPs) are essential in the success or failure of adaptation and the long-term use of technology. However, no systematic review has qualitatively explored patients' and HCPs' perspectives on mobile applications designed for diabetes self-management.

Objective: This systematic review aims to systematically review patients' and HCPs' perspectives on the use of mobile and web applications in diabetes self-management.

Search methods: Embase®, Medline®, CINHAL PLUS® and Google scholar databases were searched during May 2019 for literature published between May 2010 and May 2019.

Selection criteria: The studies selected were qualitative and surveys were used to explore the perspectives of patients and HCPs on the use of mobile and web applications for diabetes self-management in adults with type 1 or type 2 diabetes.

Data collection and analysis: A qualitative approach was taken, using a narrative synthesis.

Main results: Eight studies met the inclusion criteria. Four themes emerged from the data synthesis: (A) Factors affecting patients' acceptance and use of mobile apps; (B) Factors affecting HCPs' acceptance, use and recommendation of mobile apps; (C) Patients' experiences and attitudes towards mobile apps; and (D) HCPs' experiences and attitudes towards mobile apps

Authors' conclusions: Patients and HCPs are non-users, or limited users, of the current diabetes self-management application. They are looking for more sophisticated, interactive,

smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications.

Funding and registration: This research is a PhD scholarship; it has been funded by the Albaha University and the Ministry of Education in Saudi Arabia. The proposal was registered through PROSPERO.

1. Introduction

Many mobile and web applications have been used to promote diabetes self-management. Patient and HCPs are essential in the success or failure of the adaptation and long-term use of technology. In the last few years, a minimal number of systematic reviews have investigated the effectiveness of mobile applications on diabetes self-management(34,44,46,64,65,102,103,164). However, no systematic review has qualitatively explored patients' and HCPs' perspectives on mobile applications designed for diabetes self-management. There is growing interest in qualitative evidence as a way to explain what works, for whom and in which context(165)(166). Thus, a qualitative systematic review is needed to investigate which characteristics could make mobile applications more likely to be accepted and adopted by patients and HCPs and to evaluate their attitudes towards them. Also, it is important to integrate the findings of this systematic review with the previous systematic review and meta-analysis findings on the effectiveness of mobile and web applications to obtain a full picture of the evidence. This systematic review will benefit different stakeholders, including HCPs, policymakers, researchers and the software development industry. It will provide HCPs with evidence and knowledge about patients' perspectives on mobile and web applications. Policymakers will have the most recent evidence of patients' and HCPs' perspectives on using mobile and web applications. It identified the gaps in the research and the need for further studies on the topic. Finally, for software development industry, it highlighted if there is a need for action in developing software that is based on evidence of stakeholders' needs.

2. Aim

This systematic review aims to explore patients' and HCPs' perspectives on mobile and web applications that support the self-management of type 1 and type 2 diabetes. To achieve this aim, an objective is set to systematically review patients' and HCPs' perspectives on the use of mobile and web applications for supporting diabetes self-management.

3. Methods

This systematic review was conducted, written and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)(66) – see Appendix 3.2. The proposal for this systematic review was registered and published through PROSPERO. The registration No. is CRD42020140332. Also, PRISMA-P Checklist for Protocol (67) and PRISMA for Abstracts Checklist (68) were used to guide the proposal and abstract writing – please see Appendices 2.4 and 3.1.

3.1. Search Strategy

The search strategy has already been described in detail in Chapter 2, section 3.1.

3.2. Study Selection

The studies selected were qualitative studies and surveys to explore the perspectives of patients and healthcare on the use of mobile and web applications for diabetes self-management on adults with type 1 or type 2 diabetes – see Tables 3.1 and 3.2. The intervention of interest has already been defined in Chapter 2, section 3.

Table 3.1: PICo of included studies. Adapted from Joanna Briggs Institute (167)

Population	Patients with T1 or T2 diabetes and HCPs
Phenomenon of interest	Perspectives of patients and HCPs on mobile and web applications for diabetes self-management
Context	Use of mobile and web applications in diabetes self-management

3.2.1. Inclusion and Exclusion Criteria

Table 3.2: List of inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Time frame	2010 and after	
Study design	Qualitative studies and surveys	
Population	Adults (18 years or more) with type 1 or type 2 diabetes	Children or adolescent and gestational diabetes
Phenomenon of interest	Mobile and Web applications	Any other application group such as clinical decision support systems or any mobile or web applications used by HCPs and not the patient
Context	Use of mobile and web applications in diabetes self-management	
Language	English	Any language other than English
Publication type	Peer-reviewed journal articles	Abstracts, conference proceedings, editorials, letters, reviews, opinions

3.2.2. The Screening and Selection Process

The screening and selection process has already been described in detail in Chapter 2, section 3.2.2.

3.3. Data Extraction

The first review author (AA) independently developed an initial version of the data extraction based on data collected by the Cochrane collaboration. The second review

author (VP) independently reviewed the data extraction form. Over several meetings, the final pilot version was ready for pilot data collection. AA and VP independently piloted data extraction from, and changes made to, the form prior to the start of the actual data collection. The third review author (ZJ) reviewed the form independently during the data collection and some changes were made. Data extraction was done through Excel® and used several pages – a cover page, coding, study eligibility, study characteristics, interventions, and results – see Appendix 3.3. AA independently extracted the data from the included studies. VP and ZJ sampled, reviewed, and cross-checked the extracted data. Any disagreements were solved through discussion.

3.4. Quality Assessment

The Critical Appraisal Skills Programme (CASP) tool was used to assess the included qualitative studies(107). This tool is the most commonly used for the appraisal of qualitative studies and was adapted by Cochrane and the WHO(168). Each study was assessed on three domains: study validity, results and generalisability. AA assessed quality. Then, the results were randomly cross-checked by VP and ZJ.

3.5. Data Synthesis

A qualitative approach was taken, using a narrative synthesis(166), and the extracted data was summarised in tables. These included data on study characteristics, study settings, and the key findings of the perspectives of patients and HCPs of mobile technologies for diabetes self-management. Finally, the findings were integrated with the previous chapter in the discussion chapter (Chapter 7). AA synthesised the data, which was then double-checked by VP and ZJ.

3.6. Research Tools (Software)

Mendeley™ and RefWorks™ were used for document management and for maintaining a list of excluded and included studies. Microsoft Excel® was used for data extraction. Finally, the report writing was carried out using Microsoft Word®.

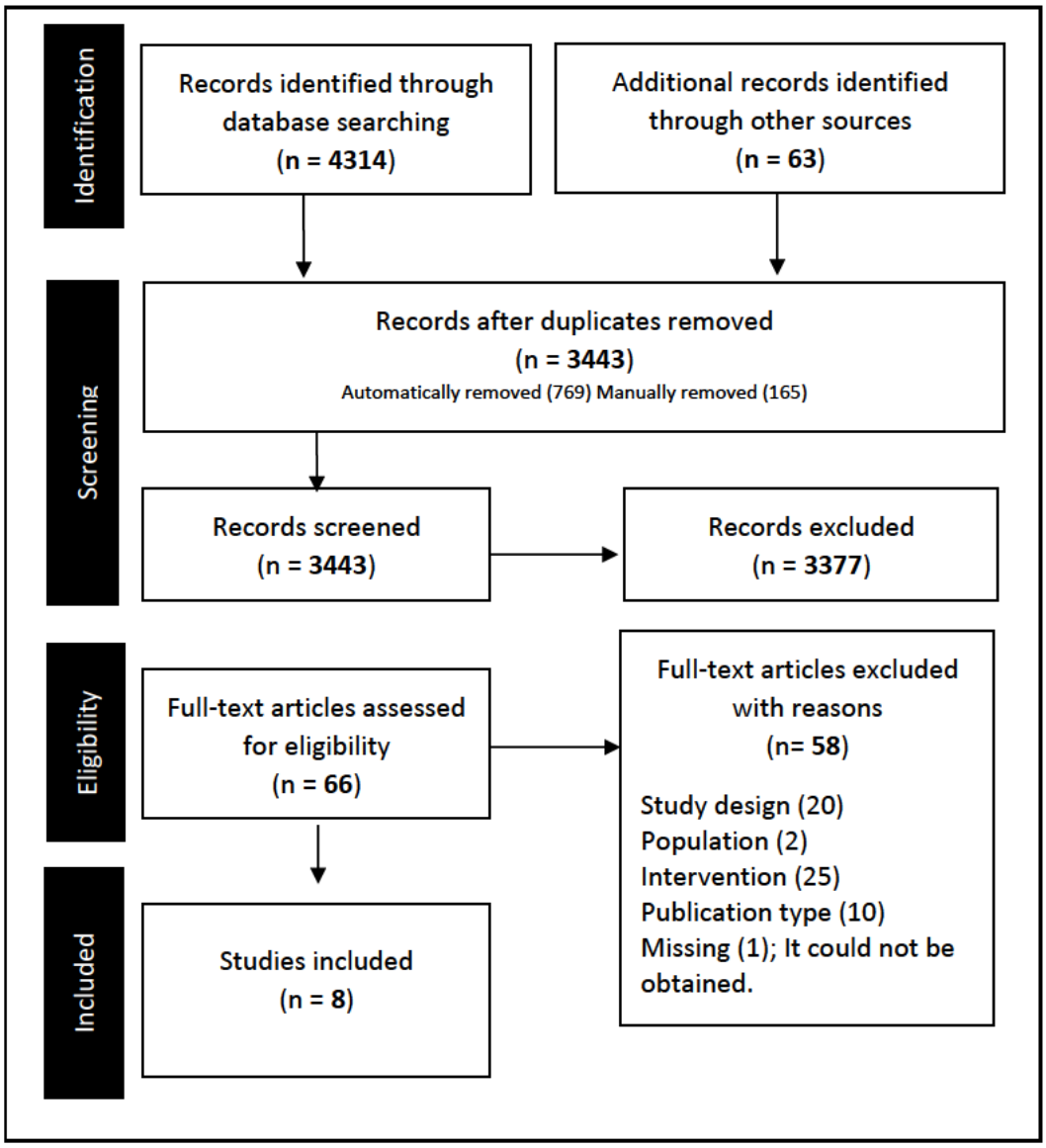
4. Results

5.1. Description of Studies

5.1.1. Search Results

In total, 4,377 records were identified: 4,314 from searching databases and 63 identified from Google or screening references of included studies. A total of 934 duplicate records were removed; 769 were removed automatically using the RefWorks™ exact method and 165 were removed manually. Based on the screening of 3,439 titles and abstracts, 66 articles were potentially relevant to mobile technology in support of the self-management of type 1 and type 2 diabetes, and these underwent full text screening. Details of the search results is presented on the PRISMA flow chart, as shown in Figure 3.1.

Figure 3.1 PRISMA flow chart. Adapted from The PRISMA Group (2009)



5.1.2. Included Studies

Eight studies met the inclusion criteria(62,169–175). A summary of contextual and methodological information of included studies is exhibited in Table 3.3. One study was based in the USA(173), two in Germany(169,171), two in China(172,174), one in the UK(175), one in New Zealand(62) and one from multiple nations(170).

Study design

The study included three qualitative interviews(169,171,175), three surveys(62,173,174) and two mixed-methods of interviews and surveys(170,172). Full details are shown in Table 3.3

Table 3.3: Contextual and methodological information of included studies.

Study	Study Date	Data Collection Method	Design	Aims	Country
Adu 2018	2018	Online questionnaire & semi-structured telephone interview	Mixed-Methods	'This study aimed to examine app usage and feature preferences among people with DM, and explore their recommendations for future inclusions to foster engagement with diabetes apps.'	International
Kelly 2018	2018	In-depth interviews	Qualitative	'The purpose of this study was to understand the impact of using Web-based and mobile technologies to support the management of type 2 diabetes.'	UK
Yan 2018	2018	Surveys	Surveys	'This study examined factors that affected patients' acceptance of a computer-based, chronic disease self-monitoring system over a 4-week period.'	China
Zhang 2018	2018	Quantitative surveys and qualitative interviews	Mixed-Methods	'The aims of this study were to explore the perspectives and needs of T1DM patients and diabetes experts concerning a diabetes app and to design a new T1DM management mobile app.'	China
Karduck 2018	2018	Surveys	Surveys	'To determine what factors may be associated with app use by clinicians working in diabetes and weight management patient care settings.'	USA
Boyle 2017	2017	Survey	Surveys	'The study aimed to establish (1) whether people with DM in Wellington, New Zealand, use apps for DM self-management and evaluate desirable features of apps and (2) whether health professionals (HPs) in New Zealand treating people with DM recommend apps to patients, the features HPs	New Zealand

				regard as important, and their confidence with recommending apps.'	
Rossmann 2019	2016	Semi-structured Interviews	Qualitative	'This study investigated the question "How people with T1 & T2 integrate mobile technology into their everyday self-management"'	Singapore & Germany
Scheibe 2015	2015	Guided interviews	Qualitative	'This study investigated the question "Which factors influence the acceptance of diabetes apps among patients aged 50 or older?"'	Germany

5.1.3. The Intervention

Most of the studies evaluated mobile applications(62,169–174) while only one study used both mobile and web applications(175). Four studies were on both type 1 and type 2 diabetes(62,169–171), one was on type 1(172) and two were on type 2(174,175). Most studies focussed on mobile applications in general, but two studies used a specific mobile application(171,174). See Tables 3.4 and 3.5.

Table 3.4: Details of the interventions, targeted group and app design.

Study	Intervention	Diabetes Type	App Design Purpose
Adu 2018	Mobile Application	T1 & T2	No specific App*
Kelly 2018	Mobile & Web Application	T2	No specific App*
Yan 2018	Mobile Application	T2	Blood Glucose Monitoring
Zhang 2018	Mobile Application	T1	No specific App*
Karduck 2018	Mobile Application	NA	No specific App*
Boyle 2017	Mobile Application	T1 & T2	No specific App*
Rossmann 2019	Mobile Application	T1 & T2	No specific App*
Scheibe 2015	Mobile Application	T1 & T2	No information

* No specific App for the research any App used by the patient

Table 3.5: Intervention's Features classified based on AADE 7 Self-Care Behaviours® for Managing Diabetes Effectively

	Healthy Eating	Being Active	Monitoring	Taking Medication	Problem Solving	Reducing Risks	Healthy Coping
Adu 2018	NA	NA	NA	NA	NA	NA	NA
Kelly 2018	NA	NA	NA	NA	NA	NA	NA
Yan 2018	☑	☑	☑	☒	☒	☒	☒
Zhang 2018	NA	NA	NA	NA	NA	NA	NA
Karduck 2018	NA	NA	NA	NA	NA	NA	NA

Boyle 2017	NA	NA	NA	NA	NA	NA	NA
Rossmann 2019	NA	NA	NA	NA	NA	NA	NA
Scheibe 2015	NI	NI	NI	NI	NI	NI	NI

NA: Not applicable **NI:** No information

5.2. Quality Assessment

Using the Critical Appraisal Skills Programme (CASP), most studies show high quality. Most of the issues were around relationship between researcher and participants as this was not described adequately in the studies. Full details are shown in Table 3.6.

Table 3.6: Quality assessment of included studies using the Critical Appraisal Skills Programme(107)

Study	Section A: Are the results valid?						Section B: What are the results?		
	Was there a clear statement of the aims of the research?	Is a qualitative methodology appropriate?	Was the research design appropriate to address the aims of the research?	Was the recruitment strategy appropriate to the aims of the research?	Was the data collected in a way that addressed the research issue?	Has the relationship between researcher and participants been adequately considered?	Have ethical issues been taken into consideration?	Was the data analysis sufficiently rigorous?	Is there a clear statement of findings?
Adu 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kelly 2018	Yes	Yes	Yes	Yes	Yes	Can't Tell	Yes	Yes	Yes
Yan 2018	Yes	No	Yes	Yes	Yes	Can't Tell	Yes	Yes	Yes
Zhang 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Karduck 2018	Yes	Yes	Can't Tell	Yes	Yes	Yes	No	Yes	Yes
Boyle 2017	Yes	Yes	Yes	Yes	Yes	Can't Tell	No	Yes	Yes
Rossmann 2019	Yes	Yes	Yes	Yes	Yes	Can't Tell	No	Yes	Yes
Scheibe 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

5.3. Synthesis Findings

Five studies were on patient population(169–171,174,175), one study focussed on HCPs(173) and two studies were related to both patients and HCPs(62,172). Data analysis results in four themes: (1) Factors affecting patient's acceptance and use of mobile apps (Barriers and Facilitators)(62,169–172,174), (2) Factors affecting HCP acceptance, use and recommendation of mobile apps(169,172,173), (3) Patients' experience and attitude on mobile apps(62,170–172,175) , (4) HCP's experience and attitude on mobile apps(62,172,173).

5.3.1. Theme 1: Factors affecting patients' use of mobile applications

Most studies reported barriers or acceptance but no studies reported facilitators as factors affecting patients' use of mobile applications. Only one study reported obstacles during app use. One study reported barriers for elderly people – see Table 3.7

The analysis of this theme resulted in two sub-themes: A.1 Barriers to using mobile applications and A.2 Patients' acceptance.

A.1 Barriers to using mobile applications: The studies reported different barriers within this theme(62,169–172). However, all studies' participants show three barriers; cost, lack of awareness, and app's reliability. These barriers are repeated in most studies on this theme. Other barriers identified in some studies include; limited time, lack of internet, lack of smartphone, App use difficulty, no advice from HCP, and previous bad experiences. Apps' use difficulty was explored in detail in the study of the age over 50 population(171). This population also shows a unique reason for not using the apps, which is not seen in other studies; privacy.

A.2 Patients' acceptance: Only one study on this theme(174). This study shows that two factors affect user acceptance of mobile apps; perceived usefulness and perceived ease of use. Additionally, the acceptance is not stable and changes over time.

Table 3.7 Summary of factors affecting patients' use of mobile apps

Study	Summary of Key Findings
Adu 2018	**BARRIERS: Reasons for not using mobile applications:** Lack of awareness No interest No smartphone Cost No internet
Yan 2018	**Acceptance:** Patients' acceptance of health information technology affected by perceived usefulness and perceived ease of use. The acceptance changing overtime.
Zhang 2018	**BARRIERS: Reasons for not using or stopping the use of mobile applications:** Limited time Not easy to use Uselessness Cost
Boyle 2017	**BARRIERS: Reasons for not using or stopping the use of mobile applications:** Lack of knowledge about app availability Feel more confident without apps Not happy with a previous app experience.
Rossmann 2019	**BARRIERS: Reasons for not using or stopping the use of mobile applications:** Have not received advice from HCPs Do not trust the application Financial issues Required time No knowledge about mobile app Mobile apps not reliable
Scheibe 2015	**BARRIERS: Reasons for not using or stopping the use of the mobile applications:** Main barriers for not using apps for elderly people (over 50s): Lack of additional benefits Training and the handling too complicated Financial cost-to-benefit Concerns about privacy **BARRIERS: Obstacles during app use** Navigating the app Adapting a new device or system or apps Touchscreen, keyboard layouts and entering data Font size and colour Difficult and time-consuming to learn a new technology

5.3.2. Theme 2: Factors affecting Healthcare Professionals' use and recommendation of mobile apps

Most studies reported barriers for recommending or using mobile applications. Only one study reported facilitators. Also, only one study discussed factors affecting recommendation decisions (see Table 3.8). The sub-theme identified for this theme is B.1 Barriers to using mobile applications, B.2 Recommendation decision factors, and B.3 Facilitators factors for using mobile apps.

B.1 Barriers to using mobile applications: This sub-theme was previously identified for patients; Theme A.1. HCPs show some similarity with patients regarding barriers to using mobile applications; time limitation, App use difficulty and lack of awareness. However, HCP show other barriers to recommending apps; apps have no effects, the effect is not evidence-based, or the government does not support apps. Generally, every study has different barriers as they have different countries, but they share time limitations as a barrier – full details in table 3.8-.

B.2 Recommendation decision factors: Only one study on this sub-theme (173). In this study, there are three reasons for controlling decision-making; access to a smartphone, patient history of using apps and patient's literacy.

B.3 Facilitators factors for using mobile apps: This sub-theme is only identified in HCPs studies. Surprisingly, HCP considers apps' low cost as one of the apps using facilitators when patients consider the cost as one of the barriers across studies.

Table 3.8 Summary of factors affecting HCP use and the recommendation of mobile apps

Study	Summary of Key Findings
Zhang 2018	**Barriers: Reasons for not using or recommending mobile applications** Apps have no effect on blood sugar No information about diabetes apps Effectiveness is not evidence-based No time to recommend Don't know which one is suitable
Karduck 2018	**Facilitators: Reasons for recommending mobile applications** Help patients in tracking diet and physical activity Apps were portable Apps offer immediate feedback Help patients in food choices and carbohydrate counting Low cost **Barriers: Reasons for not using or recommending mobile applications** Not user-friendly Lacking accuracy or access Not universal to all clients Time-consuming to use Missing desired features **The decision to recommend apps is based on:** Access to a smartphone Patient history of using apps successfully Patient's overall literacy and health literacy
Rossmann 2019	**Barriers: Reasons for not using or recommending mobile applications** The app is not supported by the government

5.3.3. Theme 3: Patients' experience and attitude on mobile apps

Several studies reported experience and the preferred specifications of mobile apps. Only one study reported recommendations to support long-term use (see Table 3.9). The analysis of this theme resulted in three sub-themes; C.1 Patients' Experience, C.2 Preferred diabetes app features, and C.3 Recommendation to support long-term use.

C.1 Patients' Experience: The general image from these studies is that most patients are limited users even though they have a positive attitude towards diabetes mobile applications – more details in table 3.9-**.** In several studies, patients reported not knowing about diabetes mobile applications. This aligns with the reported lack of awareness as a barrier in themes A1

and B1 mentioned previously. In the population over age 50, patients have a bad experience with diabetes mobile applications (171) . This experience is supported by other studies that mentioned it as a barrier(62).

C.2 Preferred diabetes app features: Most studies explored patients' needs from diabetes mobile applications. These studies showed a range of features that patients preferred in diabetes mobile applications. Moreover, glucose trackers, personalised education, personalised advice, and reminders are the most common among the studies.

C.3 Recommendation to support long-term use: one study fits on this theme(170). Patients believe that certain features will keep them long-term users. Most of these factors are around what makes them feel that application was made for them, such as personalised advice and customisable features. Reliable information and ease of use are also factors in long-term use.

Table 3.9 Summary of patients' experience and attitude on mobile apps use

Study	Summary of Key Finding
Adu 2018	**Experience:** About half of the participant used diabetes mobile apps **Preferred specifications of the mobile apps are (not all are available):** Blood glucose tracker Blood pressure tracker Body weight tracker Food calorie counter Exercise tracker Reminder Data export to health care provider Self-management education Personalised advice/education Social networking Visual analytics **Recommendations to help long-term use of mobile apps:** Interactive specification of mobile apps to include personalised advice. Reliable information sources Consolidated and customised features Ease of use
Kelly 2018	**Experience:**

	The technology used to maximise patient convenience and minimise the disruption to everyday life. Also, the technology used daily routine and help with communication with HCPs. Electronic tools are rarely provided with healthcare services
Zhang 2018	**Experience:** Most of the participants did not know about diabetes mobile app Significantly limit participant used diabetes mobile app Participant influence to use the app is HCPs or selected randomly Patients preferred mobile app compared to a traditional paper diary. Patients did not consult HCPs via the mobile app as they did not trust new doctors **Preferred specifications of the mobile apps are (not all are available):** Consulting HCPs Diabetes diary Diabetes education Insulin calculator Abnormal blood sugar alert Peer support Reminders Diabetes education Social and support with other diabetic patients Access to medical records
Boyle 2017	**Experience:** Most of the participants have use mobile applications in general, but less than a quarter of them using diabetes mobile apps Not all app users adapt the application for daily use **Preferred specifications of the mobile apps are (not all are available):** Blood glucose tracker Meals and carbohydrate tracker Reminder Insulin dose calculator Education (blood glucose level guidelines) Calendar Personalised advice (dietary) User details and condition information Contact details of patient's healthcare team
Rossmann 2019	**Experience:** Some participants do not know about diabetes app Some participants are short-term users, and some are long-term Participants used serval mobile apps Participants reported that their HCPs never recommend diabetes app **Preferred specifications of the mobile apps are (not all are available):** Blood glucose tracker (automated) Sharing with HCPs
Scheibe 2015	**Experience (Over 50s):** One-third of participant classify themselves as interest in technology A quarter of participant have a smartphone Half of the participant new about diabetes mobile applications

	Very few used diabetes mobile applications Half of the participants have a positive attitude towards mobile apps. However, half of the participants believed no one of the tested apps offers any benefits **Preferred specifications of the mobile apps are (not all are available):** Blood glucose tracker reminder (medication and glucose tracking) Education (diabetes reference books)

5.3.4. Theme 4: HCP's experience and attitude on mobile apps

All three studies reported 'Experience'. Only two reported 'Preferred specifications' and one reported 'Barriers of using mobile applications' (see Table 3.10). The analysis of this theme resulted in two sub-themes; D.1 HCPs' Experience, D.2 Preferred diabetes app features. These themes are almost close to sub-themes seen in the previous theme regarding patients.

D.1 HCPs' Experience: Generally, HCP have a positive experience and attitude toward mobile applications. However, they believe that application is are incomplete, unsystematic, and patients receive little support. One study reported that HCPs are not confident in recommending any application. They are confident in recommending some types of applications; diary. They are less confident recommending complicated features such as insulin calculators – more details are in Table 3.10.

D.2 Preferred diabetes app features: HCPs believe some features are essential for diabetes mobile applications. Across studies, education and diaries are preferred features. The educational feature was also a preferred feature by the patient, as seen previously– see theme C.2-.

Table 3.10 Summary of HCPs' experience and attitude on mobile apps use

Study	Summary of Key Findings
Zhang 2018	**Experience:** HCPs' prospects for mobile apps was good or very good Patients did not use an app for long-term Patients received little support Diabetes education unsystematic Apps' functions incomplete **HCPs' preferred specifications of the mobile apps** Communication with the patient Diabetes diary Education Abnormal blood sugar alert
Karduck 2018	**Experience** More than half of HCPs assessed patient exercise and diet via their smartphones Most HCPs believe the mobile app is effective in assessing some aspects (dietary, physical activity, glucose tracking) **Barriers:** Smartphone accessibility Illiteracy Unreliability or inaccuracy of apps Time needed
Boyle 2017	**Experience:** HCPs were confidence to recommend diaries only. Less confident to recommend insulin calculator **HCPs' preferred specifications of the mobile apps:** Diabetes diary Reminders Education (information and guidelines) Insulin calculator

5. Discussion

5.1. Summary of Main Results

The study aimed to explore patients' and HCPs' perspectives of mobile and web applications to support the self-management of type 1 and type 2 diabetes. The search resulted in 4377 records; however, 66 articles underwent full-text screening, and only 8 study included. The

search strategy used to balance sensitivity and specificity returned a very high number of records which was discussed in the previous chapter. Moreover, this approach increases confidence in achieving the study's aims by not missing relevant studies.

As done in the previous study, this study identified the nature of the intervention used in the included studies. Most studies explored diabetes mobile applications in general. No specific application was used except in one study where the application was for glucose monitoring(174). Thus, the results show a general overview of the perspectives of diabetes mobile applications.

Four themes resulted from the data synthesis: (A) factors affecting patients' acceptance and use of mobile apps; (B) factors affecting HCPs' acceptance, use and recommendation of mobile apps; (C) patients' experience and attitudes towards mobile apps; and (D) HCPs' experience and attitudes towards mobile apps. Additionally, ten sub-themes were also identified.

(A) FACTORS AFFECTING PATIENTS' ACCEPTANCE AND USE OF MOBILE APPS

The first emerging image is that most studies fit within the barrier sub-theme, and no study investigated facilitators, which may suggest that participants have barriers and not adapted to diabetes mobile applications. The most interesting barrier was the lack of awareness of the diabetes mobile application. This is in line with chapter one finding when there was a limited number of studies investigating the effectiveness of mobile applications, which led to a question: are there any applications available for diabetes self-management? Alternatively, the lack of awareness is also among researchers. Most patients' barriers mentioned across studies; are cost, lack of awareness, and app's reliability which is easy to address. Some studies reported; limited time, lack of internet, lack of smartphone, App use

difficulty, no advice from HCP, and previous bad experiences, which also could be addressable. The other identified sub-theme was patients' acceptance; where one study only fit in this theme. This study shows that acceptance changes over time but does not explain why.

(B) FACTORS AFFECTING HCPS' ACCEPTANCE, USE AND RECOMMENDATION OF MOBILE APPS:

HCPs are similar to patients regarding barriers to using mobile applications; time limitation, app use difficulty and lack of awareness. Thus, these data suggest that both patients and HCPs face the same barriers. Moreover, HCP show other barriers to recommending apps; apps have no effects, the effect is not evidence-based, or the government does not support apps. The previous systematic review would provide HCP with the evidence they need. The next chapter, Chapter 4, could address the lack of awareness.

(C) PATIENTS' EXPERIENCE AND ATTITUDES TOWARDS MOBILE APPS:

Most patients require a tool that supports them in managing their diabetes to make their lives more comfortable. In most studies, the same features are repeated. Results showed a range of features that patients preferred in diabetes mobile applications. Moreover, glucose trackers, personalised education, personalised advice, and reminders are the most common in the studies. However, the features need to be explored in detail and designed in a way that helps that patient and does not become an extra burden to the patient. For example, reminders could be as simple as setting a time and alarm. However, the apps

could be smarter by knowing the patient and offering reminders based on previous data. They could be more sophisticated and send alerts to a smartwatch or disable the alarm if the patient is asleep. Thus, diabetes mobile application development takes more than one step. It starts after the deployment of the app. During software design and after deployment, the app designers should continue monitoring patients' experiences. Patients may not be able to imagine some features. Thus, these features need experts in software development and diabetes to analyse the patients' needs in the light of their expertise. In relation to the previous example about reminders, no patients mentioned reminders or alerts that could be sent to their partners' mobiles. Moreover, there was no mention of mobile editions designed for the patient's family to provide support, even though some of these applications exist in continuous glucose monitoring (CGM). Most patients lack knowledge about diabetes mobile applications.

(D) HCPS' EXPERIENCE AND ATTITUDES TOWARDS MOBILE APPS:

HCPs share with the patient their lack of knowledge about diabetes mobile applications. However, they have a positive attitude towards the diabetes mobile applications. Across studies HCPs interested in two features; education and diaries. They may be more interested in tools that educate their patients and track their progress.

As mentioned in the introduction, no systematic review has qualitatively explored the patients' and HCPs' perspectives on mobile applications on diabetes self-management, so comparing our findings to others is not feasible. Qualitative evidence synthesis is a new approach to the synthesis of evidence. However, it may not be the reason behind the lack of qualitative systematic reviews as we saw a limited number of studies in systematic reviews in

general and not only qualitatively as discussed in the previous chapter. To draw a general picture may be beneficial to compare these results with other diseases. One systematic review aiming to explore the acceptability and usefulness of mobile applications for self-management of cardiovascular disease by Coorey(176) has reported app features needed by patients. Some of these features align with this systematic review finding, including education, personalised, and customisable content. Thus, regardless of the type of digital health application, patients may need the same features that make them feel that these applications are designed for them, such as personalised and customisable applications. The need for apps personalisation features is also seen in a study conducted by Giordan(177) regarding of heart failure apps.

IMPLICATION FOR CLINICAL PRACTICE

Evidence is sufficient to advise clinical practitioners, patients or policymakers regarding patients' and HCPs' perspectives on diabetes mobile applications. This evidence may be helpful in advising software developers regards what patients and HCPs need.

IMPLICATION FOR RESEARCH

Future research would benefit from defining diabetes mobile applications. The interview or survey would benefit if guided by models such as AADE 7 self-care behaviour and TAM. The definition of the intervention and the standardisation of it using AADE 7 self-care behaviour would be beneficial in supporting future research and facilitating comparisons. As discussed in the previous chapter, more research needs to be done to explore the availability of mobile applications in app stores and their features because of the lack of awareness

among patients and HCPs. So, this research would provide what they need of information and may their needs already have been addressed by an application.

5.2. Summary of Integrating the Findings from This Synthesis with the Findings of the Previous Chapter

In our previous study, we deduced that there was no conclusive evidence about the effectiveness of mobile and web applications in the self-management of diabetes. We hypothesised several reasons behind this. This finding may add an explanation for why they are not effective, as patients and HCPs face many barriers and issues.

5.3. Quality of the Evidence (Certainty of the Evidence)

We believe we did not introduce a bias to the study as Cochrane methodology has been followed. We have high confidence in the evidence as most of the included studies had a low risk of bias. However, we may downgrade the confidence in the evidence as the number of included studies is low.

5.4. Strength and Limitations

The main strength of this systematic review is that, to the best of our knowledge, it is the first qualitative study exploring patients' and HCPs' perspectives of mobile and web applications to support diabetes self-management. Moreover, it used a research strategy approach to ensure no study was missed. Above all, it used the Cochrane methodology and followed a transparent process that started with publishing the proposal before conducting the

systematic review. However, there is a limitation to this study. It only included studies written in English, which may lead to publication bias and affect the strength of the evidence.

5.5. Authors' Conclusions

In conclusion, patients and HCPs are not users, or limited users, of current diabetes self-management applications. They have many barriers to using these applications and are looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications. Both Patients and HCPs lack knowledge about the existence of diabetes mobile applications. Thus, researchers should investigate diabetes mobile application and their features to provide a comprehensive guide. Several factors are essential in an app's successful adaptation and long-term use; knowledge about available applications, ease of access, features, trust, reliability, privacy and cost are critical for a successful app's initial use, long-term use and effectiveness. Software development should devote effort to building an evidence-based application, taking into consideration different end-users needs.

CHAPTER 4:

Exploring the availability and features of diabetes self-management applications in app stores

ABSTRACT

Introduction: A diabetic patient spends three hours in contact with professional healthcare providers and over 8,000 hours of self-management per year. The use of mobile applications in the self-management of diabetes is promising in helping patients; However, in our previous study shows no conclusive evidence was found for the effectiveness of mobile and web applications on the self-management of diabetes. Moreover, a limited number of studies investigate the effectiveness of mobile applications on diabetes self-management. Therefore, it is unknown whether the inconclusive result was due to the lack of available software or simply that there has been insufficient research carried out on the available applications. Several studies have been conducted to investigate mobile applications in app stores for the management of chronic diseases, such as hypertension, chronic kidney disease and heart failure.(178–182) Also, other studies have been carried out on medication management and adherence.(183) A limited number of studies have been conducted in diabetes. These studies address a limited number of features(184,185) or are related to a specific country(186–188). Thus, there is a need to explore mobile applications for diabetes self-management.

Objective: This study aims to explore the availability and features of mobile applications in the Google Play Store® for the self-management of type 1 and type 2 diabetes in adults in English and Arabic. It also aims to compare these features with AADE7 Self-Care Behaviours®.

Method: A web-based search was performed through the Google Store®. The search was conducted in July and August 2020 to identify applications that are specifically designed for

the self-management of diabetes in English and Arabic for type 1 and type 2 diabetes. Search updated on May 2022. Each application that meets the inclusion criteria was downloaded, and its features explored and compared to recommended AADE7 Self-Care Behaviours®.

Result: There were 402 application results from the search. Of those, 45 apps met the inclusion criteria, and 357 did not and were excluded. Included applications comprise of 43 apps in English and two in Arabic and support a range of self-care behaviours® : 53% Healthy Eating, 42% Being Active, 96% Monitoring, 49% Taking Medication, 11% Problem Solving, 20% Reducing Risks, and 53% Healthy Coping. Only two applications support at least one feature in each domain of the self-care behaviours®.

Conclusion: A limited number of applications are designed specifically for people with diabetes in both languages. The available applications only support some self-management tasks. People with diabetes are required to install different tools to help them self-manage their diabetes, but not all tools are available to perform all of the self-diabetes management tasks. Future development should aim to develop a comprehensive, evidence-based application to support all self-care behaviours. Also, future research should investigate the quality and patients' acceptance of these applications.

1. Introduction

1.1. Background

Diabetes is a serious global issue with around 425 million patients suffering from the disease. Diabetes is considered to be a noncommunicable disease (NCD) and most premature NCD deaths are preventable.(9) Because death and long-term complications from diabetes are preventable, good management and self-management play an essential role in preventing their occurrence. A diabetic patient spends three hours in contact with professional healthcare providers and over 8,000 hours of self-management per year.(29) The amount of time spent by the patient in self-management is not the only issue; sometimes they have no option but to manage themselves, during events such as COVID-19, wars or natural crises. Therefore, diabetes self-management is essential.

The role of diabetes self-management in good diabetes outcomes has been extensively researched. Several studies have found that diabetes self-management lowers haemoglobin HbA_{1c} by 1% in patients with type 2 diabetes.(35–37) The benefits of self-management are not limited to HbA1c; other health benefits include an improvement in the quality of life,(38) increased physical activity(39) and reduced depression(40,41) All of these improvements not only benefit the patient, but also benefit healthcare systems by minimising care costs and hospital admissions.(42)

There has been increased interest in mobile health technology (mHealth) in recent years. Mobile applications are platforms used to deliver mHealth.(43) The use of mobile

applications in helping patients self-manage their diabetes is promising because they can set reminders, record data, contact healthcare providers and provide helpful advice. (44–49)

1.2. *Diabetes Self-Management Applications*

To date, there have been no regulation or registration requirements for mobile apps.(189) Consequently, the literature gives no clear classification for diabetes self-management applications. Through a scoping search, several types of application groups were identified. First, some applications offer support for diabetes self-management, such as exercise, but they are not specifically designed for people with diabetes. Second, some applications are designed specifically to support diabetes self-management; they may, or may not, calibrate with other devices, but there is no obligatory requirement to use them with the application, such as Bluetooth calibration with a glucometer. Third, some applications are designed to support a feature of diabetes self-management, but cannot work without a device such as Dexcom G6®, a continuous glucose monitoring system, which requires sensors and a transmittersee Table 4.1. Thus, there is a need to define self-management applications.

Table 4.1: App classification based on their end-user group and app features.

	Group 1	Group 2	Group 3
App Features	Apps support some diabetes self-management daily tasks	Apps designed to support some diabetes self-management daily tasks	Apps designed to support some diabetes self-management daily tasks
Requirements	No requirements	Works with or without an external device (an external device is optional)	Works only with an external device (an external device is obligatory)
Target Group	For any end-user	**People with diabetes**	**People with diabetes**

Examples	Fitbit®	One Drop®	Dexcom G6® Or Freestyle libre

For the purpose of this study, and based on the FDA definition of 'health mobile app',(25) a diabetes self-management application is defined as *'Any application that can be executed on a mobile platform by direct installation, which is used by a patient to provide any diabetes self-management feature that supports people with diabetes, and can be used with or without an external device. However, an external device is not obligatory for using the application'*.

1.3. What is Already Known and the Gap in the Knowledge

During the first stage of this project, a systematic review was conducted, through which the nature and effectiveness of mobile and web tools to support self-management of type 1 and type 2 diabetes were explored. No conclusive evidence was found for the effectiveness of mobile and web applications on the self-management of diabetes. Moreover, a limited number of studies investigate the effectiveness of mobile applications on diabetes self-management. This has led to several questions: Are they not effective or is the number of studies insufficient? Does the limited number of applications result in limiting the number of studies or is there no application available to be studied? Have the applications been designed in such a way that they are not effective in accomplishing their goal? Surprisingly, a very limited number of applications were investigated in the included studies. Some applications were designed specifically for research purposes and were not available on app stores. Therefore, it is unknown

whether the inconclusive result was due to the lack of available software or simply that there has been insufficient research carried out on the available applications.

Several studies have been conducted to investigate mobile applications in app stores for the management of chronic diseases, such as hypertension, chronic kidney disease and heart failure.(178–182) Also, other studies have been carried out on medication management and adherence.(183) A limited number of studies have been conducted in the field of diabetes. These studies address a limited number of features(184,185) or are related to a specific country(186–188). There are many reason to explore mobile applications for diabetes self-management. First, the fast growth of application development makes it crucial to have an up-to-date overview of mobile applications for diabetes self-management and their features. Second, the analysis of their availability and features based on AADE 7 Self-Care Behaviours® provides a useful overview for patients and healthcare providers. This need is supported by a study performed by Rossmann (2019)(169) and Zhang (2018)(172), who found that most patients and healthcare professionals lack knowledge of what is already available for the self-management of diabetes. Third, it is necessary to highlight the missing features needed to inform future development; the phase one systematic review revealed that most applications investigated had a lack of basic features, such as solving problems with diabetes issues and, surprisingly, taking medication. It is important to investigate these features in a wider range of applications. Finally, the dearth of research on mobile applications for diabetes self-management in English is similar to the research shortage in Arabic; no studies have explored Arabic mobile apps designed for diabetes self-management.

2. Aim and Objectives

This study aims to explore the availability and features of diabetes self-management mobile applications in the Google Play Store® (Android™) for adults with type 1 and type 2 diabetes.

Objectives

(1) To explore and summarise available diabetes self-management mobile applications

(2) To explore diabetes self-management mobile application features and classify these features based on AADE 7 Self-Care Behaviours®

(3) To shed light on the specifics of these applications (such as missing common features and technical features)

(4) To provide an up-to-date overview for healthcare professionals and a summary for patients

(5) To compare the availability of applications in English and Arabic

(6) To inform the next phase of this study's survey.

3. Method

3.1. Planning & Conduct

To enhance quality and follow good academic practice, a protocol was written and agreed with the supervisors prior to conducting this study. Data collection forms were ready before actual data collection, and several meetings were set to discuss the results with the supervisory team during the data collection. These results were

discussed over three meetings and were published as abstracts and as a poster at a conference.

3.2. Search Strategy and Data Collection

The searching of app stores has been a growing trend in recent years.(184,187,188,190–197) A web-based search was performed between July and August 2020, which was update in May 2022 using same mobile phone. The Google Play Store® (Android™) was searched for applications, in English and Arabic, which are designed specifically to self-manage diabetes and meet the definition mentioned above. Due to research budget and time, only the google play store was used. However, Google app is the largest app store, with more than 3.55 million Android apps in 2022 compared to 1.6 million apps in the Apple store(198,199). Thus, it is expected to miss a few applications released only in the Apple store, and Google Play will be enough to achieve the study's aim. Each application that met the inclusion criteria (see Table 4.3) was downloaded, and its features were explored. Investigations continued until no new applications appeared in the search results. The AADE 7 Self-Care Behaviours® for managing diabetes effectively by the Association of Diabetes Care and Education Specialists (ADCES) was followed to record the features of each application under the appropriate category (see Table 4.2). The details of self-management mobile app features and their classification, which had been published elsewhere,(200) were followed. Any features that did not fit with AADE7 Self-Care Behaviours® categories were classified under 'other'. The scoping search helped with the designing of data collection forms.

Table 4.2: Aspects of self-care as recommended by AADE7 Self-Care Behaviours®

AADE7 Self-Care Behaviours® for managing diabetes effectively
Healthy eating
Being active
Monitoring
Taking medication
Problem solving
Reducing risks
Healthy coping

Keywords

The following keywords were used: diabetes, diabetes mellitus type 1, diabetes mellitus type 2, diabetes management. As well as the keywords, Google Play Store suggestions of downloaded applications were also relied upon.

Technical considerations

Google Play Store® works by region. Thus, the search result is based on the region in which a user is based. For example, searching app stores in the UK for Dexcom G6 will results in the mmole/dl version. However, searching the store from the USA will result in a completely different version of the app, which works differently using mg/dl. Moreover, searching the store for the same thing but from different countries would lead to no results. Based on this, we performed a UK-based search for English versions of mobile applications and a Saudi Arabia-based search for Arabic versions. We achieved this by using a virtual private network (VPN) application and by changing the mobile regional settings.

3.3. *Inclusion and Exclusion Criteria*

Based on the previously mentioned definition of diabetes self-management mobile applications, we included only applications that were designed specifically to self-manage diabetes (see Table 4.3).

Table 4.3: Application inclusion criteria

Criteria	Included
End-user population	Adults with type 1 or type 2 diabetes
Purpose of application	Self-manage diabetes (not educational)
Language	English & Arabic
Number of downloads	Not fewer than 10,000 times
Version	Should be a stable, final version, (not on beta or testing)

Due to budget limitations, applications were not purchased. Trial, demo, or free versions were relied upon. However, this was not an issue as all include applications was available as free or trial.

Excluded applications

To make this study comparable, consistent, and of high quality, we excluded some types of applications regardless of whether they offered features that supported diabetes self-management. Thus, several reasons for exclusion were followed based on end-user population, purpose of application, language, the number of downloads, version and special requirements (see Table 4.4).

Based on the end-user population, applications designed for children were excluded; this is because children may not be able to use the application appropriately, or the application may be used by their guardians. Also, applications designed for pregnant

women with diabetes would only be using the app for a short period, so this population was not considered for long-term self-management. In addition, this project is intended for adults with type one and type two diabetes only.

Every effort was taken to make applications comparable. Thus, the purpose of the application was a crucial factor. Any application that was not specifically designed for the self-management of diabetes was excluded. Educational applications were also excluded; even though they were related to self-management, if the application was solely for education, it no longer matched our previous definition. Moreover, these applications could be considered as interactive e-books and not mobile applications.

Beta versions of applications were considered for testing purposes only; because these versions were unstable, they were excluded from the search. Some applications failed to indicate whether they were the beta version, so we used the number of downloads as an indicator to ensure app reliability. The number of downloads is a good indicator for this purpose. Any applications with fewer than 10,000 downloads were excluded.

Dexcom & FreeStyle Libre systems

Applications that could not be used without a specific gadget from a company were also excluded. For example, Dexcom G6 from Dexcom® and FreeStyle Libre from Abbotts®, which need a transmitter and sensor connected to the patient and the mobile application simultaneously; testing these types of software requires patient recruitment, which is outside of the scope of this study. Based on AADE 7 self-care domains, these systems support monitoring domain. Moreover, these types of

applications are part of a system that offer continuous glucose monitoring (CGM), so they require a special study to compare their specific features around CGM, which is not comparable with other self-management software (see Figure 4.1). Additionally, the mobile application is for reading glucose readings and could be replaced by a specialised reader, where is no need for a mobile phone. The estimated monthly cost of a system is around £140-200, in the UK.

Figure 4.1: The Dexcom G6 application does not work without a gadget and patient involvement.(201)

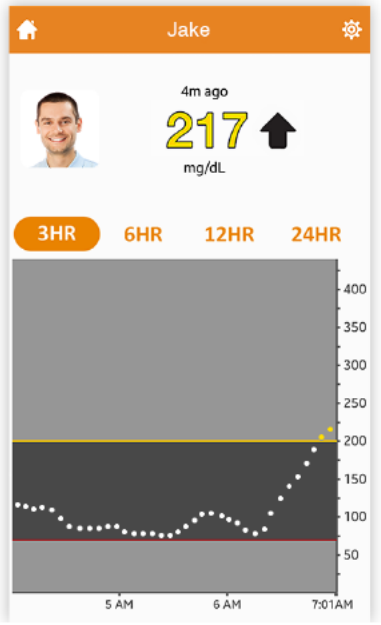


Table 4.4: Application exclusion criteria

Criteria	Excluded
Application user population	Children or pregnant women
Purpose of application	If the focus is exclusively on educational or social communication
Language	Any language other than English and Arabic
Number of downloads	Fewer than 10,000 times

Version	Beta versions
Special requirements	Applications that cannot be used without a gadget from a company
Update	Applications that have not been updated within the last 12 months

3.4. Data Synthesis

Based on the nature of the study, data were extracted and summarised in tables. Basic descriptive statistics were used to show the frequency and percentage of application features. Applications were analysed from both medical capabilities and technical specifications. The AADE 7 Self-Care Behaviours® were used to categorise the applications' features.

3.5. Software (Tools and Equipment)

A variety of software was utilised. Mendeley™ was used for document management based on the Windows 10® system. Microsoft Word® 2016 was used for data collection and writing. Using Sony® mobile, apps were downloaded and tested on Android® version 9 through the Google Play® Store.

3.6. Ethics

This study did not deal with any humans, nor did it access any human data. It used only information that was freely available in the public domain. Thus, there was no necessity to obtain ethical approval. This was confirmed by contacting the ethical committee administration at the University of Birmingham and filling out a self-assessment form (SAF).

4. Results

4.1. *Included Applications and Self-Care Behaviour*

In total, 402 applications resulted from the search. Of those, 322 were excluded after screening and only 80 applications were downloaded. In addition, 45 apps met the inclusion criteria, but 357 did not and were excluded – See appendix 4.3-. Of the included applications, 43 apps were in English and two were in Arabic; they supported a range of self-care behaviours: 53% Healthy Eating, 42% Being Active, 96% Monitoring, 56% Taking Medication, 13% Problem Solving, 20% Reducing Risks, and 16% Healthy Coping (see Figures 4.2 and 4.3). Only two applications support at least one feature in each self-care domain of the self-care behaviours (see Table 4.5).

Figure 4.2: Number of apps in each self-management area.

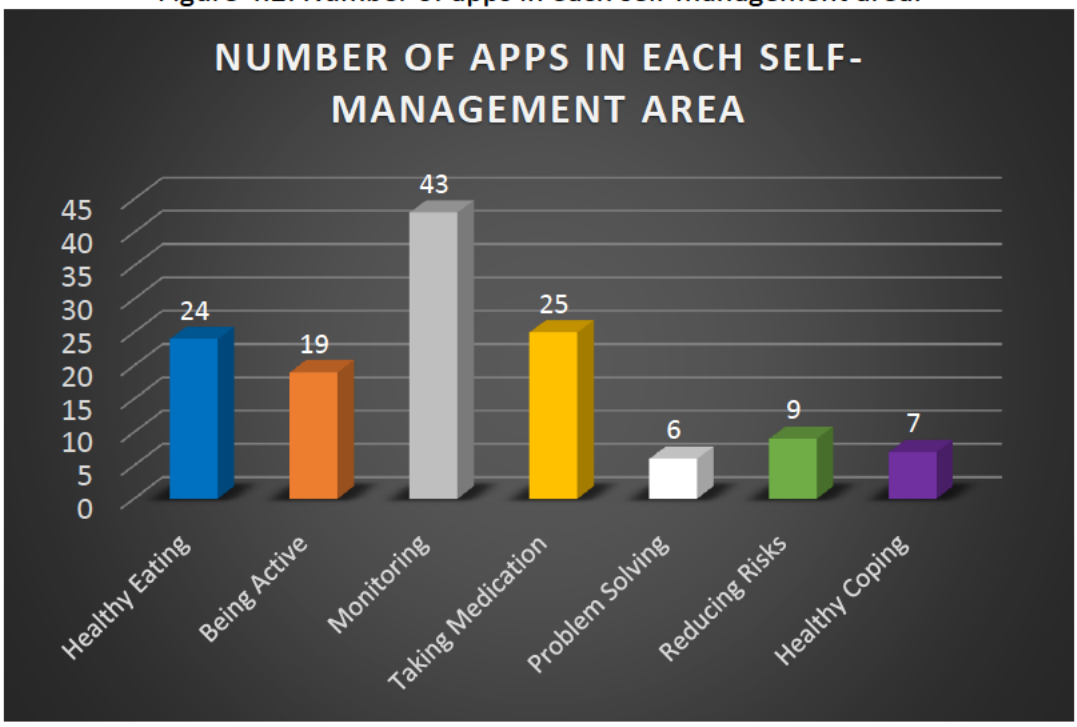


Figure 4.3: Percentage of apps in each self-management area.

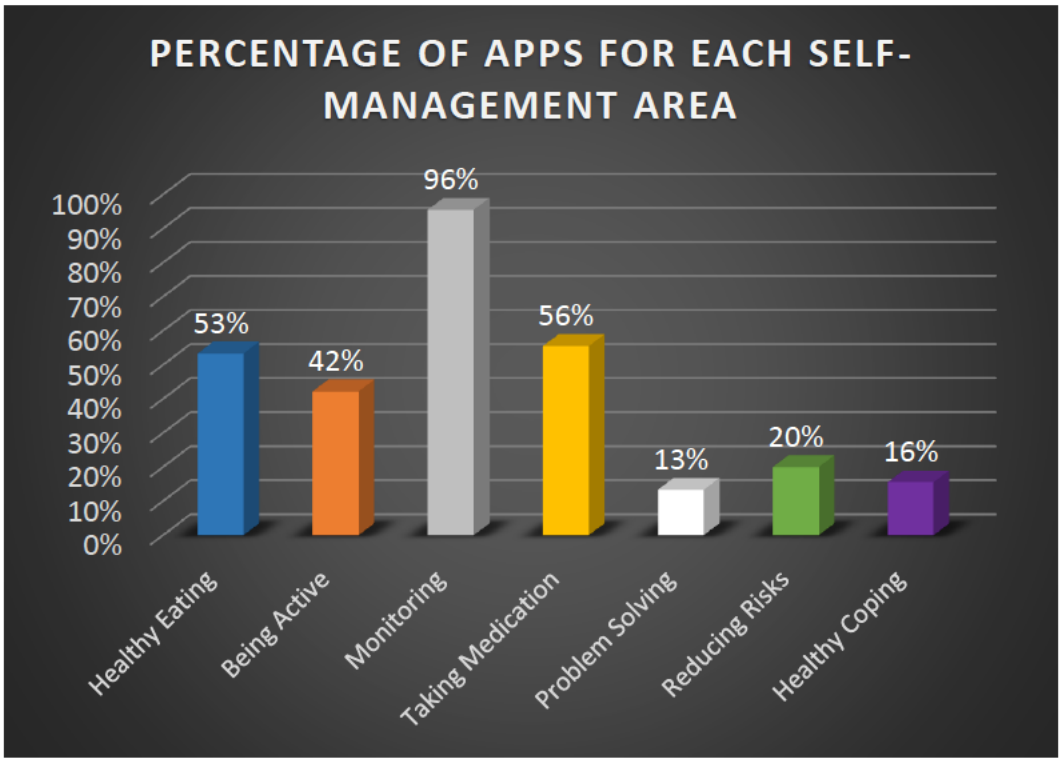

PERCENTAGE OF APPS FOR EACH SELF-MANAGEMENT AREA
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
53%
42%
96%
56%
13%
20%
16%
Healthy Eating
Being Active
Monitoring
Taking Medication
Problem Solving
Reducing Risks
Healthy Coping

Table 4.5: Application features of included applications classified based on AADE 7 Self-Care Behaviours®.

	App Name	Application Features							
		Healthy Eating	Being Active	Monitoring	Taking Medication	Problem Solving	Reducing Risks	Healthy Coping	Other
1.	A1C Blood Sugar Calculator Tracker Diabetes app	RAU: Log food	×	Log glucose Estimated HbA1c	×	×	×	×	×
2.	Apollo Sugar	Log food	Log exercise	Log glucose Reminders	Set reminders	×	Coaching	×	×
3.	BeatO SMART Diabetes Management	×	×	Log glucose Estimated HbA1c AAU: Log Blood AAU: Log weight	×	Recommendation based on Glucose	coaching	Social: Rewards Program	e-store
4.	Blood Glucose Monitor | Sugar Test Converter	×	×	Log glucose Unit Converter	×	×	×	×	×
5.	Blood Glucose Tracker - Monitor, Levels & Test	×	×	Log glucose	×	×	×	×	×
6.	Blood Sugar Checker / Blood Glucose Tracker	×	×	Log glucose	×	×	×	×	×
7.	Blood Sugar Checker Diary : Track Glucose History	×	×	Log glucose Log Blood Pressure	×	×	×	×	×
8.	Blood Sugar Diary - Health Tracker	×	×	Log glucose	AAU: Log medications	×	×	×	×
9.	Blood sugar diary App - Insulin	×	×	Log glucose Unit Converter	×	×	×	×	×
10.	Blood Sugar Log – Diabetes Tracker	×	×	Log glucose Log HbA1c Log Blood Pressure	Log medications	×	×	×	AAU: Weight
11.	Blood Sugar Test By Finger Info	×	×	Log glucose	×	×	×	×	×
12.	Blood Sugar Test Tracker and Info	×	×	Log glucose Unit Converter	×	×	×	×	×

13.	Blood Sugar Tracker: Glucose Diary Average Records	×	×	Log glucose	×	×	×	×	×
14.	Carb Calc	Carb calculator	×	×	×	×	×	×	×
15.	Diabetes	Log food	×	Log glucose Reminder	RAU: insulin calculator	×	×	×	×
16.	Diabetes	×	×	Log glucose	×	×	×	×	×
17.	Diabetes Connect	Log food	Log exercise	Log glucose Log Blood Pressure AAU: Reminder	Log medications Log insulin	×	×	×	×
18.	Diabetes Diary	Log food	Log exercise time	Log glucose Log weight	Log medications Log insulin	×	×	×	×
19.	Diabetes Diary - Blood Glucose Tracker	×	×	Log glucose Log HbA1c Log Blood Pressure Log weight AAU: Reminder	Log medications	×	×	×	×
20.	Diabetes Logbook - Blood Glucose Tracker	Log food	Log exercise	Log glucose Log HbA1c Reminder Log Blood Pressure Log weight	Log medications Reminder	×	×	×	×
21.	Diabetes Tracker Free	×	×	Log glucose Reminder	×	×	×	×	×
22.	Diabetes:M - Management & Blood Sugar Tracker App	Log food	Log exercise time	Log glucose Log HbA1c Reminder Log Blood Pressure Log weight Lab results	Log medications Reminder	×	×	×	×
23.	Diabetic Calculator	×	×	×	Insulin Calculator	×	×	×	×
24.	DIABNEXT Make your diabetes management easy	Log food	Log exercise time	Log glucose Log weight	Log insulin	×	×	Social: in app Patient Group	×
25.	Diacomp (diabetes diary)	Log food	×	Log glucose Notes	Log insulin	×	×	×	×

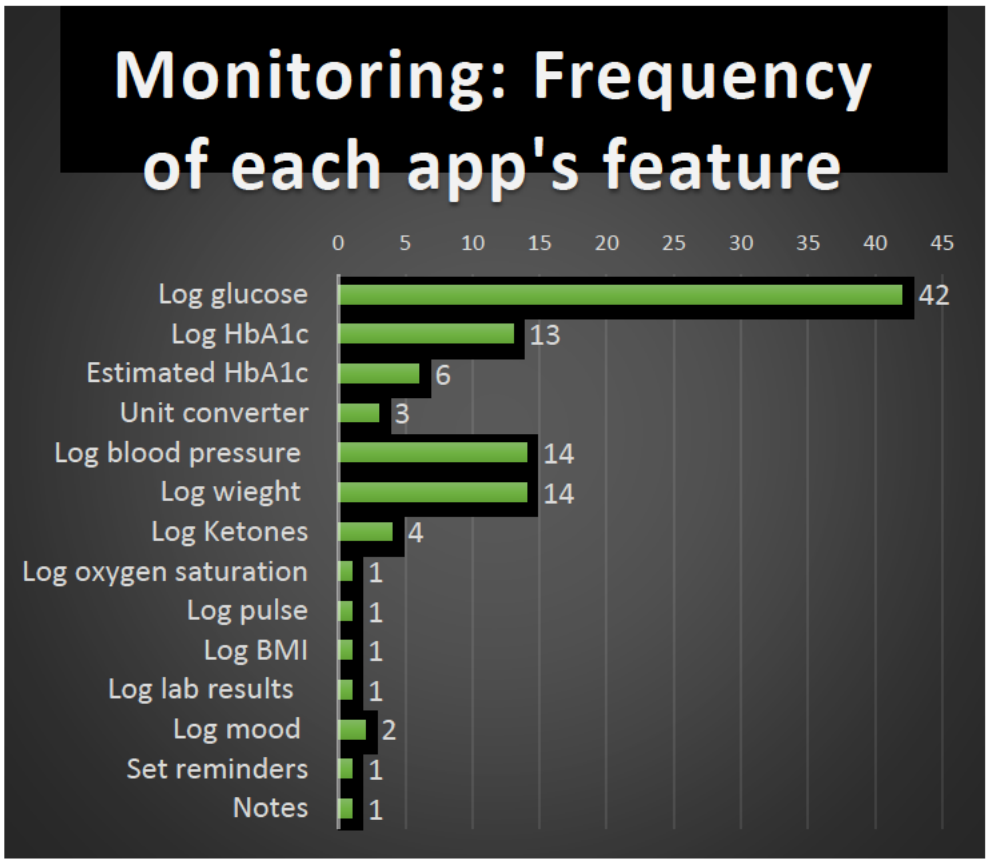
26.	Diaguard: Diabetes Diary	Log food Calculate Carbohydrates (Food database)	Log exercise time	Log glucose Log HbA1c Reminder Estimated HbA1c Log Blood Pressure Log weight Log oxygen saturation Log Pulse AAU: Reminder	Log insulin	✗	✗	✗	✗
27.	diasend	✗	✗	diabetes data management system; visualisation of information	✗	✗	✗	✗	✗
28.	Dottli : Diabetes Made Simple	Log food	Log exercise	Log glucose Estimated HbA1c	✗	Personalised recommendations	✗	Social: Chat with diabetic patients	✗
29.	forDiabetes: diabetes self-management app	Log food	Log exercise type and time	Log glucose Log HbA1c Log Blood Pressure Log weight AAU: Reminder	Log medications Log insulin	✗	✗	✗	✗
30.	Glucose Buddy Diabetes Tracker	Log food	Log exercise type and time	Log glucose Log HbA1c Log Blood Pressure Log weight Log Ketones	Log medications	✗	✗	✗	✗
31.	Glucose Control	✗	✗	Log glucose Reminder Log lab results	Log medications Reminder	✗	✗	✗	✗
32.	Glucose tracker & Diabetic diary. Your blood sugar	AAU: Log food	AAU: Log exercise Type and time and calorie consumption and decrease in insulin	Log glucose AAU: Log weight AAU: Reminder AAU: Log oxygen AAU: Log Ketone AAU: Log Haemoglobin	AAU: Log medications	✗	✗	✗	✗

33.	Habits: Diabetes Coach	Log food	Log exercise type and time	Log glucose Log HbA1c Log mood Log weight Lab results	Log medications Reminder	Set and Track Goals	✗	✗	✗
34.	Intellin Diabetes Manager. Blood Sugar Tracker.	Log food	Log exercise time	Log glucose Log Blood Pressure Log BMI	✗	✗	Safety warnings	Social: in app Patient Group	✗
35.	Jade Insulin Dose Calculator	Log food	Log exercise level and time	Log glucose Log mood	Log medications Insulin calculator	✗	Safety warnings	✗	✗
36.	Mazboot: Personal Assistant for Diabetes & High BP	Log food	Log exercise time	Log glucose	Log medications	Personalised recommendations	Coaching Connect with HCP	Motivational challenges Social: Rewards Program	✗
37.	MedM Diabetes	✗	✗	Log glucose Log mood	✗	✗	✗	✗	✗
38.	mySugr - Diabetes App & Blood Sugar Tracker	Log food	AAU: Log exercise	Log glucose Log HbA1c Set reminder Log mood Log Blood Pressure Log weight Log Ketones	Log medications Insulin calculator	✗	Automatic Reminders	Motivational challenges	✗
39.	One Drop	Food database Log food	Log exercise level and time	Log glucose Log HbA1c Log Blood Pressure Log weight	Log medications	Personalised recommendations	coaching	Health and community news	✗
40.	OneTouch Reveal	Log food	Log exercise level and time	Log glucose Log HbA1c	Log medications Insulin dose recommendation	Personalised recommendations	Safety warnings	✗	✗
41.	RT Diabetes	✗	✗	Log glucose Log HbA1c Log lab results Log weight	Log medications Reminder	✗	✗	✗	Patient Education
42.	SmartLog	Log food	Log exercise level and time	Log glucose Log Blood Pressure	Log medications AAU: Insulin dose	✗	✗	✗	✗

				Log weight Log Ketones AAU: Reminder					
43.	SocialDiabetes. Take control of your diabetes	Log Food Carb Calculator	Log exercise time	Log glucose Log HbA1c Estimated HbA1c Log Blood Pressure Log weight Log Ketones AAU: Reminder	Log medications Insulin Calculator Dose recommendation	✗	Connect with HCP	✗	✗
44.	Sugar Tester App Info	✗	✗	Log glucose	✗	✗	✗	✗	✗
45.	سكري (Sukari)	Log Food	Log exercise type & time	Log glucose Estimated HbA1c	Log medications	✗	✗	✗	✗

RAU: Removed after search update, AAU: Added after search update.

Figure 4.4 : Frequency of monitoring app's features.



The most frequent category among applications was monitoring, which was available in 96% of the applications. However, the features were different within the monitoring category (see Figure 4.4). Almost all applications that support monitoring also support log glucose features.

4.2. *Applications' Specifications & User Interaction*

After installation, some of the downloaded applications had different names to those listed in the app store. Most of the applications were in English, but three of them supported multiple languages. Not all applications were developed by IT companies; some of them were developed by individuals. The applications were developed in several countries but ten applications provided no information about where they were developed. The country with

the highest number of developed apps was the USA with seven applications, then India with four applications. The number of downloads ranged from 10,000 to 1 million. The highest overall rating was 4.7 out of five while the lowest was 2.9 out of 5 (see Table 4.6).

Table 4.6: General application specifications

	App Name	Application's Basic Information							User Interaction		
		Language	Version	Company	Country	Price	No. of Editions	Date of last update	No. of Downloads	No. of User Ratings	Overall Rating
1.	A1C Blood Sugar Calculator Tracker Diabetes app NAU: A1C Blood Sugar Calculator /Tracker	English	3.1	Little Gray Cells - Creative Developers	USA	FREE	1	28/3/2020 29/10/2021	+10K	181 284	4.3 2.4
2.	Apollo Sugar	English/Arabic/Multilanguage	3.7	Apollo Diabetes Care Management	India	FREE	2	22/6/2020 30/7/2021	+50K	486	3.7
3.	BeatO SMART Diabetes Management NAU: (BeatO)	English/Indian	4.0	BeatO	India	FREE	1	20/8/2020 10/3/2022	+100K 1M	11K 20605	4.4 3.8
4.	Blood Glucose Monitor | Sugar Test Converter[redacted]	English	2.0	Micromeriaso[redacted]	Australia	FREE	1	5/8/2019 NAAU	+100K	215	4.3
5.	Blood Glucose Tracker - Monitor, Levels & Test[redacted]	English	1.2	Vive Apps Studio	Spain	FREE	1	30/12/2019 NAAU	+10K	52	2.9
6.	Blood Sugar Checker / Blood Glucose Tracker * NAD: Blood Sugar Health Dia[redacted]	English	1.0	Rockstar Status	NI	FREE	1	5/1/2020 NAAU	+10K	54	4.0
7.	Blood Sugar Checker Diary: Track Glucose History * NAD: Blood Sugar Health Dia[redacted]	English	1.0	Health Therapy Fitbot	NI	FREE	3	8/5/2020 NAAU	+50K	934	4.4
8.	Blood Sugar Diary - Health Tracker NAD: Blood Sugar Diary	English	1.3	Visionary Labs	NI	FREE	2	19/1/2020 26/1/2022	+50K +100K	58	4.2
9.	Blood sugar diary App – Insulin NAD: Insulin Diary	English	1.1	F. Zander	Germany	FREE	1	19/8/2020 8/3/2022	+10K +50K	233 1679	4.4 3.4
10.	Blood Sugar Log – Diabetes Tracker NAD: Diabetes Tracker	English	1.6	Futuretech Apps	NI	FREE	1	5/8/2020 13/10/2021	+50K +100K	1030 2159	4.3 4.4
11.	Blood Sugar Test By Finger Info	English	1.0.4	Rean Apps	NI	FREE	1	NI 21/12/2021	+100K +100K	369 1155	3.5 3.5
12.	Blood Sugar Test Tracker and Info *	English	3	Chriscatstudio	NI	FREE	1	24/6/2020 NAAU	+10K	186	4.4
13.	Blood Sugar Tracker: Glucose Diary Average Records * NAD: Blood Sugar Health Dia[redacted]	English	1.0	Digital Health Fitness Log	NI	FREE	1	27/12/2019 NAAU	+10K	162	4.2
14.	Carb Calc *	English	2.23	Bee's Apps	UK	FREE	1	17/12/2019 No	+50K +50K	83 110	3.2 4.2

15.	Diabetes	English	2.3.5	Hint Solutions	Russia	FREE	2	17/8/2020 31/3/2022	+10K +50K	1060	4.7
16.	Diabetes [redacted]	English/Arabic/ Multilanguage	4.4	Klimaszewski Szymon	Poland	FREE	1	14/5/2020 NAAU	+500K	8000	4.6
17.	Diabetes Connect	English	2.5	SquareMed Software GmbH	Germany	FREE	3	29/9/2019 20/12/2020	+100K +100K	4607 4811	4.4 4.3
18.	Diabetes Diary *	English	2.0	Nasjonalt senter for e-helseforskning	Norway	FREE	1	17/2/2020 No	+10K	56	4.3
19.	Diabetes Diary - Blood Glucose Tracker NAD: Sugar Tracker NAU: Diabetes Diary Sugar Tracker	English	1.21	MS International	NI	FREE	2	6/6/2020 15/11/2021	+50K +100K	844 2273	4.5 4.5
20.	Diabetes Logbook - Blood Glucose Tracker * NAD Diabetes Logbo[redacted]	English	2.7	Dr.KM Chohan	Switzerland	Free	1	9/10/2019 NAAU	+10K	67	3.9
21.	Diabetes Tracker Free [redacted]	English	1.8	Pragma Infotech	India	Free	1	28/12/2019 NAAU	+10K	51	4
22.	Diabetes:M - Management & Blood Sugar Tracker App NAD: Diabetes:M	English	8.0.8	Sirma Medical Systems	Bulgaria	Free	2	11/5/2020 10/1/2022	+500K +100K	19930 21754	4.5 4.2
23.	Diabetic Calculator	English	3.5	Jake2701	Australia	Free	2	29/12/2019 11/6/2021	+10K +10K	35 41	3.7 2.7
24.	DIABNEXT Make your diabetes management easy* NAD: DIABNEXT	English	1.2	DIABNEXT	Hong Kong	Free	1	14/8/2020 NAAU	+10K +10K	126 No	3.8
25.	Diacomp (diabetes diary) NAU: Diacomp	English	2.9.1	Nikita Bosik	NI	Free	1	23/7/2019 26/7/2019	+10K +10K	88 No	4.3
26.	Diaguard: Diabetes Diary NAD: Diaguard	English	3.5.1	Philipp Fahlteich	Germany	Free	1	22/8/2020 2/4/2022	+10K +10K	206 No	4.5
27.	Diasend	English /Multilanguage	1.9.2	Glooko AB	Multinational	Free	1	20/5/2020 14/2/2022	+50K +50K	202 283	3.1 2.5
28.	Dottli : Diabetes Made Simple * NAD: Dottli	English	1.40	Dottli	Finland	Free	1	6/10/2019 No	+100K +100K	462 463	4.2 2.4
29.	forDiabetes: diabetes self-management app	English/ Multilanguage	1.16	Tessera Multimedia	Greece	Free	1	9/7/2020 22/9/2021	+10K +50K	174 264	4.5 4.1
30.	Glucose Buddy Diabetes Tracker NAD: Glucose Buddy	English	5.36	Azumio, Inc.	USA	Free	1	25/8/2020 19/7/2021	+100K +500K	14471 14571	4 4.2

31.	Glucose Control	English	1.9.1	Lehreer		Free	1	3/6/2020 4/4/2022	+100K +100K	1806 No	4.7
32.	Glucose tracker & Diabetic diary. Your blood sugar NAD: blood sugar Tracker NAU: Glucose tracker	English	3.2.6	mEL Studio	Russian	Free	1	17/5/2020 21/2/2022	+100K +100K	2197 4009	4.5 4.5
33.	Habits: Diabetes Coach NAD: Habits	English	1.7.33	Jana Care	USA	Free	1	21/5/2020 31/5/2020	+50K +50k	915 921	4.1 3.8
34.	Intellin Diabetes Manager. Blood Sugar Tracker[redacted]	English	1.7.136	Intellin	UK	Free	1	27/8/2020 NAAU	+100K	276	4.1
35.	Jade Insulin Dose Calculator * NAD: PredictB[redacted]	English	2.5.1	Jade Diabetes	Australia	Free	1	30/1/2020 NAAU	+10K	72	3.1
36.	Mazboot: Personal Assistant for Diabetes & High BP NAU: Mazboot	Arabic / English	5.1.6	Mazboot LLC	Egypt	Free	1	23/8/2020 4/6/2021	+10K +10K	119 No	4.6
37.	MedM Diabetes NAD: Diabetes	English	2.8.248	MedM Inc	USA	Free	1	22/10/2019 29/3/2022	+10K +50K	209 565	3.8 3.3
38.	mySugr - Diabetes App & Blood Sugar Tracker NAU: mySugr	English	3.78	mySugr GmbH	Austria	Free	1	24/08/2020 11/4/2022	+ 1M +1M	44970 66250	4.6 4.4
39.	One Drop	English	2.0	One Drop	USA	Free	1	21/8/2020 9/2/2022	+ 1M +1M	2456 3052	3.7 4
40.	OneTouch Reveal NAD: OneTouch	English	4.7	LifeScan Europe GmbH	USA	Free	1	21/8/2020 9/12/2021	+1M +1M	15428 21259	4.2 3.9
41.	RT Diabetes *	English	2.0.3	Raneem Technologies	USA	Free	1	15/10/2019 No	+10 K	47	4.3
42.	SmartLog	English	2.6.0	i-SENS,Inc.	Korea	Free	1	27/5/2020 17/1/2022	+50K +100K	494 794	3.2 3.2
43.	SocialDiabetes. Take control of your diabetes NAD: SocialDiabetes	English	4.17.22	SocialDiabetes	Spain	Free	1	26/8/2020 12/4/2022	+100K +100K	3426 3589	4.3 4.1
44.	Sugar Tester App Info	English	6.0.1	BFF APPS STUDIO	India	Free	1	27/12/2019 17/12/2021	+50K +50K	119 No	4.1
45.	سكري (Sokary) *	Arabic	4.0.1	Hussain Albar	Saudi Arabia	Free	1	26/1/2020 No	+10K	60	3.9

* Excluded after update. **NAAU:** Not available after search update, **NAD:** Name after download, **NAU:** Name after update

4.3. *Privacy*

Most of the applications provided end-user agreements and privacy policies; however, seven applications provided neither. All of these applications were transparent about where data would be stored (either in the user's mobile or in the cloud). Most of the applications (18) needed no permission to access the mobile device. However, some applications required a lot of permission such as contact, location, camera, identity, storage, photos/media files, and Wi-Fi (see Table 4.7).

Table 4.7: Summary of applications' specification related to patient privacy.

	App Name	Privacy		
		End-User Agreement and Privacy Policy	Data Storage	Software Permissions
1.	A1C Blood Sugar Calculator Tracker Diabetes app	Yes	Users' mobile + Cloud	No AAU: Media location photo
2.	Apollo Sugar	Yes	Users' mobile + Cloud	Calendar, Camera, Contacts, GPS, Mic, Storage. AAU: location
3.	BeatO SMART Diabetes Management	Yes	Users' mobile + Cloud	Audio AAU: Mic
4.	Blood Glucose Monitor | Sugar Test Converter	NO	Users' mobile	NO
5.	Blood Glucose Tracker - Monitor, Levels & Test	YES	Users' mobile	NO
6.	Blood Sugar Checker / Blood Glucose Tracker	YES	Users' mobile	NO
7.	Blood Sugar Checker Diary : Track Glucose History	YES	Users' mobile	NO
8.	Blood Sugar Diary - Health Tracker	YES	Users' mobile	AAU: Storage
9.	Blood sugar diary App – Insulin	YES	Users' mobile	Storage, Camera, Phone
10.	Blood Sugar Log – Diabetes Tracker	YES	Users' mobile	NO
11.	Blood Sugar Test By Finger Info	YES	Users' mobile	NO
12.	Blood Sugar Test Tracker and Info	YES	Users' mobile	NO
13.	Blood Sugar Tracker: Glucose Diary Average Records	YES	Users' mobile	NO
14.	Carb Calc	NO	Users' mobile	NO
15.	Diabetes	YES	Users' mobile	NO
16.	Diabetes	YES	Users' mobile	Location
17.	Diabetes Connect	YES	Users' mobile + Cloud	No
18.	Diabetes Diary	NO	Users' mobile	Storage
19.	Diabetes Diary - Blood Glucose Tracker	YES	Users' mobile	No

20.	Diabetes Logbook - Blood Glucose Tracker	Yes	Users' mobile	Location, Storage
21.	Diabetes Tracker Free	Yes	Users' mobile	No
22.	Diabetes:M - Management & Blood Sugar Tracker App	Yes	Users' mobile + Cloud	No
23.	Diabetic Calculator	No	Users' mobile	Location, Storage
24.	DIABNEXT Make your diabetes management easy	Yes	Users' mobile + Cloud	Location, Storage
25.	Diacomp (diabetes diary)	Yes	Users' mobile + Cloud	No
26.	Diaguard: Diabetes Diary	Yes	Users' mobile	Storage
27.	Diasend	Yes	Users' mobile	AAU: Photo & Media Files
28.	Dottli : Diabetes Made Simple	Yes	Users' mobile + Cloud	Camera, Contacts, Storage, Location
29.	forDiabetes: diabetes self-management app	Yes	Users' mobile	Contact, location, storage
30.	Glucose Buddy Diabetes Tracker	Yes	Users' mobile	Camera, Location, Storage, Body Sensors
31.	Glucose Control	Yes	Users' mobile	Storage
32.	Glucose tracker & Diabetic diary. Your blood sugar	Yes	Users' mobile	Photo & Media Files, Storages
33.	Habits: Diabetes Coach	Yes	Users' mobile + Cloud	Device & app history, Identity, Contacts AAU: Location
34.	Intellin Diabetes Manager. Blood Sugar Tracker.	Yes	Users' mobile + Cloud	Device & app history, Wi-Fi
35.	Jade Insulin Dose Calculator	No	Users' mobile + Cloud	Photo & Media Files, Storages, Mic, Camera, Location, Phone, Device ID
36.	Mazboot: Personal Assistant for Diabetes & High BP	Yes	Users' mobile + Cloud	Camera, Storage, Wi-Fi, Photo & Media Files.
37.	MedM Diabetes	Yes	Users' mobile + Cloud	Location, Camera, Photo & Media Files, Storage.
38.	mySugr - Diabetes App & Blood Sugar Tracker	Yes	Users' mobile + Cloud	Location, Camera, Photo & Media Files, Storage.
39.	One Drop	Yes	Users' mobile + Cloud	Contact, Location, Camera, Identity, Storage, Photo & Media Files, Wi-Fi.
40.	OneTouch Reveal	Yes	Users' mobile + Cloud	Location, Storage, Photo & Media Files, Wi-Fi.
41.	RT Diabetes	No	Users' mobile + Cloud	Phone, Photo & Media Files, Storage, Camera and Device ID.
42.	SmartLog	Yes	Users' mobile	Device & app history, Identity, Contacts, Location, Phone, Photo & Media Files, Storage, Camera, Wi-Fi, Deceive ID
43.	SocialDiabetes. Take control of your diabetes	No	Users' mobile + Cloud	Storage, Device & app history, Photo & Media Files, Mic, Camera, Location, Identity, Phone, Device ID
44.	Sugar Tester App Info	Yes	Users' mobile	Location AAU: Device ID
45.	سكري	Yes	Users' mobile	Phone, Photo & Media Files, Storage, Mic, Device ID

AAU: Added after search update

4.4. Technical Features & Collaboration

Application sizes ranged from 2.5 MB to 106 MB. Most of the applications did not collaborate with other medical devices. Only 13 applications supported a glucometer, one insulin pumps, five continuous glucose monitoring (CGM), four scale, and two blood pressure monitors. Smart watches were supported by only five applications. There was no app support other smart features such as Alexa or Google assistance. Other technical features that facilitated data transfer and sharing were available in 19 applications for sharing data and in 30 applications for exporting records. Only one application provided technical support by phone, three with chat features but the rest offered only email support (see Table 4.8).

Table 4.8: Technical features of included applications.

Technical								
	App Name	Application Size	Collaborate with Other Medical Devices	Produce Chart and Graphs	Sharing Data with Others	Support Smart Watch	Export Records	Support
1.	A1C Blood Sugar Calculator Tracker Diabetes app	30MB	No	Yes	Yes	No	Yes	Email
2.	Apollo Sugar	63MB	Yes, Glucometer	Yes	Yes	No	No	Phone Chat
3.	BeatO SMART Diabetes Management	93.78MB	Yes, Glucometer	YES	YES	YES	No	Email
4.	Blood Glucose Monitor | Sugar Test Converter	14.25 MB	No	No	No	No	No	Email
5.	Blood Glucose Tracker - Monitor, Levels & Test	15.5 MB	No	Yes	No	No	No	Email Phone Chat
6.	Blood Sugar Checker / Blood Glucose Tracker	22.25MB	No	Yes	No	No	No	Email
7.	Blood Sugar Checker Diary : Track Glucose History	6.22 MB	No	Yes	No	No	No	Email
8.	Blood Sugar Diary - Health Tracker	26.23MB	No	Yes	No	No	Yes	Email
9.	Blood sugar diary App - Insulin	28.30 MB	No	Yes	No	No	Yes	Email
10.	Blood Sugar Log – Diabetes Tracker	31.36 MB	No	Yes	No	No	Yes	Email
11.	Blood Sugar Test By Finger Info	20.14 MB	No	Yes	No	No	No	Email
12.	Blood Sugar Test Tracker and Info	34.89 MB	No	No	No	No	No	Email
13.	Blood Sugar Tracker: Glucose Diary Average Records	15.67 MB	No	No	No	No	No	Email
14.	Carb Calc	2.56 MB	No	No	No	No	No	Email
15.	Diabetes	65 MB	No	Yes	Yes	No	Yes	Email Chat
16.	Diabetes	25.12 MB	Yes	Yes	Yes	No	Yes	Email Facebook
17.	Diabetes Connect	17.64 MB	No	Yes	No	No	Yes	Email

18.	Diabetes Diary	21.05 MB	No	No	No	No	Yes	Email
19.	Diabetes Diary - Blood Glucose Tracker	21.97 MB	No	No	No	No	No	Email
20.	Diabetes Logbook - Blood Glucose Tracker	21.29 MB	No	No	Yes	No	Yes	Email
21.	Diabetes Tracker Free	17.92 MB	No	Yes	No	No	Yes	Email
22.	Diabetes:M - Management & Blood Sugar Tracker App	54.94MB	Yes, Glucometer	Yes	No	No	Yes	Email
23.	Diabetic Calculator	7.69 MB	No	No	No	No	No	Email
24.	DIABNEXT Make your diabetes management easy	31.93 MB	Yes, Glucometer	Yes	Yes	No	Yes	Email
25.	Diacomp (diabetes diary)	5.98MB	No	Yes	No	No	No	Email
26.	Diaguard: Diabetes Diary	16.08 MB	No	Yes	No	No	Yes	Email Facebook
27.	diasend	57.13 MB	Yes, Glucometer, insulin pumps, CGMs, pens	Yes	Yes	No	Yes	Email
28.	Dottli : Diabetes Made Simple	100 MB	Yes, Glucometer, CGM	Yes	Yes	YES	Yes	Email In-app
29.	forDiabetes: diabetes self-management app	18.06 MB	No	Yes	No	No	Yes	Email
30.	Glucose Buddy Diabetes Tracker	106 MB	Yes, CGM, Scale	Yes	No	YES	Yes	Email
31.	Glucose Control	51.51 MB	No	Yes	Yes	No	Yes	Email
32.	Glucose tracker & Diabetic diary. Your blood sugar	18 MB	No	No	No	No	Yes	Email
33.	Habits: Diabetes Coach	30 MB	Yes, Glucometer	Yes	No	No	Yes	Email
34.	Intellin Diabetes Manager. Blood Sugar Tracker.	18 MB	Yes, All types	Yes	Yes	YES	Yes	Email
35.	Jade Insulin Dose Calculator	5.7 MB	Yes, CGM	Yes	Yes	No	Yes	Email
36.	Mazboot: Personal Assistant for Diabetes & High BP	17MB	No	Yes	No	No	No	Email
37.	MedM Diabetes	13 MB	Yes, Glucometer	No	No	No	Yes	Email
38.	mySugr - Diabetes App & Blood Sugar Tracker	61 MB	Yes, Glucometer, CGM, Scale	Yes	Yes	No	Yes	Email
39.	One Drop	40 MB	Yes, Glucometer, Scale, BP	Yes	Yes	No	Yes	Email

40.	OneTouch Reveal	41 MB	Yes, Glucometer	Yes	Yes	No	Yes	Email
41.	RT Diabetes	26 MB	No	Yes	Yes	No	Yes	Email
42.	SmartLog	23 MB	Yes, Glucometer, Scale, BP	Yes	Yes	No	Yes	Email
43.	SocialDiabetes. Take control of your diabetes	44 MB	Yes, Glucometer	Yes	Yes	Yes	Yes	Email
44.	Sugar Tester App Info	6.3 MB	No	Yes	No	No	No	Email
45.	سكري	14 MB	No	Yes	Yes	No	Yes	Email

CGM: Continuous glucose monitoring, BP**:** blood pressure monitors

4.5. Search Update

The search update resulted in 17 applications being excluded. Of those, 12 applications had been removed completely from app stores and five had not been updated since our first search.

5. Discussion

This study aimed to explore the availability and features of diabetes self-management mobile applications. This aim was achieved by setting six objectives and addressing them. The search resulted in 402 applications which is a vast number of applications. However, only 45 applications met the inclusion criteria and were included in the study. The findings suggest that there are many applications that patients and healthcare professionals may find overwhelming if there is no guidance or accreditation system in place. Healthcare professionals may find it challenging to look for an application and go through the same process that has been done in this study to find a good application for his/her patients without guidance and information. This assumption is supported by the previous chapter (Chapter 3) results, where HCPs stated that one of the barriers was that they did not know which application was useful and there was a lack of information. In the same context, patients may also have difficulties finding a good application from 402 applications, as previous chapter results showed that patients also have barriers as HCPs in terms of lack of knowledge and information about diabetes mobile applications. The first systematic review's results (chapter 2) helped to shape this study's aim as one of these questions we asked, after having a few included research, are there any diabetes applications available? This finding helped to answer this question and show us that there are many applications, but not all of these could be useful or effective. Moreover, it shows there is limited research done on these applications.

Included applications & AADE 7 self-care behaviour

Applications were screened, downloaded and analysed in terms of medical and technical capabilities, including availability, diabetes tasks features, privacy and technical features. The applications' features were analysed based on AADE 7 self-care behaviour. The two sides of the analysis could offer a complete overview of these applications' capabilities. Testing the quality of the applications is out of scope; however, a general overview of what is available. If applications are full of medical capabilities but have a low-quality design or programming, the features may not work or help the patient as required. The same thing must be said if the application has a sophisticated design and technical capabilities but only supports a few tasks required by patients or healthcare professionals, which would not support achieving its goal.

Regarding AADE7 self-care behaviour, the included mobile applications in this study support different domains; they supported a range of self-care behaviours: 53% Healthy Eating, 42% Being Active, 96% Monitoring, 56% Taking Medication, 13% Problem Solving, 20% Reducing Risks, and 16% Healthy Coping; only two applications, namely One Drop® and Mazboot®, support at least one feature in each self-care domain. This result suggests that most available applications are electronic monitoring records and do not offer complete self-management of all tasks that diabetic patients must perform. This may lead a patient to install several applications to access all self-management tasks. This is impractical for day-to-day diabetes management, not only for the patient but also for healthcare professionals, as they may need many apps to access patients' data and to be able to communicate with them. Needless to say, the importance of collaboration and integration between applications as installing many applications may not result in these

applications collaborating with each other. For example, the data from an app that support sports activities would not make sense if it was not linked to glucose monitoring to spot hypo episodes resulting from exercise from the sport. Thus, separating the data on an app for each task may lead to a lack of sense of gathered data. Another example, if a patient has two separate applications, one for glucose monitoring and one for dose calculation, it is impossible to send an automated suggested dose based on the glucose reading. Installing different applications is not the only burden. As discussed previously, there are many applications, and this study included only 45 by applying simple exclusion criteria. The patient may need to repeat the process several times for each task or self-care domain and may not necessarily find an application as some domains, for example, Problem Solving, found only in 13% of applications. Additionally, as seen in qualitative systematic review results (chapter 3), patients do not know that diabetes mobile applications exist. The patient may not know about 7 self-care behaviour and may not try to find applications.

The analysis of app features in this study was comprehensive to record every feature in the appropriate domain. Thus, the results show that there are different features within a domain. For example, in the monitoring domain, all applications supported glucose logging. However, other features such as logging lab results, pulse, and BMI are seen only on one application. Thus, besides the issue of finding applications, the patient and HCPs may find it difficult and time-consuming to compare these applications. Moreover, similar features do not necessarily suggest the same capabilities. If applications offer a glucose log feature, this does not mean they are equal to or offer the same as another app offering a glucose log. So, the included 45 apps may not suggest these applications are advisable

or recommended. However, this study may help the HCP and patient in knowing what is available, how to compare, and what to look for based on their features and self-care domains.

One app for all

'One app for all', 'one app to rule them all' or 'All-in-One mHealth Application' concepts have been used in literature in recent years(202,203). The previous results show that the current status of diabetes mobile applications is far from achieving this concept.

English & Arabic applications

As one of the objectives was to compare what is available in English and Arabic, of included applications, only two applications were in Arabic and 43 were in English. Most importantly, the study sheds light on the Arabic application situation. So, the extra burden for an Arabic patient is learning English vocabulary to use an application in English. This is not the only extra burden; however, it may introduce a risk of misinterpretation of the application's messages and alerts.

Applications' Specifications & User Interaction

Approximately 19 applications (42%) had different names after they were installed. Changing the app's name after installation is not a good indicator. This may confuse the user or lead to a lack of trust. It is out of the scope of this study to evaluate these applications, but the general view is that most of these applications lack quality. For example, some applications were developed by an individual, and some have no information about where they were developed or by whom.

The number of downloads may reflect the interest or usefulness of an application. If we compare the highest downloaded app on the included list, which is one million, with PUBG game, for example, which is over 500 million, a question may arise is why these applications are not downloaded in equal numbers or more of games in the light of importance of diabetes management compared to games. This does not only apply to games. One study conducted by A.D. Carlo et al., regarding behavioural health applications shows that the number of downloads ranged from 800K to 42M in the group of applications they investigated(204). So here, there is a surprising question. Why do diabetes mobile applications have a limited number of end-users? Returning to previous chapter results (chapter 3) may help clarify why. The study found that both patients and HCP lack awareness that diabetes mobile applications exist in two included studies(62,170).

Privacy

This study shows that some applications request permission and access to mobile information when it is unnecessary. For example, a log data app asked for device and app history, identity, contacts, location, phone, photo and media files, storage, camera, Wi-Fi, and user's deceive ID. None of these permissions were necessary to perform the task of logging glucose data.

Technical features and collaboration

This study shows that almost all applications lack advanced smart features, such as supporting Alexa or Google assistance. Nowadays, these features are not difficult to adapt. It could be found in an electric smart adapter, for example, and one may expect to find it in serious, demanding tasks such as diabetes self-management tasks.

Sharing data may facilitate the daily task of diabetes management. However, not all applications offer the sharing or exporting of data. This may limit patients' use of the app or lead them to take time-consuming steps such as taking screen captures of the application data and sharing it.

Change over time

The research update results showed that around 50% of applications were unavailable in app stores after two years. This could result in a lack of trust in these applications by patients.

Suspicious app behaviour

As mentioned previously, quality investigation of diabetes mobile applications is not the aim of this study. However, some of the data we collected show suspicious behaviour. For example, some applications requested many device permissions when there is no need for these permissions to perform the task. Also, some of the applications are developed by a person where there is no information about the developer. These results suggest that patients' awareness of security and suspicious app behaviour needs to increase.

As mentioned in the introduction, studies investigating diabetes mobile applications are limited. A study conducted by Brzan et al.,(184) included only nine applications with few features, and there is no model used. This study is explored diabetes applications in depth and is guided by AADE 7 self-care model. Another study by Huang et.al (192) looked only at medication self-management and blood glucose logging features. However, this study covered all self-care tasks guided by 7 self-care model with no limitation on features as long as the application was designed specifically for people with diabetes. Another study was also done where they are limited to non-English speaking countries (188). None of

these studies explored the technical features of diabetes mobile applications as this study did.

Other studies investigated mobile applications for other chronic diseases (178–182). The included application in these studies ranged between 15 and 186 apps, which differs from this study. The highest number of applications was for hypertension self-management. This suggests that the applications availability is different for chronic diseases. More importantly, none of these studies explored the technical features of mobile applications as this study did.

5.1. Implications for Practice

This study provides an in-depth current status of available diabetes self-management applications in English and Arabic for patients and healthcare providers. It may help patients and healthcare professionals to spot popular downloaded applications and their features at a glance. Also, in combination with chapter two, it will inform application developers and policymakers about any missing features and shortcomings and inform them about the current status of these applications. It will also be combined with chapter two to answer why studies have been performed on fewer than ten applications and why some were developed for research purposes only. Developers should aim to support smart devices such as Alexa and smartwatches. Developers should develop a platform that supports most of the daily tasks required of patients with diabetes using the AADE 7 self-care behaviour model. Moreover, developers may support add-ons where other developers could develop extra tools for the same application.

5.2. Implications for Research

This study fills a gap and summarises the current status of diabetes self-management mobile applications and results through research questions. We would encourage researchers to examine the quality of these applications. Also, the question of why diabetes mobile applications have a limited number of end-users may be answered partially in the finding of the previous chapter (chpater3). However, it should be investigated thoroughly and answered. More research is needed to explore patients' and healthcare professionals' requirements, knowledge, experience and attitudes toward these applications.

5.3. Strength & Limitations

This study's strength is using a model to explore mobile application features. Also, this study explored both medical and technical features. However, there are some limitations to this study. First, we relied only on demo and trial versions due to budget constraints. However, almost all included applications offered a trial version. Second, even though most apps were published on both Google Play® and Apple® app stores, we relied only on Google Play®. Thus, some applications may be missed.

5.4. Conclusion

The available applications are limited to supporting only some self-management tasks based on AADE 7 self-care behaviour. The findings suggest that there are many applications that patients and healthcare professionals may find overwhelming if there is no guidance or accreditation system in place. Moreover, patients are required

to install a variety of tools for the self-management of their diabetes. Future development should aim to develop a comprehensive evidence-based application to support tasks in all areas of self-care behaviours and provide these applications with the ability to collaborate with other applications and tools. Future development should provide these applications with cutting-edge technologies like smart devices. Future research should investigate the quality of these applications. It should also investigate patient and healthcare professionals' requirements, knowledge, experiences and attitudes toward these applications. Only two applications support Arabic; more software is needed.

CHAPTER 5:

Explore Patients' Beliefs, Experiences, Attitudes and Knowledge of Using Diabetes Mobile Applications in Supporting Diabetes Self-Management

ABSTRACT

Objective:

This study aimed to explore patients' beliefs, experiences, attitudes and knowledge of using mobile applications in supporting diabetes self-management.

Method:

The AADE 7 self-care behaviour model, MARS tools and the TAM model were utilised to develop a web-based questionnaire. This questionnaire was administered online through different social media platforms and targeted members of the Saudi Arabian population with type 1 and type 2 diabetes, who are familiar with the use of mobile applications. The data collection started in February 2022 and lasted for two months. Ethical approval was obtained prior to data collection.

Result:

Of the 277 survey participants, only 179 were eligible. The majority of participants (62%) installed at least one application to help self-manage their diabetes, while 38% did not install any applications. Only 11% installed these apps following professional healthcare advice, while most reported different advice sources. Of the total number of participants, 24.5% used mobile applications more than once a day. Mobile applications were used for longer than 12 months by 20% of participants. Most application users faced issues while using the applications, such as application crashes, inaccurate results and problems with units. Regardless of these issues, on a five-point scale, the majority considered the mobile applications to be very useful (Mean 4.38 SD 0.84). There were many reasons behind not

using applications among participants; however, the majority of non-users were not aware that these applications existed.

Conclusion:

Most of the study participants used mobile applications and considered them to be very useful, regardless of the issues that some of them faced. Further efforts should be made to design an application that meets users' expectations. Awareness needs to be raised for people with diabetes with regard to applications.

1. Introduction

During the first stage of this project, two systematic reviews were conducted. The first systematic review explored the nature and effectiveness of mobile and web applications to support the self-management of type 1 and type 2 diabetes. The second systematic review explored patients' and healthcare professionals' (HCPs') perspectives of mobile and web applications to support the self-management of type 1 and type 2 diabetes. In the second systematic review, only eight studies were eligible for inclusion(62,169–175) and these were conducted in different countries. However, none of these studies investigated the Saudi Arabian population on patients' and HCPs' perspectives of mobile apps in support of diabetes self-management (see Table 5.1).

Table 5.1: Studies that explore patients' and healthcare professionals' perspectives of mobile and web applications to support the self-management of type 1 and type 2 diabetes.

Study	Country	Study Aims	Data Collection Method	Design	Intervention	Diabetes Type
Adu 2018	International	'This study aimed to examine app usage and feature preferences among people with DM, and explore their recommendations for future inclusions to foster engagement with diabetes apps.'	Online questionnaire & semi-structured telephone interview	Mixed-methods	Mobile Application	T1 & T2
Kelly 2018	UK	'The purpose of this study was to understand the impact of using web-based and mobile technologies to support the management of type 2 diabetes.'	In-depth interviews	Qualitative	Mobile & Web Application	T2
Yan 2018	China	'This study examined factors that affected patients' acceptance of a computer-based, chronic disease self-monitoring system over a four-week period.'	Surveys	Surveys	Mobile Application	T2
Zhang 2018	China	'The aims of this study were to explore the perspectives and needs	Quantitative surveys and	Mixed-Methods	Mobile Application	T1

		of T1DM patients and diabetes experts concerning a diabetes app and to design a new T1DM management mobile app.'	qualitative interviews			
Karduck 2018	USA	'To determine what factors may be associated with app use by clinicians working in diabetes and weight management patient care settings.'	Surveys	Surveys	Mobile Application	NI
Boyle 2017	New Zealand	'The study aimed to establish (1) whether people with DM in Wellington, New Zealand, use apps for DM self-management and evaluate desirable features of apps and (2) whether health professionals (HPs) in New Zealand treating people with DM recommend apps to patients, the features HPs regard as important, and their confidence with recommending apps.'	Survey	Surveys	Mobile Application	T1 & T2
Rossmann 2019	Singapore & Germany	'To find out how people with T1 & T2 integrate mobile technology into their everyday self-management.'	Semi-structured Interviews	Qualitative	Mobile Application	T1 & T2
Scheibe 2015	Germany	'Investigated the question Which factors influence the acceptance of diabetes apps among patients aged 50 or older?'	Guided interviews	Qualitative	Mobile Application	T1 & T2

T1: Type 1, **T2:** Type 2, **NI:** No information

Of the included studies, five studies focussed on patient population(169–171,174,175), one study on HCPs(173) and two studies on both patients and HCPs(62,172). The data analysis generated four themes: first, factors affecting patient's acceptance and use of mobile apps (62,169–172,174). Second, factors affecting HCP acceptance, use and recommendation of

mobile apps(169,172,173). Third, patients' experience and attitudes towards mobile apps(62,170–172,175). Finally, HCPs' experience and attitudes towards mobile apps(62,172,173).

The results suggest that many patients and HCPs are non-users or limited users of current diabetes self-management applications. Patients are looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use, and cost-effective applications. For example, some applications might have a basic alert function while others could include a very sophisticated alert function that could send alerts to smart watches or family members. However, we do not know about the generalisability of the results to the Saudi Arabian population. Based on the systematic review results, we would like to explore the use of mobile applications in support of diabetes self-management in the Saudi Arabian population. To the best of our knowledge and from our second systematic review, no previous study has explored patients' and healthcare professionals' perspectives on the use of mobile diabetes self-management applications in Saudi Arabia.

The literature gives no precise classification for diabetes self-management applications. In chapter 4, we explored the availability and features of mobile applications for the self-management of diabetes in the Google Play Store® (Android™) for adults with type 1 and type 2 diabetes. Based on the findings of the previous chapter, there appear to be three distinct classifications of mobile applications based on their features. First, applications offer support for healthy living linked to better outcomes, such as physical exercise, but they are not specifically designed for diabetic patients. Second, some applications have been designed specifically to support diabetes self-management; they may, or may not,

calibrate with other devices, but there is no obligatory requirement to use them with the application, such as Bluetooth calibration with a glucometer. Third, some applications have been designed to support a feature of diabetes self-management, but cannot work without a device such as Dexcom G6®, a continuous glucose monitoring system, which requires sensors and a transmitter (see Table 5.2).

Table 5.2: Diabetes App classification based on their end-user group and applications' features.

Group	Group 1	Group 2	Group 3
App Features	Apps that support some of diabetes self-management daily task	Apps designed to support some of diabetes self-management daily task	Apps designed to support some of diabetes self-management daily task
Requirements	--	Works with or without external device	Works only with external device
Target Group	For any end-user	People with diabetes	People with diabetes
Examples	Fitbit®	One Drop® or Jade® Diabetes	Dexcom G6® Or Freestyle libre®

For this study, and based on the FDA definition of 'health mobile app' and the AADE 7 Self-Care Behaviours®, mobile applications will be defined as *'Any application that can be executed on a mobile platform by direct installation from mobile app stores, which is used by a patient to provide a support for any diabetes self-management area in accordance with AADE 7 self-management behaviour, and can be used with or without an external device.'* Based on this definition, our study will exclude 'apps category one', in which these applications were not designed specifically for people with diabetes.

2. Aim and Objectives

The aim of this study was to explore patient's' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications in supporting diabetes self-management in the Saudi Arabian population. To achieve this aim, the following objectives were set:

Objectives

- To explore patients' knowledge about the availability of mobile applications for self-management of diabetes.
- To explore patients' views and experiences of mobile applications for diabetes self-management.
- To explore patients' beliefs in regard to the usefulness of mobile applications in the self-management of diabetes (the reasons behind patients using, or not using, diabetes mobile applications).
- To explore Saudi Arabian patients' attitudes towards the use of mobile applications for diabetes self-management (preferred features and ease of use).

3. Method

To enhance quality and follow good academic practice, a protocol was written and agreed with the supervisors prior to conducting this study. The protocol was submitted to the ethics committee, which requested some amend to the protocol and survey. Piloting and the actual data collection began after obtaining full ethical approval form the University of Birmingham. The approval reference number is RN_21-1237.

3.1 Design, Setting and Recruitment

Design:

Various modes of survey are used in research, including email surveys, web-based

surveys and mobile survey(205). Email surveys use emails as a platform to disseminate a survey link; however, a web-based surveys, survey links are shared on web pages. Mobile surveys use mobile apps to recruit participants and collect data(205). Online surveys has several benefits, including low cost in the long-term, faster modes of data collection, a wider geographical reach, and efficient management of data through controlling data entry and managing contingency questions (205). However, this method also has drawbacks, such as high costs related to the use of software and setting up questionnaires required for survey administration (205). For example, there is often a fee associated with buying and setting up software at the outset. A web-based survey was developed for this study. There are several reasons for opting for this type of survey. This study aims to reach patients across a large geographical area in Saudi Arabia. During initial discussions, an interview study was considered. However, interview studies do not allow access to a wider population. Also, we built in previous qualitative studies. A mailed survey was another option; however, this method would require a sampling frame and participants' addresses, which were not available, so this mode of administration was not used. After comparing other survey methods' advantages and disadvantages, such as postal, telephone interview, and face-to-face interviews, an online survey was identified as the most appropriate method based on the research aims, objectives, settings, time and research budget. This study used a web-based explorative questionnaire that was administered online.

Settings: In 2020, according to The World Bank, more than 97.8% of the Saudi Arabian population were using the internet in their daily lives(206) compared to 77% across the world's population(207). Moreover, approximately 112.7% of Saudi Arabian populations were users of mobile devices in Jan 2021, which suggests that some

people have more than one mobile device(208). These figures show how the internet is part of daily life and that using it as a platform for the research of diabetes mobile apps is beneficial. In this study, the setting include any region in Saudi Arabia as the surveys were administered online.

Participant identification and recruitment:

As this study relates to an online survey, all eligible populations in Saudi Arabia were able to participate. Therefore, non-probability sampling is the closest description of our sampling strategy. In addition, participants could distribute the survey link with other eligible people, enabling us to utilise snowball sampling methods(205,209). Through non-probability sampling, the target population was recruited by providing a link for this survey, which was posted on several internet social media platforms such as Twitter. Also, specialised diabetes accounts on Twitter such as T1D and Diabetes Support Group SA were contacted to distribute the link. Snowball sampling was also used by asking the participants at the beginning and at the end of their survey to share it with people who they knew had diabetes. Because this survey was online, we expected a fast response as no time was needed for mailing. Thus, the survey was opened for participation in Feb 2022. It would close after two months or when it reached 300 participants. After two months, we reached 277 responses and the survey was closed.

Sample size estimation: No similar studies related to diabetes mobile applications had been undertaken in Saudi Arabia, so it was not possible to estimate a similar population. However, a national web-based survey in Saudi Arabia, related to COVID-19 vaccine acceptance, reported 992 responses(210). Similar studies had also been

carried out elsewhere(62,211,212). These studies ranged between 98 and 746 responses. For online surveys with an open population, Sue et al., suggested that sample size should be between 30 and 500(205). Thus, the aim was to have 300 responses based on the previous evidence above.

Inclusion criteria:

- Adult patients diagnosed with type 1 or type 2 diabetes
- Participants had be native Arabic speakers or speak Arabic as a second language
- Participants had to be familiar with mobile devices by knowing at least one mobile platform (Windows mobile, Android or iOS) for at least 3 months
- Participants had to be resident in Saudi Arabia

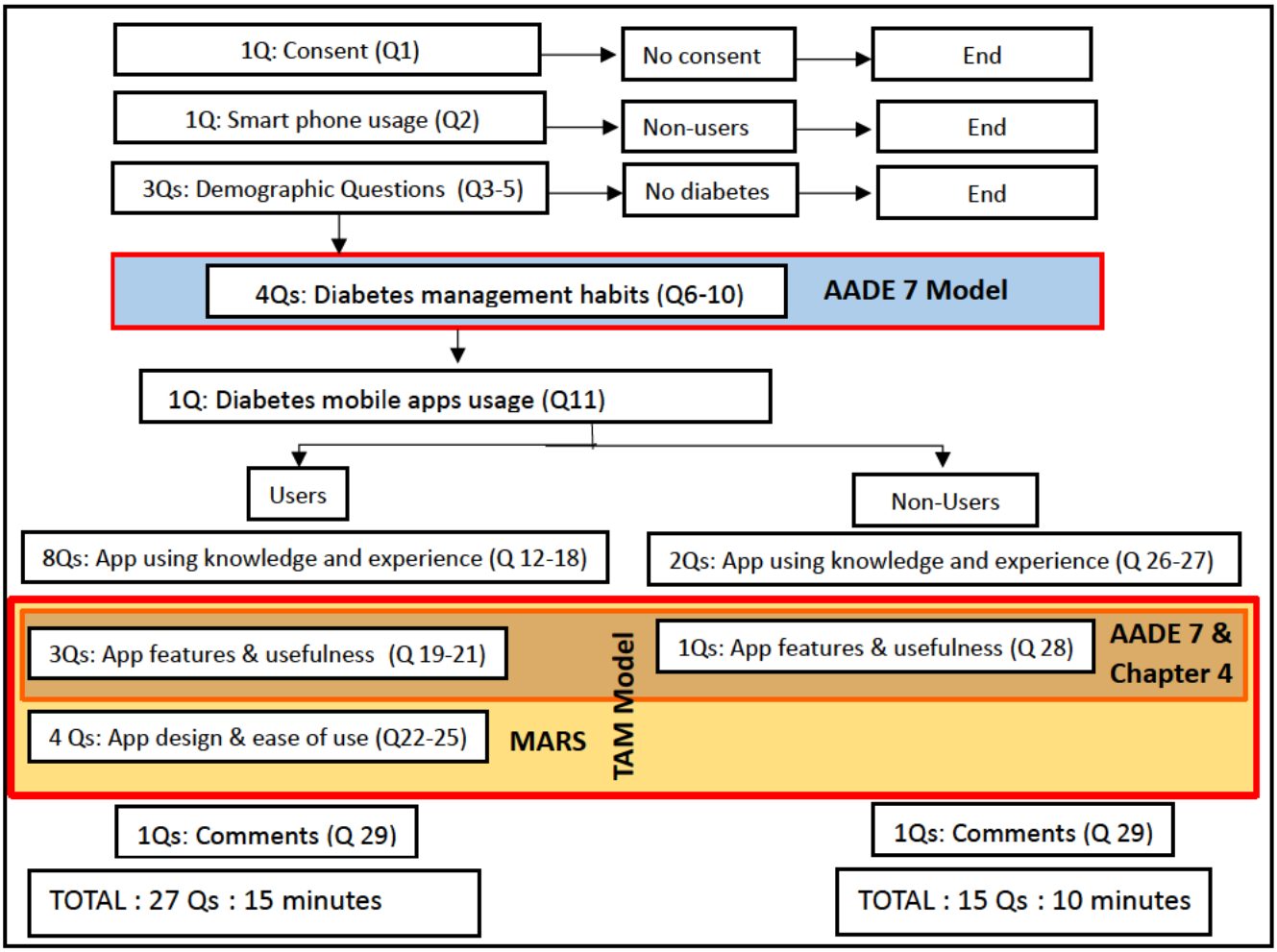
3.2 Survey Development, Validation & Data Collection

Because this research was intended for an Arabic speaking population, the survey was developed in English and then translated to Arabic by AA as he is bilingual. To ensure the accuracy of the translation, we recruited a certified translator to back-translate the survey into English. through discussion with the supervisory team, we assumed that, if the translator was able to provide an English version close to the original, then the translation was accurate. The certified back-translated version – see Appendix 5.3 – was very close to the original and so the supervisory team approved the survey to proceed to the next step – piloting.

The AADE 7 Self-Care Behaviour® model, MARS tools, the TAM model and published literature were utilised to develop a web-based questionnaire. The initial survey was adapted from a similar study conducted by Boyle et al.,(62) but some changes were

made to advance the survey and build on previous studies seen in Chapters 3 and conducted on Chapter 4. Diabetes management domains and app features were organised according to the AADE 7 model (17,110,213) – please see the survey measurement items in Figure 5.1 and Appendix 5.1. The survey sections were for diabetes application users and the questions were around app use, preferred features, usefulness, app design, ease of use and reasons for using apps. The other section was for diabetes application non-users, for whom the questions were around app use, preferred features and reasons for not using the apps. Boyle's study was limited to nine app features. However, when we investigated diabetes mobile apps and their features in chapter 4, one of the objectives was to inform data collection tools on diabetes application features. Thus, comprehensive results of app features that came from a previous study in Chapter 4 were used instead of Boyle's study. One question about technology adaptation was taken from another study (214). For some questions in Boyle's study, which were adapted from MARS tools, the wording of MARS used rather than that of Boyle. As this survey is explorative, an open-ended question was added to all applicable questions. The final question was dedicated to an open-ended free text in which participants could comment on any aspect related to diabetes self-management applications.

Figure 5.1: Measurement items, contingency question flowchart, and how items are related to theories and other studies in this project.



The patient survey collected data to answer the research aim and objectives. The data collected included patients' demographic data, diabetes management habits, and their beliefs, experiences, attitudes, and knowledge. The questions were a mix of multiple-choice questions, binary Yes/No questions and a Likert 5-point scale. Contingency questions were used to direct the participants to questions related to their type as 'app user' or non-app user. Also, a question identified non-diabetic participants so they could be excluded from the analysis.

The survey was reviewed within the study team including the back translation. A pilot version was conducted with ten patients to ensure the validity of the survey in terms

of time taken and the clarity of questions to avoid bias. Patients were recruited through the personal and professional network of the research team. In the pilot version, the participants offered a telephone number, email and WhatsApp® to AA so they could call if they faced any problems, needed any clarification, or wanted to make comments. Outcomes of the calls and feedback were summarised and discussed with the supervisory team – please see 3.7 pilot section. Based on the pilot results and team discussion, the original survey was amended. The final version was reviewed again by the supervisory team and was sent to the ethics committee for approval. Finally, after approval was granted from the ethics committee, the final version conducted the survey using online software.

3.3 Software (tools)

A variety of software was used during this study. LimeSurvey™ is an approved online survey tool by the IT department at the University of Birmingham. It is classified as a safe tool and is hosted on the University of Birmingham's servers, which made it a good consideration. More importantly, it supports the Arabic language and right-to-left mode of transcription. Thus, it was used to design the survey and collect data from the participants. Other survey software was considered, included Survey Monkey and JISC online surveys. However, these were excluded because they either were not approved by the university or did not support Arabic. Mendeley™ was used for document management based on the Windows 11® system. Microsoft Word® 2021 was used for report writing.

3.4 Data Analysis

Because we used non-probability sampling, we were not able to use inferential statistics. Therefore, the generalisability of the data was viewed with caution when

discussing the results. However, the main aim was to explore rather than generalise, so a descriptive statistics synthesis approach was used to analyse and present these data using text, tables and charts. The reasons for using the app in the app user group and reasons for not using the app in the non-user group were summarised and compared in tables and graphs.

3.5 Ethics & Governance

This study followed good research ethics practice by developing a proposal that following Saudi Arabian law (215) and the University of Birmingham' research governance frameworks(216,217) in terms of anonymity, confidentiality, consent, data storage and incentives.

Anonymity & Confidentiality: No personal data was collected that could identify the participants (e.g. email or mobile number). The survey was anonymously conducted online. In addition, participants' mobile device operating system data, such as IP location, were not collected. All options on the online software were set to not use cookies. Thus, by using an online survey, not collecting personal data, using sampling method with no sampling frame and no device data collected, participants' anonymity and confidentiality were completely protected. There was no risk of breaching this before, during or after the data collection, as there were no means of identifying the participants. The anonymity and confidentiality information was made clear to the participants in the survey introduction – please see Appendix 6.1. No personal or sensitive questions were asked. Thus, no potentially adverse effects on the participants or researcher were anticipated.

Informed Consent: Informed consent was included on the data collection form and was obtained by first asking participants if they agreed to participate. It was made clear to the participants that clicking on the 'proceed' button and answering the question with 'yes' would be considered consent. The participants had the right to exit the survey at any time or not press the submit button at the end. Ethical approval was obtained through the University of Birmingham. Registration number: ERN_21-1237. Albaha University in Saudi Arabia confirmed that there was no need to apply for ethical approval in Saudi Arabia. No piloting or data collection began before obtaining the full approval of the proposal according to Saudi Arabian law (215) and the University of Birmingham's research governance frameworks(216,217).

Data storage: Data was stored, accessed and archived in compliance with the University of Birmingham research and data protection policy and code of practice(216,217). A primary copy of the data was stored on password encrypted computers. Several backups were done bi-weekly, and were sent to the supervisors for storage. A monthly check for backup data was done. Online survey data was stored on the university servers for the duration of the project. It was also downloaded and sent to supervisors for backup bi-weekly. It will be downloaded, archived and deleted from the online platform after the PhD is complete. All data will be archived at the end of the PhD study and will be stored for 10 years, as required by university policy, in the university data archive: university BEAR Research Data Store (RDS). The data will be accessible to the research team.

Incentives: No incentives were offered.

3.6 Development of the Online Survey

LimeSurvey Community Edition, Version 3.27.9+210726 was used for the online survey design. This version is open source and hosted on the University of Birmingham's servers. All introductions, instructions, and questions had been added as they appear on the proposal. LimeSurvey® is very flexible, as it gives the freedom to mix questions. To prevent repetition, questions Q19 & Q20 emerged. Conditions were added to questions to manage a contingency question. The survey hide and showed questions based on the participants' responses. The survey would end if the participant was not eligible. Conditions followed the same chart mentioned previously (please see Figure 5.1). While the online survey was being designed, some technical issues required contact with the university IT department. The issue was related to an internal server error and the survey webpage's availability. The IT department fixed these issues before the pilot began.

3.7 Piloting

The pilot lasted 12 days as it started on 2/2/2022 and was completed on 14/2/2022. When the survey was activated, it asked whether the survey would be anonymised. This option would add a note about anonymisation and tokens on the survey's introductory page, which was not on the original introductory page approved by the ethics committee. Also, the note about tokens could confuse the participants. Given that all options that anonymised participants had already been activated, a decision was made not to opt for the anonymisation option. According to the LimeSurvey website(218), this option did not allow the participation date or time to be collected so a token would be saved on a separate database. Using the survey's option, participation date and time were set to not be recorded. Tokens were not used in the

survey distribution. After a discussion with the supervisory team, this decision was confirmed (please see the survey settings in Appendix 5.4).

During piloting, notes were taken of the participants' comments. A meeting with the supervisory team was set to discuss these notes and changes. After the meeting, it took several days to reach 10 responses. However, no new notes were obtained. After this, data was exported, and the online version was deactivated so the changes could be addressed. In total, there were 16 responses: 10 full response and six partial responses. The notes were categorised into survey issues and technical issues.

Survey issues: The participants faced some issues. Some had difficulty rounding numbers for question number 8; what is your HbA1c level?. Accordingly, this question was changed to a range. One participant suggested adding a social media option to question 12; Who recommended installing diabetes mobile applications. Even though there was an option for 'others' in which participants could write what they want, this option was added. Finally, some spelling errors were spotted by participants and fixed.

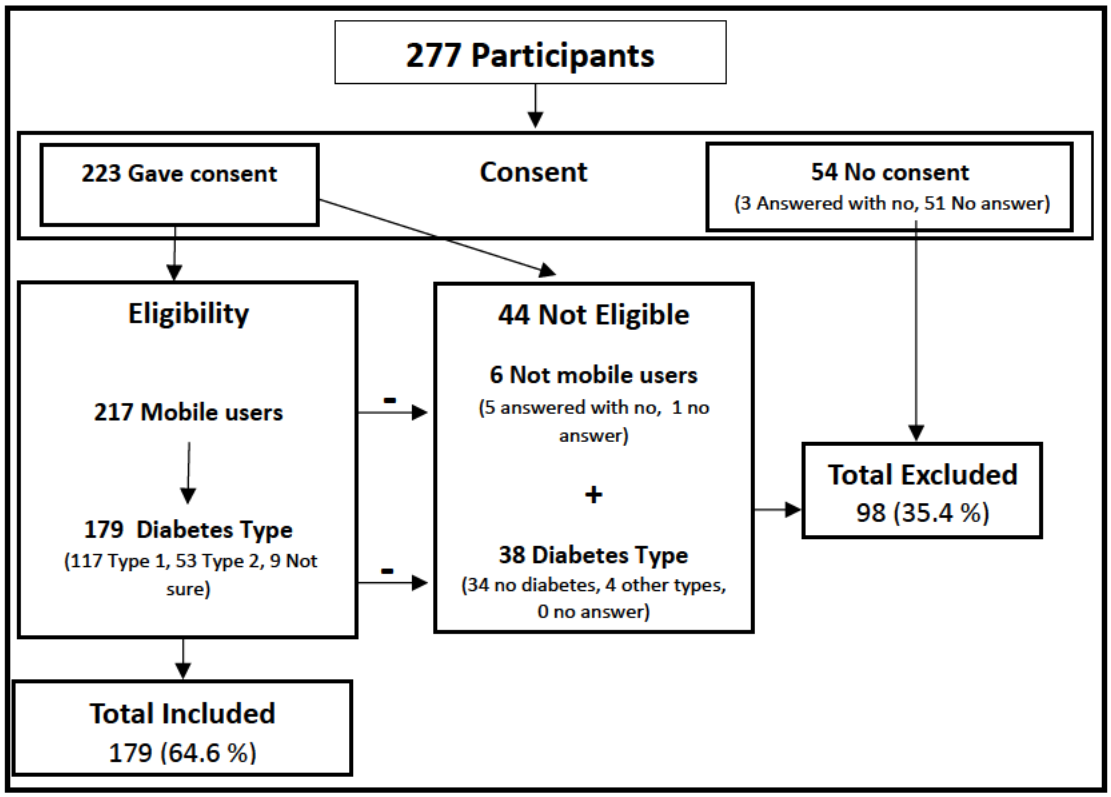
Technical issues: During the pilot, only three technical issues were faced: partial response, dealing with emoticons and the back button. Regarding the first issue, the survey records answers page by page, even if the participant does not reach the final page and press the submit button. This was recorded as a partial response. There was no way to change this option on the software, but the ethics committee were informed about it. The second issue was that most pilot participant faced an issue with the emoticons. Efforts were made to utilise the software interactive options by using emoticons to make it as attractive and as engaging as possible. However, even though the LimeSurvey supported the right-to-left direction very well, this caused

issues as the slide direction was completely opposite to that of the emoticons. For example, the participant needed to click on the second emoticon to choose the fourth option and vice versa. Thus, all of the questions with emoticons changed to ordinary radio options. Finally, the participants asked for a return back button and this option was activated. All of these minor changes were sent to the ethics committee to obtain approval. All of these were addressed and tested before activating surveys for actual data collection, which started in February 2022 and lasted for two months as planned.

4. Results

In total, 277 participants began by reading the introductory page of the survey and hit the start button. Only 179 (64.6%) were eligible and included in the analysis – please see Figure 5.2.

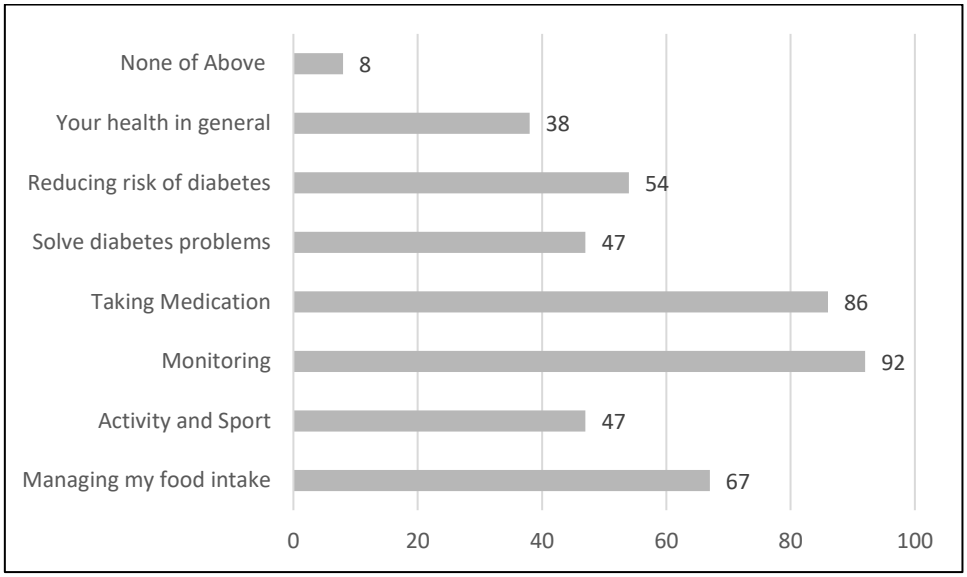
Figure 5.2: Details of participants' eligibility based on inclusion criteria.



4.1 Demographic Data & Diabetes Management Habits

Of the included participants, (n=117) had type 1 diabetes, (n=53) had type 2 diabetes and (n=9) were uncertain. The majority of participants were in the youngest age group: 18-25 (n=51), 26-35 (n=35), 36-45 (n=22), 46-55 (n=16), 56-65 (n=17) and (n=3) were aged over 65. The majority of the participants were highly educated: postgraduate degree (n=7), bachelor's (n=74), diploma (n=23), tertiary school (n=35), secondary school (n=3), primary school (n=4), and no formal education (n=1). The first contact point for participants who faced problems with their diabetes was only (n=5) for mobile applications, while other options had a higher number of participants: specialised diabetes clinic (n=45), internet (n=35), primary care (n=30), others (n=14), family and friends (9), diabetes dietician (n=7), and pharmacy (n=1). For participants who chose the 'others' option, their results was almost themselves, their family and the internet. They chose this option to provide more details. The vast majority of the participants demonstrated that they cared about their diabetes by visiting a clinic at least once every six months and by keeping their HBA1c lower than seven. Regarding diabetes daily management, the majority were confident. On a scale of 1-5, the majority was 3 or higher; the arithmetic mean was 3.45 and SD 1.15. Based on AADE 7 Self-Care Behaviour® domains, participants showed different engagement (see Figure 5.3).

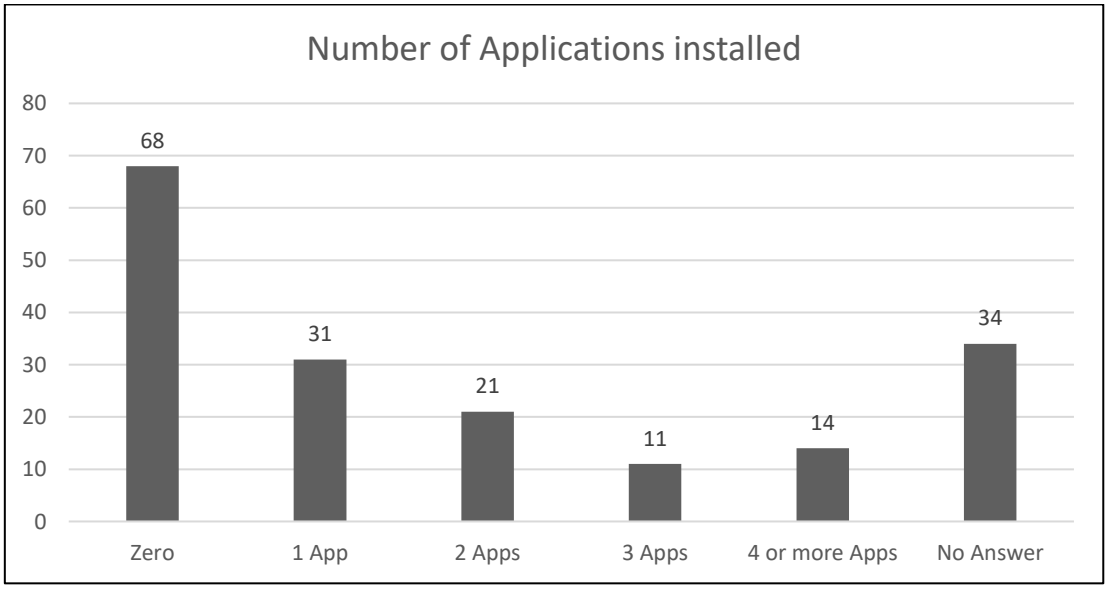
Figure 5.3: participants' engagement in self-management tasks, classified according to AADE 7 Self-Care Behaviours®



4.2 Knowledge, Experience and Barriers

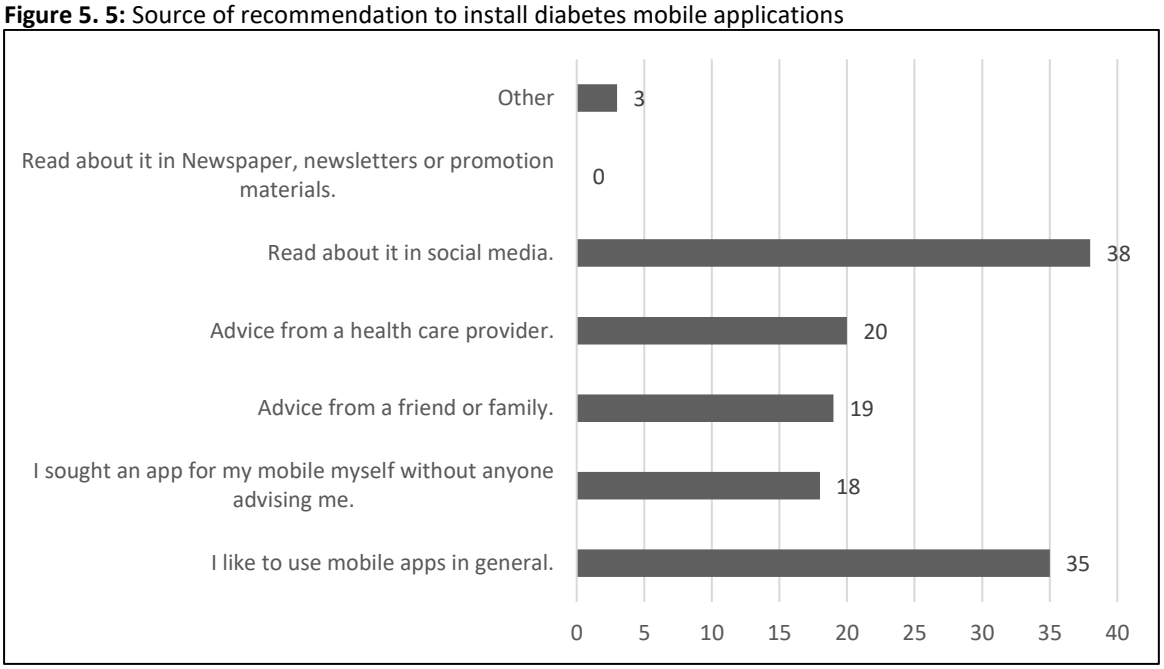
Participants' knowledge about the availability of mobile applications for diabetes self-management was different. The majority of participants installed at least one application (n=77); some did not install any mobile applications (n=68), while the rest gave no answer or did not complete the survey at this stage (n=34) (see Figure 5.4).

Figure 5.4: Number of installed applications by participants



Among the mobile app users (n=77), the participants showed a different source of recommendation for installing diabetes applications, different used languages, different daily use, and verity of applications. The majority received no advice (n=53); of these, some liked mobile apps in general (n=35) and others obtained app with no advice (n=18) (please see Figure 5.5). The majority used both Arabic and English apps (n=36), some used Arabic only (n=20) and the rest used English only (n=12).

Figure 5. 5: Source of recommendation to install diabetes mobile applications



The majority of mobile app users (n=77) used diabetes mobile applications frequently, more than one time a day (n=44), daily (n=13), a few days per week (n=5), weekly (n=1), monthly (n=1), only when guidance is needed (n=3), and never used the app after installation (n=1). The duration of application use was different: more than 12 months (n=36), between 7 and 11 months (n=10), between 2 and 6 (n=16), and less than one month (n=6). The majority of application users (n=52) used FreeStyle LibreLink then mySugr (N=22), while others used different applications.

Regarding mobile apps for the self-management of diabetes, participants have different behaviours (see Figure 6.6) and classified themselves differently regarding their technology adaptation (see Figure 5.7).

Figure 5.6: Participants' behavioural statements regarding mobile apps for self-management of diabetes

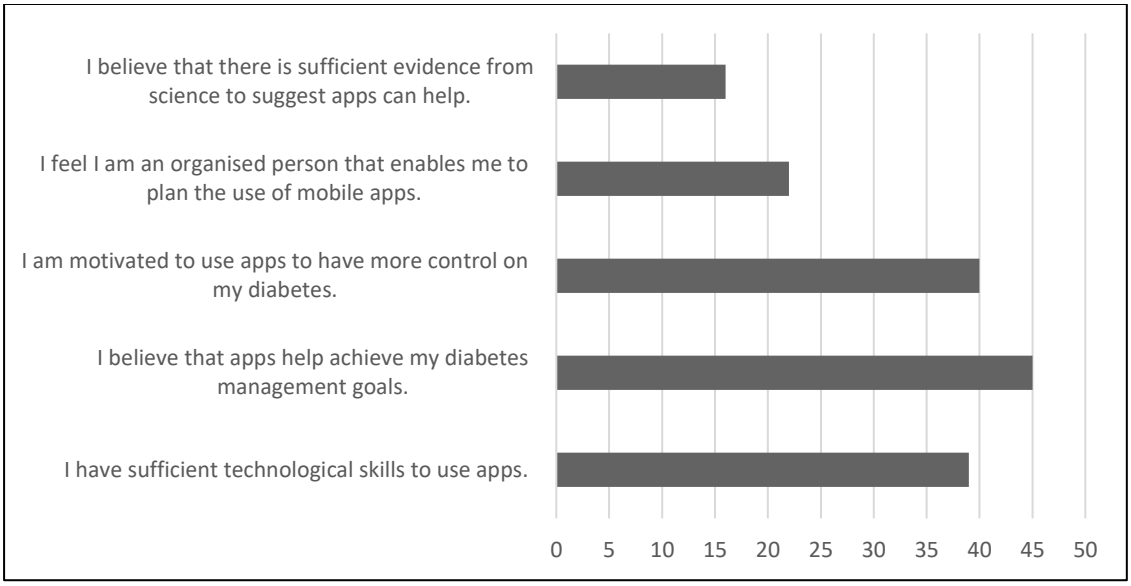
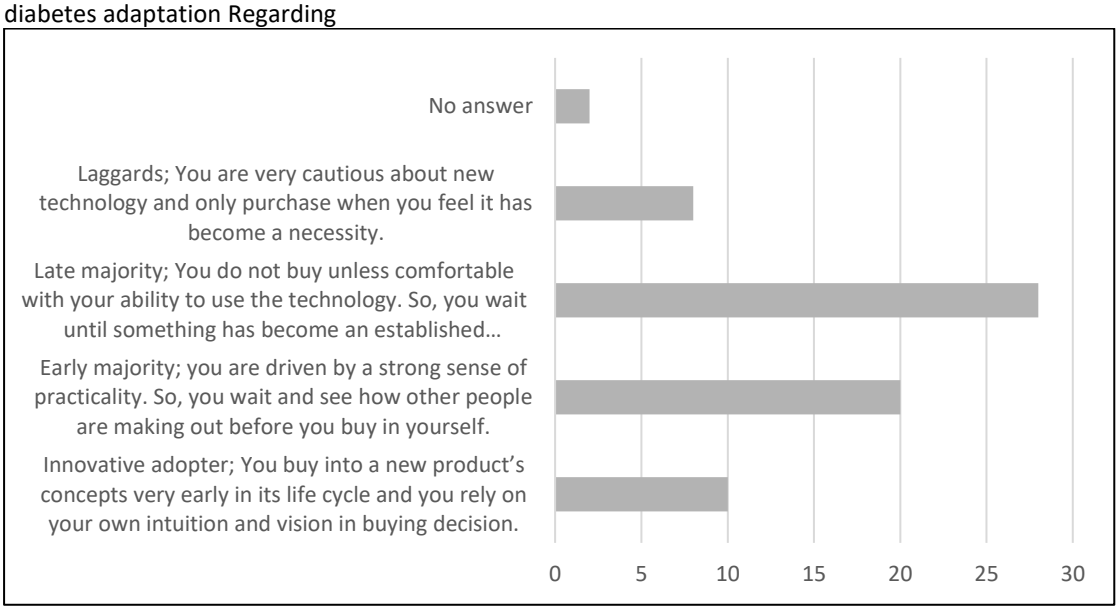


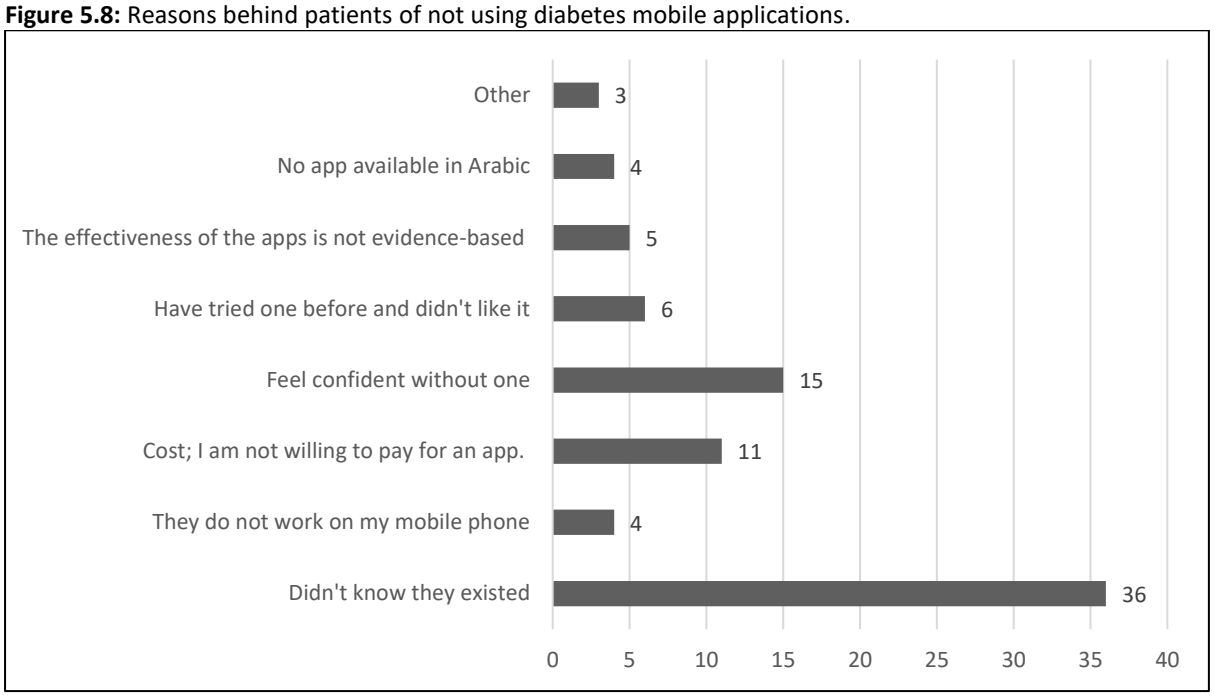
Figure 5.7: Participant classifying themselves regarding and mobile apps for self-management of diabetes adaptation Regarding



The reasons behind patients not using diabetes mobile applications were different (see Figure 5.8). Regardless of the reasons for not using mobile applications, the future intention of most non-users was towards using applications for diabetes self-

management; (n=40) answered yes to 'using these applications in the future', (n=11) answered no, while others were not sure (n=15).

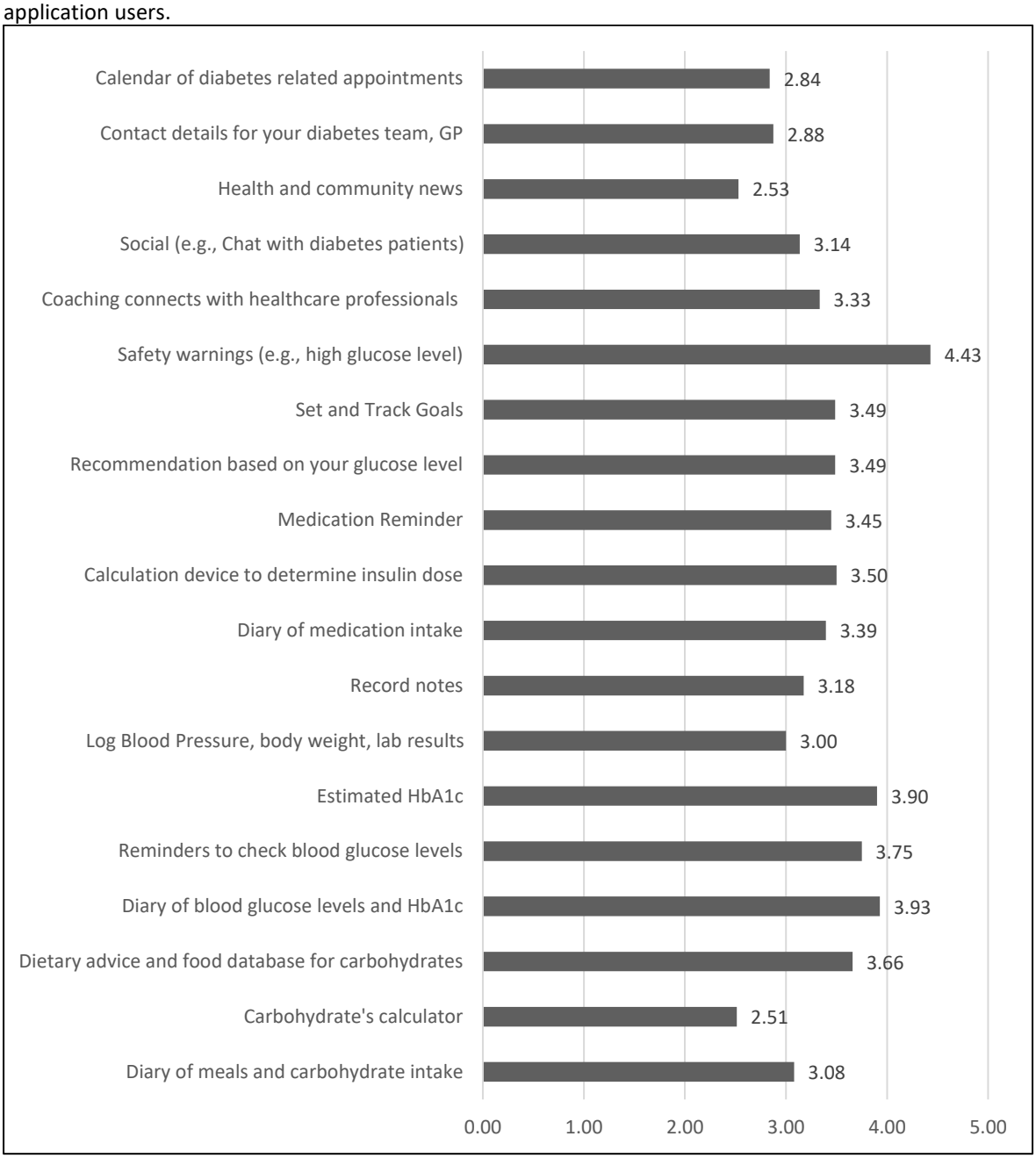
Figure 5.8: Reasons behind patients of not using diabetes mobile applications.



4.3 Preferred Features and Usefulness

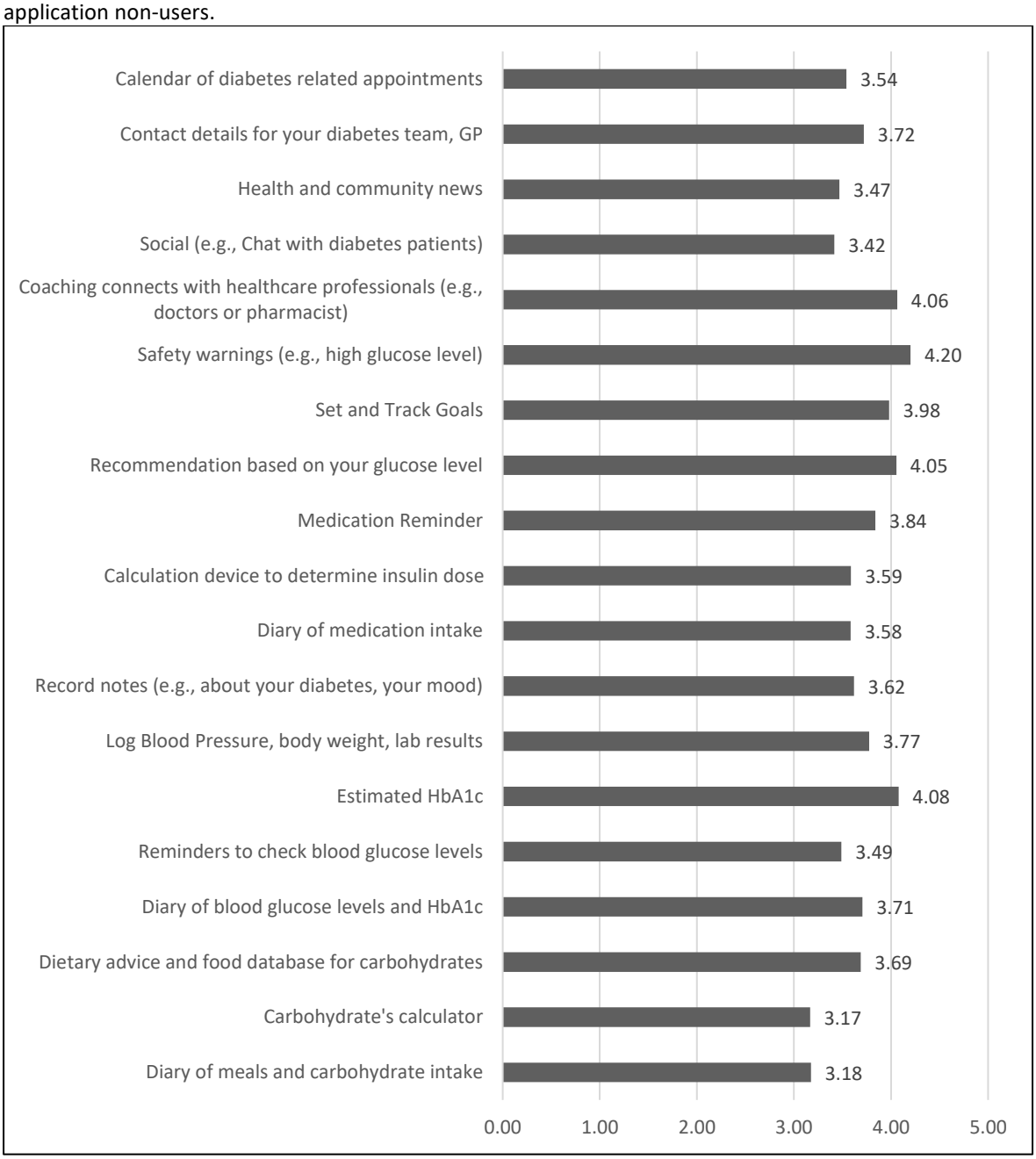
Among mobile application users, preferred features and their usefulness varied. The mean of the 5-Point Likert Scale, after excluding participants who 'did not know', or 'believed these features did not apply to them', or those that did not answer the question, shows the preferred features shown in Figure 5.9 and Figure 5.10 . The highest preferred feature among applications users was safety warning, while the lowest was the carbohydrate calculator. The same interest was seen in non-users: safety warning was the most preferred feature, and the carbohydrate calculator was the least preferred.

Figure 5.9: Preferred diabetes mobile application features* in 5-Point Likert Scale (mean) among application users.



* Features were based on Chapter 4, where diabetes mobile application features were explored in the Google Play store.

Figure 5.10: Preferred diabetes mobile application's features in 5-Point Likert Scale (mean) among application non-users.

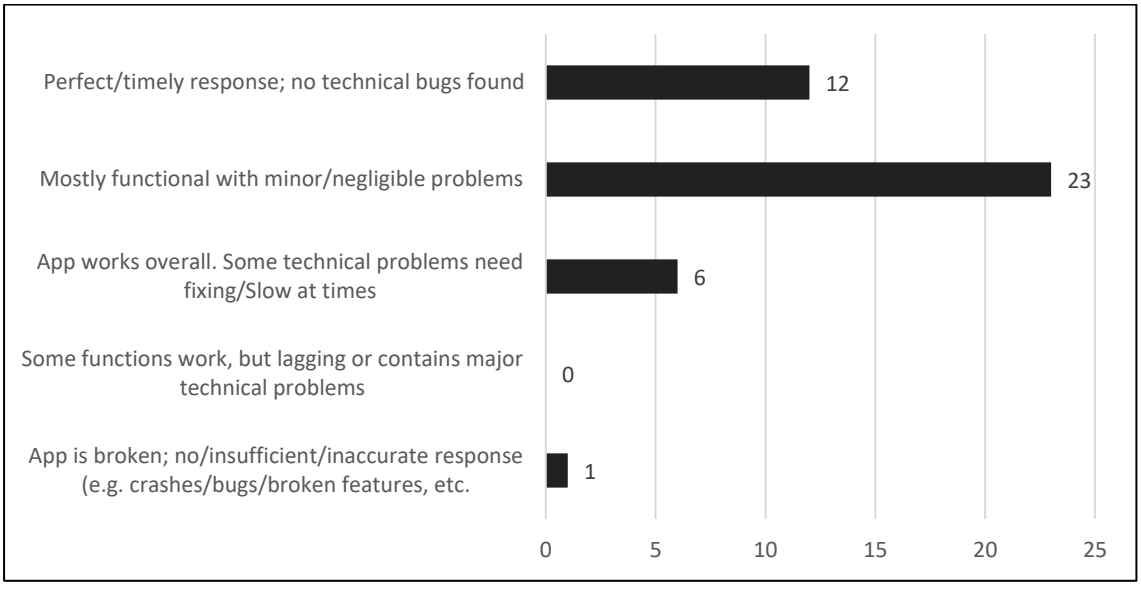


Among app users, the general overall mean of usefulness on the 5-Point Likert Scale of used applications was very high: 4.38 (0.84SD).

4.4 App Design and Ease of Use

According to the apps users group, issues were faced regarding the application design and ease of use. Mobile application users reported several issues: crashing software (n=11), inconsistent results (n=21), problems with units (n=7), difficulty understanding advice given (n=1), results that do not align with other medical advice given (n=1), and (n=18) experienced no problems. When asked how accurately and how quickly the app features (functions) and components (buttons/menus) work, the majority of participants reported negligible problems or no problems at all: the app is broken (n=1), some functions work (n=0), app works overall (n=6), mostly functional (n=23), perfect/timely response (n=12) (see Figure 5.11). The majority believed that their application was easy to learn. According to the 5-Point Likert Scale, the mean was 4.07 (SD 1.09). Most participants believed it was easy to navigate through the app, with a mean of 4.4 (SD 1.058).

Figure 5.11: How accurately/fast do the app features (functions) and components (buttons/menus) work?



4.5 General Comments

The last question was open-ended to allow the participants to add any comments about mobile apps for participants' diabetes self-management. Only 32 participants added comments or suggestions. Of those, (n=8) answered 'no comment to add' and others added comments. These comments varied and there was no particular theme, except the 'lack of awareness about these application' and the lack of 'Arabic applications'. Moreover, some of the points that were added were already covered in the survey, such as the cost of the applications, but participants preferred to explain further. Other participants expressed their gratitude to the research team. One participant highlighted that the applications are not available in all app stores.

5. Discussion

This study aimed to explore patients' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications in supporting diabetes self-management. It has shed light on patients' knowledge, experience, and attitudes about preferred app features, attitudes about app design and the ease of use of diabetes mobile applications in Saudi Arabia. This study may be beneficial for people with diabetes, HCPs, decision makers, application developers, and researchers. As with any research, this research had some limitations.

The survey collected data about demographics, knowledge and experience, app features and usefulness, and app design and ease of use. Of the 277 participants, only 179 were eligible and gave consent. A number of participants started the survey but did not continue, and some completed around half. The reason behind this may have been the length of the survey. The majority of participants (28%) were young (18-25 years) and had type 1 diabetes, which may

show the younger generation's interest in using the technology. However, even older generations showed interest and participated.

AADE 7 self-care behaviour

This study explored what daily tasks are performed by participants according to AADE 7 self-care domains. Not all participant engages in all self-management tasks. However, the highest domain was monitoring (n= 92 participants). This result suggests that most of the used applications will also support monitoring. This may explain chapter 4 results where most of the applications support monitoring.

Knowledge, experience and barriers

Most participants (62%) had installed at least one application to help self-manage their diabetes, while 38% did not install any applications. These results are consistent with previously published studies (62,170) but are in conflict with other published studies (172); this study found that most participants did not know about diabetes mobile apps. Most participants were highly educated, and not being aware of diabetes apps may highlight the lack of awareness and education about diabetes mobile applications. Thus, it is not surprising that only 11% installed these apps following professional healthcare advice, while most reported various other advice sources. These figures suggest that mobile application users rely heavily on themselves rather than on professional advice. Of the participants, 24.5% used mobile applications more than once a day. Mobile applications were used for longer than 12 months by 20% of participants. These results show adaptation in daily life for long term. Most application users faced issues while using applications, such as application crashes, inaccurate results and problems with units. Regardless of these issues, on a 5-point scale, the majority considered mobile applications to be very useful (mean 4.38 SD 0.84). These results are

promising in that any effort spent on developing these applications will benefit people with diabetes. The participants gave many reasons for not using applications; however, most non-users were unaware that these applications existed. Most of these reasons are addressable, such as lack of awareness, availability of Arabic versions and high costs. Other reasons include a lack of trust in the applications. Thus, it is necessary to develop evidence-based software. More importantly, there is a need for an accreditation system. The need for an accreditation system was also supported by data presented on the previous chapter. From an author's point of view, and after working with mobile applications for diabetes for almost four years, the author is unable to recommend any particular applications.

Preferred features and usefulness

Surprisingly, the usefulness of diabetes application features was high in general. The mean of the 5-Point Likert scale ranged from 2.5 to 4.4 for application users. These results were similar to those of the non-users, where the mean ranged from 3.17 to 4.4. The general view was that all participants believed that the presented features in this study were useful. According to the TAM model, usefulness affects adaption. Thus, the high perception that diabetes mobile applications are useful will affect adaption, which is promising. The most important applications features were safety alerts which were 4.43 in the user group and 4.2 in the non-user group. As safety alerts may result in advice for dosing of high-alert medications, Thus, there is a need for applications designed based on evidence.

App design and ease of use

The majority of the participants said they found the application they used easy to learn. According to the 5-point Likert scale, the mean was 4.07 (SD 1.09). Most participants believed it was easy to navigate through the app, with a mean of 4.4 (SD 1.058). By referring to the second item of the TAM – ease of use-, these results are promising and predict future adaptation.

As presented in the introduction and explored in depth in the qualitative systematic review in Chapter 3, there are a few studies comparable to this study (169–171,174,175). No study explored app features as this study does. However, the results of this study regarding barriers to using mobile applications show the same reasons. Lack of awareness that seen in most of studies was the major reason for participants in this study not using an application (n=36). The need for personalised content and alerts that seen regarding diabetes mobile applications among participants in this study was also seen in other diseases such as heart diseases (176,177).

5.1 Implications for Practice

These results may be beneficial for people with diabetes, HCPs, decision-makers, application developers and researchers. By incorporating desirable features in mobile applications in a new evidence-based application, patients can benefit through technology assisted self-care. The majority either do not know about diabetes mobile applications or installed applications with no advice. This may suggest the need for HCPs to educate patients about the applications. The previous chapter; chapter 4, may provide healthcare possessional for an in-depth exploration of what is available and

what they are capable. Even though this study was conducted in Saudi Arabia, its generalisability could extend to other countries with similar demographic populations and levels of access to mobile devices. Decision-makers may understand what patients are looking for and what their requirements are. Also, application developers may have a general idea about patients' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications to support diabetes self-management. By incorporating these results with the results in Chapter 4, where we explored the availability and features of mobile applications in the Google Play Store® for diabetes self-management, the developers could produce an application based on this evidence.

5.2 Implications for Research

Researchers may have recent evidence and identify gaps in this area. The survey in this research was long. It is recommended that future research surveys should take no longer than 10 minutes to complete, to maximise the responses and increase the number of survey participants completing the survey in full. However, as this study developed a comprehensive survey, the survey could be split into two or three surveys. The app's features were analysed based on that were available in the apps already on the market. However, some features should be studied further to determine what people with diabetes need that is not already available. In the research, MARS tools were used with some changes. However, developing tools specialised for diabetes mobile applications will be beneficial for both research and practice.

5.3 Strength and Limitations

The are many strengths of this study. First, it used technology to access a wider range of the population. Second, it is part of a research project dedicated to diabetes mobile applications, where Chapter 4 works as a base to inform survey development. Finally, it used several models and theories; MARS, TAM and AADE 7 self-care behaviours. To the best of our knowledge, no study in the literature has all of these advantages.

During this study, some limitations emerged, including the availability of Arabic applications, the research budget and familiarity with the research environment. When we investigated the availability of diabetes mobile applications (Chapter 4), only two were available in Arabic. Even though some people used English apps, we expected to see a large number of participants who were non-users of diabetes mobile applications. To overcome this, we included both users and non-users and expanded the questionnaire to explore barriers to using diabetes mobile applications. The research budget did not cover travelling to different parts of Saudi Arabia, which is a very large country. However, an online survey helped the researchers access a nationwide population. Participants in Saudi Arabia are not familiar with the research environment; many participants started the survey but refused to consent. We tried to overcome this by waiting for longer periods and communicating through a specialised diabetes Twitter account. Some of these accounts had more than 50K followers and encouraged people to participate, which helped us to reach our target. Moreover, most of the limitations' effect was minimised and may not affect the results. Thus, the strength of the evidence is believed to be high with low bias.

5.4 Conclusion

Most of the study participants used mobile applications and considered them to be very useful and easy to use, regardless of the issues that some of them faced. Also, non-user groups show the same interest. The general view that emerged from this study was that diabetes mobile applications are useful and easy to use, and this will affect future adaption based on TAM theory. In the previous chapter, the results suggested that participants may need to install different applications to perform daily tasks. The results of this chapter confirm this. Thus, the availability of applications that cover most of the daily tasks based on AADE 7 self-care behaviours needed by people with diabetes will minimise the need for installing many applications. Further efforts should be made to design and develop an application that meets users' expectations and is based on evidence. Moreover, awareness of mobile applications needs to be raised for people with diabetes. Finally, research and practice may benefit from developing tools for diabetes self-management applications based on MARS.

CHAPTER 6:

Explore Healthcare Professionals' Beliefs, Experiences, Attitudes And Knowledge of Using Diabetes Mobile Applications in Supporting Diabetes Self-Management.

ABSTRACT

Objective: This study aimed to explore healthcare professionals' beliefs, experience, attitudes and knowledge with regard to patients' use of mobile applications in supporting diabetes self-management.

Method: The AADE 7 Self-Care Behaviour® model and the TAM model was utilised to develop a web-based questionnaire. This questionnaire was administered online through different social media platforms and targeted Saudi Arabian healthcare professionals (HCPs) who are familiar with the use of mobile technology and work directly with people with diabetes. The data collection started in February 2022 and lasted for two months. Ethical approval was obtained prior to data collection.

Result: Of the 89 survey participants, only 71 were eligible. Their various roles included physician (15%), pharmacist (22%), nurse (13%), dietician (25%) and diabetes educator (10%). Of those, only 30% had recommended the use of a mobile app to their patients. The reasons for their recommendations included that the apps are helpful for patients (46%), easier for counting carbohydrates and dose calculations (27%), cost-free (18%), and that they make it possible to track patients' health (20%). However, several reasons prevented HCPs from recommending the apps, including that they have no effect (8%), they have no information about diabetes apps (25%), the effectiveness of the apps is not evidence-based (6%), they are busy and have no time to make recommendations (3%), and that there are numerous apps and they do not know which one is suitable (18%).

Conclusion: A limited number of HCPs recommend mobile applications for their patients even though they believe that diabetes mobile applications are useful. Further effort should be

made to design an application that meets users' expectations and fixes the issues that cause concern.

1. Introduction

During the first stage of this project, two systematic reviews were conducted. The first systematic review explored the nature and effectiveness of mobile and web applications to support the self-management of type 1 and type 2 diabetes. The second systematic review explored patients' and healthcare professionals' (HCPs') perspectives of mobile and web applications to support the self-management of type 1 and type 2 diabetes. In the second systematic review, only eight studies were eligible for inclusion(62,169–175) and these were conducted in different countries. Only three studies explored HCPs(62,172,173). However, none of these studies investigated the Saudi Arabian population on, and HCPs' perspectives of, mobile apps in support of diabetes self-management. This systematic review resulted in four themes. Only two of these themes were related to HCPs; (1) Theme 2: Factors affecting HCPs' use and recommendation of mobile apps (2) Theme 4: HCPs' experience and attitudes towards mobile apps. Based on the systematic review results, we would like to explore the use of mobile applications in support of diabetes self-management by patients in the Saudi Arabian population. To the best of our knowledge, and from our second systematic review, no previous study has explored HCPs' perspectives on the use of mobile diabetes self-management applications in Saudi Arabia. The literature gives no precise classification for diabetes self-management applications. In our previous phase of this research, we explored the availability and features of mobile applications for the self-management of diabetes in the Google Play Store® (Android™) for adults with type 1 and type 2 diabetes. Based on the findings of the previous chapter, there appear to be three distinct classifications of

mobile applications based on their features. First, applications offer support for healthy living linked to better diabetic and prevention outcomes, such as physical exercise, but they are not specifically designed for diabetic patients. Second, some applications have been designed specifically to support diabetes self-management; they may, or may not, calibrate with other devices, but there is no obligatory requirement to use them with the application, such as Bluetooth calibration with a glucometer. Third, some applications have been designed to support a feature of diabetes self-management, but cannot work without a device such as Dexcom G6®, a continuous glucose monitoring system, which requires sensors and a transmitter (see Table 6.1).

Table 6.1: Diabetes App classification based on their end-user group and applications' features.

Group	Group 1	Group 2	Group 3
App Features	Apps that support some of diabetes self-management daily task	Apps designed to support some of diabetes self-management daily task	Apps designed to support some of diabetes self-management daily task
Requirements	--	Works with or without external device	Works only with external device
Target Group	For any end-user	People with diabetes	People with diabetes
Examples	Fitbit®	One Drop® or Jade® Diabetes	Dexcom G6® Or Freestyle libre®

For this study, and based on the FDA definition of 'health mobile app' and the AADE 7 Self-Care Behaviours®, mobile applications will be defined as *'Any application that can be executed on a mobile platform by direct installation from mobile app stores, which is used by a patient to provide a support for any diabetes self-management area in accordance with AADE 7 self-management behaviour, and can be used with or without an external device.'*

Based on this definition, our study will exclude 'apps category one', in which these applications were not designed specifically for diabetic patients.

2. Aim and Objectives

The aim of this study was to explore HCPs' beliefs, experience, attitudes and knowledge in regard to the use of mobile applications in supporting diabetes self-management by patients in the Saudi Arabian population. To achieve these aims, the following objectives were set:

Objectives

(1) To explore Saudi Arabian HCPs' knowledge about the availability of diabetes mobile applications

(2) To explore Saudi Arabian HCPs' beliefs in regard to the usefulness of mobile applications in the self-management of diabetes by patients (the reasons behind patients using – or not using – diabetes mobile applications)

(3) To explore Saudi Arabian HCPs' attitudes towards the use mobile applications for diabetes self-management by patients (preferred features)

(4) To explore the reasons for the recommendation and non-recommendation of mobile applications for diabetes self-management to patients and associated reasons from the perspective of HCPs

3. Method

To enhance quality and follow good academic practice, a protocol was written and agreed with the supervisors prior to conducting this study. The protocol was submitted to the ethics committee, which requested some amendments to the protocol and survey. The piloting

and actual data collection began after obtaining full ethical approval form the University of Birmingham. The approval reference number is RN_21-1237.

3.1 Design, Setting and Recruitment

Design:

A web-based survey was developed for this study. There were several reasons for opting for this type of survey. This study aimed to reach HCPs across a large geographical area in Saudi Arabia. During initial discussions, an interview study was considered. However, interview studies do not allow access to a wider population. Also, we built in previous qualitative studies. A mailed survey was another option; however, this method would require a sampling frame and participants' addresses, which were not available, so this mode of administration was not used. After comparing other survey methods' advantages and disadvantages, such as postal, telephone interview, and face-to-face interviews, an online survey was identified as the most appropriate method based on the research aims, objectives, settings, time and research budget. This study used a web-based, explorative online questionnaire.

Settings: In 2020, according to The World Bank, more than 97.8% of the Saudi Arabian population were using the internet in their daily lives(206) compared to 77% across the world's population(207). Moreover, approximately 112.7% of the Saudi Arabian population were users of mobile devices in Jan 2021, which suggests that some people have more than one mobile device(208). These figures show how the internet is part of daily life and that using it as a platform for the research of diabetes mobile

apps is beneficial. In this study, the setting included any region in Saudi Arabia as the surveys were administered online.

Participant identification and recruitment:

As this study relates to an online survey, all eligible populations in Saudi Arabia were able to participate. Therefore, non-probability sampling is the closest description of the sampling strategy we used. In addition, participants could distribute the survey link with other eligible people, enabling us to utilise snowball sampling methods.(205,209) Through non-probability sampling, the target population was recruited by providing a link for this survey, which was posted on several internet social media platforms such as Twitter. Also, specialised diabetes accounts on Twitter, such as T1D and Diabetes Support Group SA, were contacted to distribute the link. Snowball sampling was also used by asking the participants at the beginning and at the end of their survey to share it with people who they knew had diabetes. We expected a fast response as no time was needed for mailing. Thus, the survey was opened for participation in Feb 2022. It would close after two months or when it reached 100 participants. After two months, we reached 89 responses and the survey was closed.

Sample Size Estimation: No similar studies related to diabetes mobile applications had been undertaken in Saudi Arabia, so it was not possible to estimate a similar population. However, a national web-based survey in Saudi Arabia, related to COVID-19 vaccine acceptance, reported 992 responses(210). Similar studies had also been carried out elsewhere(62,211,212), and reported between 98 and 746 responses. For

online surveys with an open population, Sue et al. suggested that the sample size should be between 30 and 500(205). Thus, based on this previous evidence, we aimed to obtain 100 responses from the HCP surveys.

Inclusion criteria:

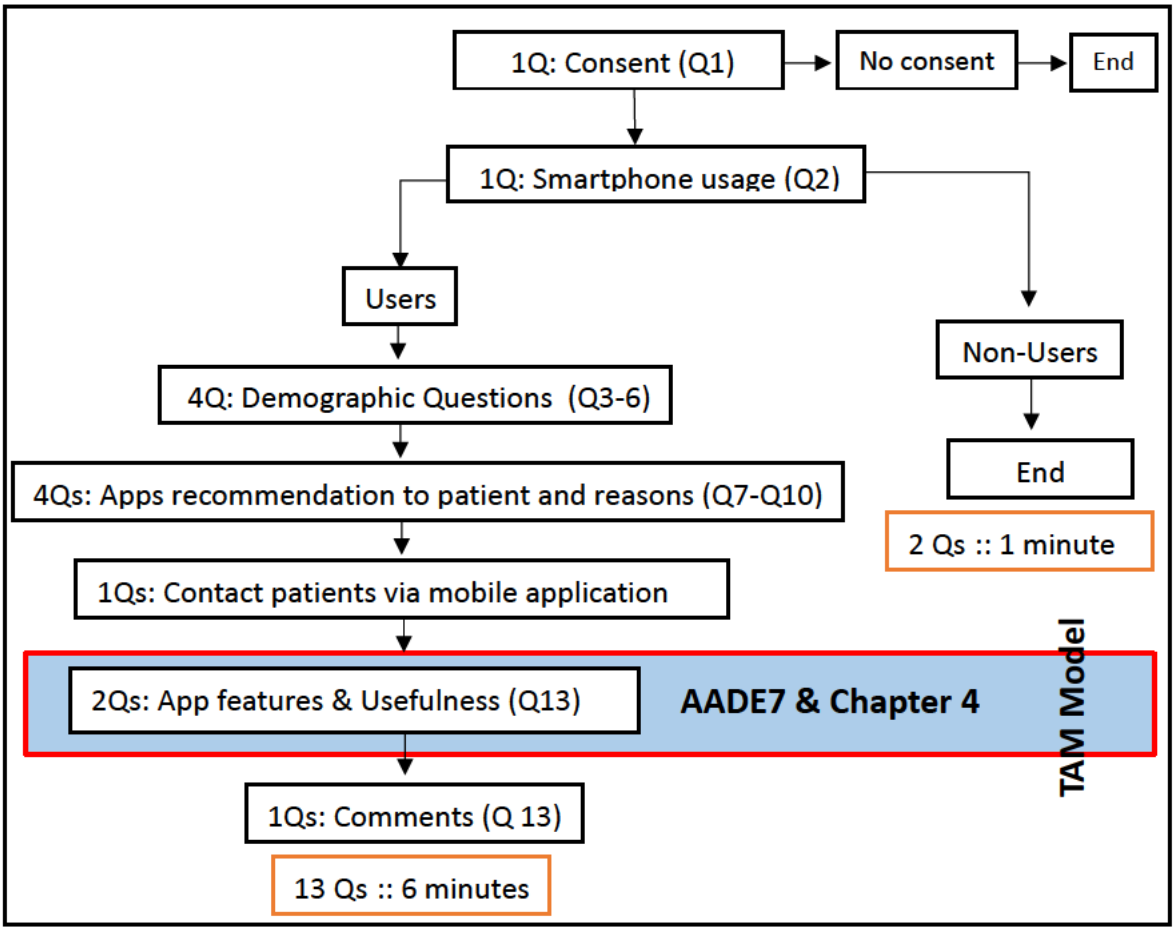
- Healthcare professionals who worked directly with diabetic patients of type I or type II either by treatment, providing advice or education, inlcuding physicians, pharmacists, dieticians and educators.
- Participants had to be Arabic speakers as their native or second language.
- Participants had to be to be familiar with mobile devices by using at least one mobile platform (Windows mobile, Android or iOS) for more than three months.
- Participants had to be a resident in Saudi Arabia.

3.2 Survey Development, Validation & Data collection

Because this research was intended for an Arabic speaking population, the survey was developed in English and then translated into Arabic by AA as he is bilingual. To ensure the accuracy of the translation, we recruited a certified translator to back-translate the survey into English. Through discussion with the supervisory team, we assumed that, if the translator was able to provide an English version close to the original, then the translation was accurate. The certified back-translated version – see Appendix 6.3 – was very close to the original, so the supervisory team approved the survey to proceed to the next step – piloting.

The AADE 7 Self-Care Behaviour® model and the TAM model and published literature were utilised to develop a web-based questionnaire. The initial survey was adapted from a similar study conducted by Boyle et al.(62) but some changes were made to advance the survey and build on the previous studies through this project (see Chapters 3 and 4). Diabetes management domains and app features were organised according to the AADE 7 model (17,18,110,213). Boyle's study was limited to nine app features. However, when we investigated diabetes mobile apps and their features, one of the objectives was to inform data collection tools on diabetes application features. Thus, comprehensive results of app features that came from a previous study were used instead of Boyle's study. Another measurement item adapted from other studies was related to barriers to mobile app use (169,173). As the survey was explorative, an open-ended question was added to all applicable questions. The final question was dedicated to an open-ended free text box in which participants could comment on any aspect related to diabetes self-management applications. The survey collected data to answer the research aim and objectives, including demographic data, the participants' beliefs, experiences, attitudes and knowledge in the use of mobile applications, app recommendations and reasons, using apps, preferred features of apps and their usefulness. The questions were a mix of multiple-choice questions, binary Yes/No questions and the Likert 5-point scale. Contingency questions were used to exclude smartphone non-users – please see Figure 6.1 and Appendix 6.1.

Figure 6.1: Measurement items, contingency question flowchart, and how items related to theories and other studies in this project.



The survey was reviewed within the study team including the back translation. A pilot version was conducted with 10 patients to ensure the validity of the survey in terms of time taken and the clarity of questions to avoid bias. Patients were recruited through the personal and professional network of the research team. In the pilot version, the participants offered a telephone number, email and WhatsApp® to AA so they could call if they faced any problems, needed any clarification, or wanted to make comments. Outcomes of the calls and feedback were summarised and discussed with the supervisory team – please see Section 3.7 (the pilot). Based on the pilot results and team discussion, the original survey was amended. The final

version was reviewed again by the supervisory team and was sent to the ethics committee for approval. Finally, after approval was granted from the ethics committee, the final version conducted the survey using online software.

3.3 Software (Tools)

A variety of software was used during this study. LimeSurvey™ is an approved online survey tool by the IT department at the University of Birmingham. It is classified as a safe tool and is hosted on the University of Birmingham's servers, which made it a good consideration. More importantly, it supports the Arabic language and right-to-left mode of transcription. Thus, it was used to design the survey and collect data from the participants. Other survey software was considered, included Survey Monkey and JISC online surveys. However, these were rejected because they either were not approved by the university or did not support Arabic. Mendeley™ was used for document management based on the Windows 11® system. Microsoft Word® 2021 was used for report writing.

3.4 Data Analysis

Because we used non-probability sampling, we were not able to use inferential statistics. Thus the study's generalisability was viewed with caution when discussing the results. However, the main aim was to explore rather than generalise, so a descriptive statistics synthesis approach was used to analyse and present these data using text, tables and charts. A comparison was carried out between HCPs who recommend diabetes mobile apps and HCPs who do not make recommendations. Also, tables and graphs were used to show the reasons for recommending and not

recommending diabetes mobile apps. Finally, HCPs' attitudes about the usefulness of diabetes mobile features were presented.

3.5 Ethics & Governance

This study followed good research ethics practice by developing a proposal that followed Saudi Arabian law (215) and the University of Birmingham' research governance frameworks(216,217) in terms of anonymity, confidentiality, consent, data storage and incentives.

Anonymity and Confidentiality: No personal data was collected that could identify the participants (e.g. email or mobile number). The survey was anonymously conducted online. In addition, participants' mobile device operating system data, such as IP location, were not collected. All options on the online software were set to not use cookies. Thus, by using an online survey, not collecting personal data, using a sampling method with no sampling frame and no device data collected, participants' anonymity and confidentiality were completely protected. There was no risk of breaching this before, during or after the data collection, as there were no means of identifying the participants. The anonymity and confidentiality information was made clear to the participants in the survey introduction – please see Appendix 6.1. No personal or sensitive questions were asked. Thus, no potentially adverse effects on the participants or researcher were anticipated.

Informed Consent: Informed consent was included on the data collection form and was obtained by first asking participants if they agreed to participate. It was made clear to the participants that clicking on the 'proceed' button and answering the

question with 'yes' would be considered consent. The participants had the right to exit the survey at any time or not press the submit button at the end. Ethical approval was obtained through the University of Birmingham. Registration number: ERN_21-1237. Albaha University in Saudi Arabia confirmed that there was no need to apply for ethical approval in Saudi Arabia. No piloting or data collection began before obtaining the full approval of the proposal according to Saudi Arabian law (215) and the University of Birmingham's research governance frameworks(216,217).

Data storage: Data was stored, accessed and archived in compliance with the University of Birmingham research and data protection policy and code of practice(216,217). A primary copy of the data was stored on password encrypted computers. Several backups were done bi-weekly, and were sent to the supervisors for storage. A monthly check for backup data was done. Online survey data was stored on university servers for the duration of the project. It was also downloaded and sent to supervisors for backup bi-weekly. It will be downloaded, archived and deleted from the online platform after the PhD is complete. All data will be archived at the end of the PhD study and will be stored for 10 years, as required by university policy, in the university data archive: university BEAR Research Data Store (RDS). The data will be accessible to the research team.

Incentives: No incentives were offered.

3.6 Online Survey Developed

LimeSurvey Community Edition, Version 3.27.9+210726 was used for the online survey design. This version is open source and hosted on the University of

Birmingham's servers. All introductions, instructions, and questions were added as they appear on the proposal. Conditions were added to questions to manage contingency. The survey hid and displayed questions based on the participants' responses. The survey ended if the participant was not eligible. Conditions followed the same chart mentioned previously (please see Figure 6.1). While the online survey was being designed, some technical issues required contact with the university IT department. The issue was related to an internal server error and the survey webpage's availability. The IT department fixed these issues before the pilot began.

3.7 Piloting

The pilot lasted for 12 days as it started on 2/2/2022 and was completed on 14/2/2022. When the survey was activated, it asked whether the survey would be anonymised. This option would add a note about anonymisation and tokens on the survey's introductory page, which was not on the original introductory page approved by the ethics committee. Also, the note about tokens could confuse the participants. Given that all options that anonymised participants had already been activated, a decision was made to not opt for anonymisation. According to the LimeSurvey website (218), this option did not allow the participation date or time to be collected so a token would be saved on a separate database. Using the survey's option, the date and time of the participation were set to not be recorded. Tokens were not used in the survey distribution. After a discussion with the supervisory team, this decision was confirmed. The survey's settings was the same as the patients' survey. Please see Appendix 5.4.

During piloting, notes were taken for the participants' comments. A meeting with the supervisory team was set to discuss these notes and changes. After the meeting, it took several days to reach 10 responses. However, no new notes were obtained. After this, data was exported, and the online version was deactivated so the changes could be addressed. In total there were 10 responses: nine full response and one partial response. The notes were categorised into survey and technical issues.

Survey issues: There were some spelling errors spotted by participants and these were fixed.

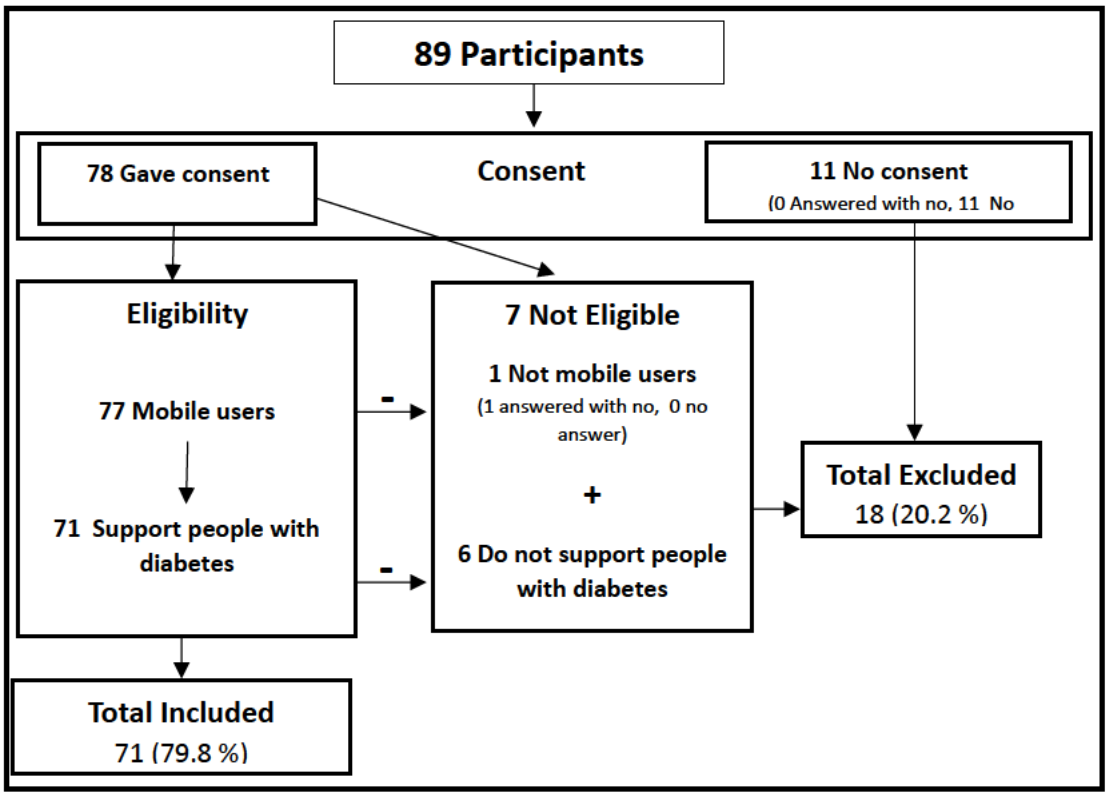
Technical issues: During the pilot, only three technical issues were faced: partial response, survey availability and the back button. For the first issue, the survey recorded answers page by page even if the participant did not reach the final page and press the submit button. This was recorded as a partial response. There was no way to change this option on the software. However, the ethics committee were informed about it. For the second issue, one of the participants had a problem with the survey's availability. This issue fixed itself after the participant made a second attempt a minute later. Finally, the participants asked for a back button to be included, and this option was activated.

All of these minor amendments were sent to the ethics committee to obtain approval. These were all addressed and tested before activating the survey for actual data collection, which started in February 2022 and lasted for two months as planned.

4. Results

In total, 89 participants started reading the introductory page of the survey and hit the start button. Only 71 (79.8%) were eligible and included in the analysis – please see Figure 6.2.

Figure 6.2: Details of participants' eligibility based on inclusion criteria.



4.1 Demographic

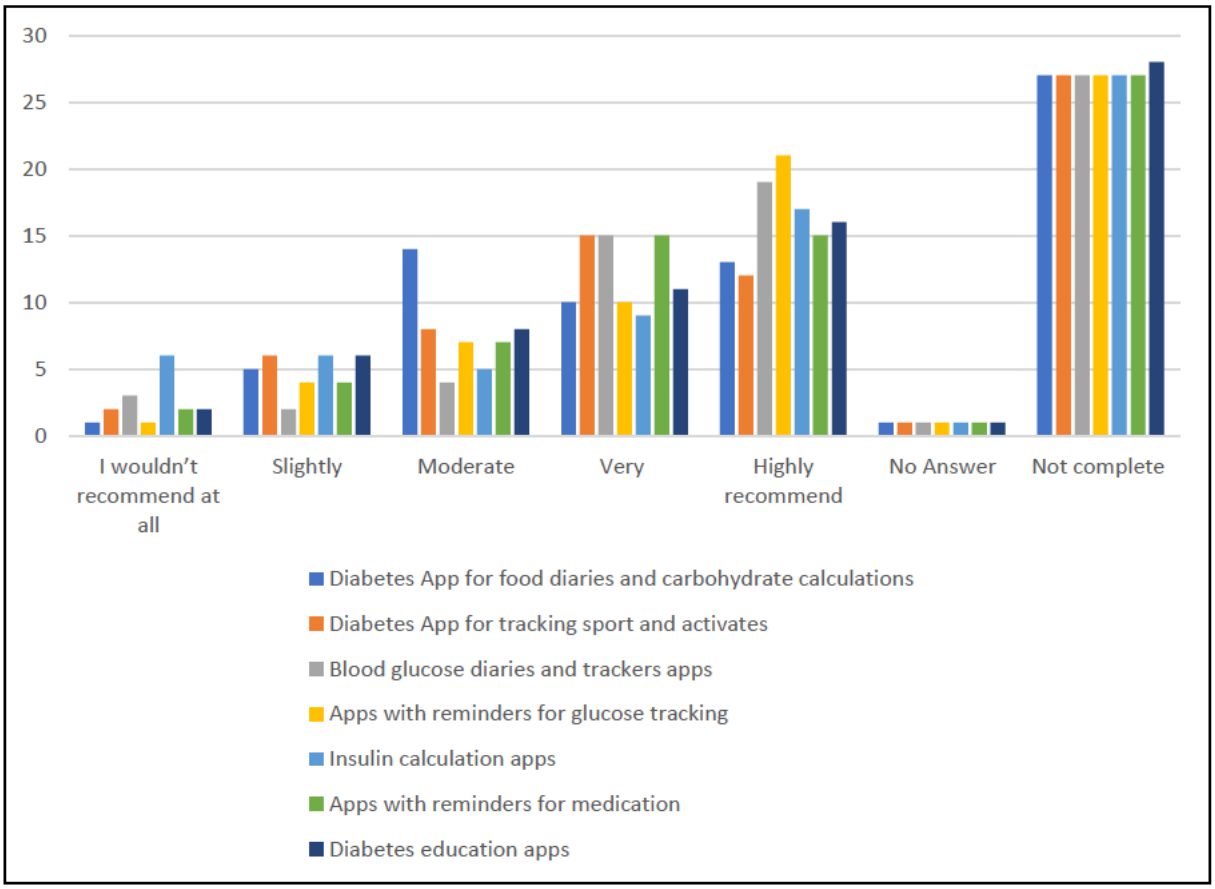
Of the included participants, (n=11) were doctors, (N=15) were pharmacists, (n=9) were nurses, (n=18) were dieticians, (n=7) were diabetes educators, (3) stated they were 'other', while (7) did not complete the survey at this point. Some participants (n=6) made comments about their role as they had more than one. The majority of participants were in the youngest age group 26–35 (n=42), then 36-45 (n=11), 46-55 (n=4) 56-65 (n=4). Only one participant was aged over 65. The number of years that participants spent supporting people

with diabetes varied; one year or less (n=18), 2–5 years(n=22), 6–10 years (n=12), more than 10 years (n=12).

4.2 Healthcare Professionals' Recommendations

Approximately half of the participants recommended diabetes self-management applications (n=21) while (n=23) never recommended these applications. Surprisingly, (n=27) did not complete the survey at this stage. Among participants who recommended such apps, (n=19) gave names of the application they recommended. The application that were recommended were Dexcom (n=3), FreeStyle Libre (n=5) , OneDrop (1), My dose coach (1), One touch verio (1). Others participants gave categories rather than specific application name. Several reasons given for recommending an application: 'helpful for patients' (n=33), 'easier to accomplish complicated tasks such as carbohydrate counting or dose calculations' (n=19), 'no cost for patients' (n=13), 'I can track my patients' diabetes management online' (n=14), and 'other' (n=5). Other comments included: 'never thought about using technology' (n=1), 'increased quality of life' (n=1), and 'not applicable' (n=3). Many reasons prevented HCPs from making recommendations: 'apps have no effect on patients' clinical outcomes' (n=6), 'I have no information about diabetes apps' (n=18), 'the effectiveness of the apps is not evidence-based' (n= 4), 'I'm busy and have no time for a recommendation' (n=2), 'apps are numerous so I do not know which one is suitable' (n=13), and 'other' (n=9). 'Other' comments included 'no information about Arabic application' (n=1), 'patients are too old to use technology, and 'not applicable' (n=3). Recommendations based on application groups were varied among participants (see Figure 6.3).

Figure 6.3: Healthcare professionals' recommendations based on application group.



4.3 *Experience*

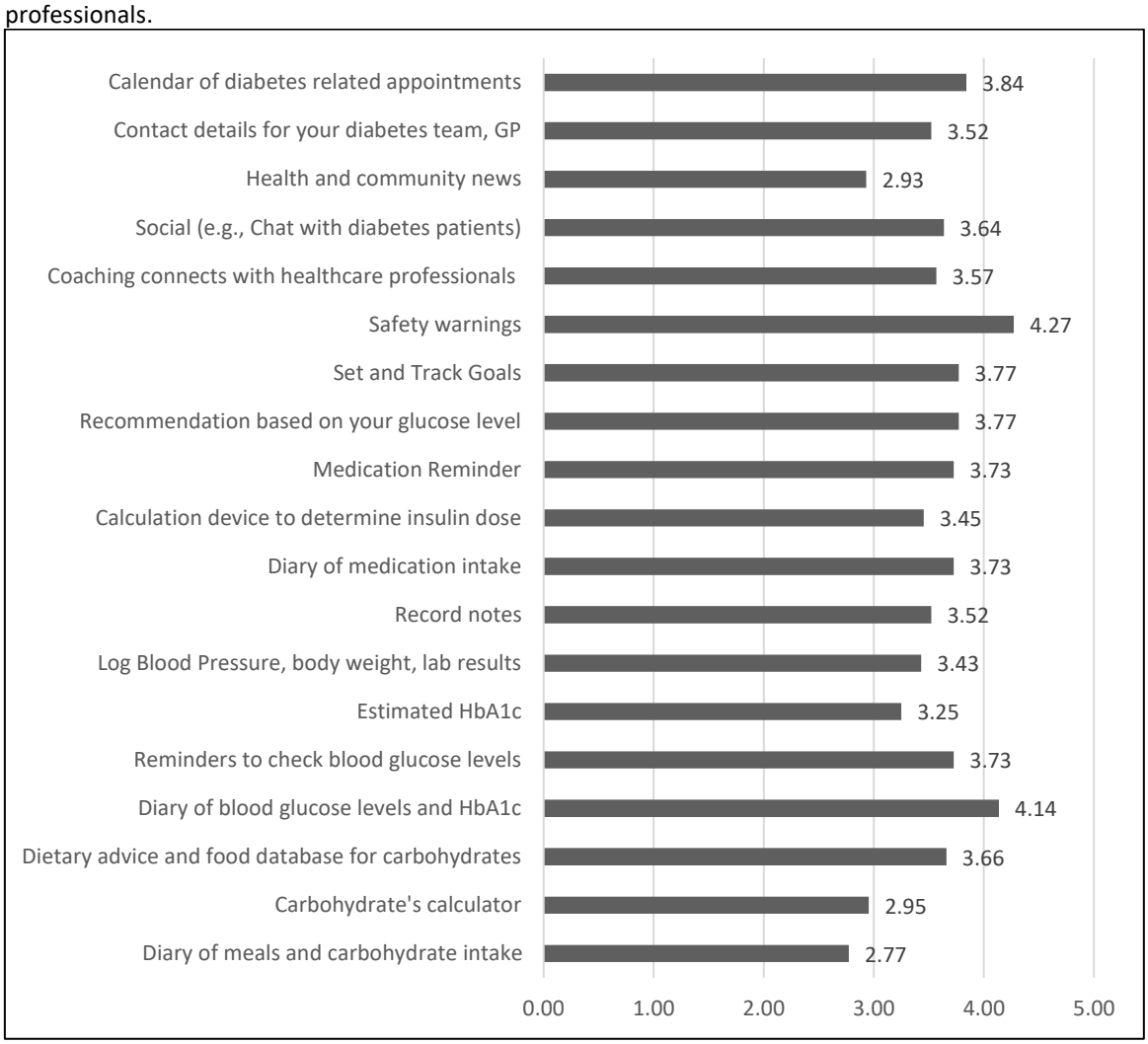
Participants reported different experiences regarding contacting people with diabetes or viewing their data through a smartphone application. The majority of participants never experienced these (n=23) while others did contact someone or see data online (n=13). However, (n=13) did not know these applications. For all participants who showed patient data, the focus was on continuous glucose monitoring: Dexcom® or FreeStyle LibreLink®.

4.4 *App Features' Usefulness*

The features preferred by HCPs and their usefulness varied. The mean of the 5-Point Likert scale, and after excluding participants who did not know these features were not applicable

to them or did not answer the questions, are shown in Figure 6.4. The highest preferred feature was 'safety warning' while the lowest was 'Diary of meals and carbohydrate intake'.

Figure 6.4: Preferred diabetes mobile applications' features in 5-Point Likert Scale (mean) among healthcare professionals.



4.5 General Comments

A final open-ended question was asked regarding participants' comments about mobile apps for diabetes self-management. Only (n=9) particpants chose to answer this question. These results varied between suggestions, experience or thanking the research team. The suggestions included: HCPs' not educated about apps and most applications lack features mentioned on the survey. Others shared their experiences as they believed

that these applications are very useful with uncontrolled cases. Others believed that any application that does not educate people with diabetes about insulin dose adjustment is not useful.

5. Discussion

This study aimed to explore HCPs' beliefs, experiences, attitudes and knowledge with regard to patients' use of mobile applications in supporting diabetes self-management. The number of participants was within the planning; however, around 34 participants stopped completing the survey partway through. There are no apparent reasons for not completing the survey. However, no cookies were used and consequently, progress could not be saved. So, due to the HCPs' busy professional lives, if something interrupted the survey, it would need to be started again from the beginning, which participants may deem to be a waste of time.

Healthcare professionals' recommendation

The general impression that emerged from this study is that only 30% had recommended using a mobile app to their patients. Most of the recommended applications were continuous glucose monitoring applications (CGMs), so it is unclear whether these recommendations were intended for CGMs technology in general or whether they chose these applications specifically. If an HCP recommends CGMs, there is no option but to use the application provided with the sensor. Only two CGM applications were recommended, and only two were available in Saudi Arabia while conducting the study.

There were several reasons behind the application recommendations: the apps are helpful for patients (46%), they make it easier for a patient to count carbohydrates and calculate their doses (27%), they are cost-free (18%), and make it possible to track patients' health (20%). The top reason 'apps are helpful for patients' is supported by HCPs' preferred diabetes mobile application features in the 5-Point Likert Scale (mean) and their perception of usefulness, which was at least 2.9 out of 5 for all of the 17 listed features. The HCPs' attitudes towards diabetes mobile applications were positive and promising. However, many reasons prevented HCPs from making a recommendation. The top two reasons were that they either had no information or were confused about which application was suitable. These findings confirmed our results from a previous study (Chapter 4) in which we suggested that there was a very high number of applications that patients and HCPs may find overwhelming without guidance or an accreditation system in place. Additionally, reasons that prevent HCPs from recommending align with previously published studies(169,172).

Experience

The majority of participants never contacted their patients through a diabetes mobile application. However, a quarter of the participants did not know about these applications. Participants who saw patient data stated it was for continuous glucose monitoring, either Dexcom ® or FreeStyle LibreLink®, which suggests no applications are used for support, coaching or virtual appointments.

App features' usefulness

The general image was that all participants believed the presented features in this study were useful. According to the TAM model, usefulness affects adaption. Thus, the perception that diabetes mobile applications are useful will affect their adaption. It is promising that every effort in developing software will be useful and adapted by end-users. The highest preferred feature among HCPs is safety warning, the same as the patient in the previous chapter. As safety alerts may result in advice for dosing of high-alert medications, Thus, there is a need for applications designed based on evidence.

As presented in the introduction and explored in depth in the qualitative systematic review in Chapter 3, a few studies are comparable to this study(62,172,173). No study explored app features as this study does. However, the results of this study regarding recommendations for using mobile applications show the same reasons. Surprisingly, HCPs in Saudi Arabia consider applications to be low cost in line with the previous studies. However, the patients in the previous chapter and other previous studies (169,170,172) consider the cost a barrier. This result may suggest that HCPs not aware of the actual cost.

5.1 Implication for Practice

These results may benefit HCPs, decision-makers, application developers, and researchers. By incorporating desirable features in mobile applications, HCPs can benefit through technology-assisted communication. Even though this study was conducted in Saudi Arabia, its generalisability could extend to other countries with similar demographic populations and levels of access to mobile devices. Decision makers may know what HCPs are looking for and their requirements. Application

developers may have a general idea about HCPs' beliefs, experiences, attitudes and knowledge with regard to patients' use of mobile applications in supporting diabetes self-management. By incorporating these results with the result in Chapter 4, in which we explored the availability and features of mobile applications in the Google Play Store® for diabetes self-management, an evidence-based application could be developed.

5.2 Implications for Research

Researchers may have recent evidence and gaps in this area. We analysed the features that were available in apps on the market. However, some features discussed previously (Chapter 4) should be studied further to determine what HCPs need and what is not available. The analysis of applications' features should cover all aspects of diabetes self-management as recommended by AADE 7 self-care behaviours. Future research should allow online surveys to be saved and the use of cookies where possible and allowed by law. This may minimise partial responses.

5.3 Strength and Limitations

The are many strengths of this study. First, it used technology to access a wider range of the population. Second, it is part of a research project dedicated to diabetes mobile applications, where Chapter 4 works as a base to inform survey development. Finally, it used several models and theories; TAM and AADE 7 self-care behaviours. To the best of our knowledge, no study in the literature has all of these advantages.

While working on this study, some limitations were raised, including the research budget and the partial responses. The research budget could not cover travelling to different parts of Saudi Arabia, as it is a very large country. However, using an online survey helped to access the wider national population. The partial responses could be due to not allowing the participant to save the progress in their survey. However, this option was chosen to protect patient privacy and encourage participation. Moreover, most of the limitations' effect was minimised and may not affect the results. Thus, the strength of the evidence is believed to be high with low bias.

5.4 Conclusion

A limited number of HCPs recommend mobile applications for their patients, even though the belief is that diabetes mobile applications are useful. The general view that emerged from this study was that diabetes mobile applications are helpful, and this may affect future adaption based on TAM theory. Further effort should be made to design an application that meets HCPs' expectations and fix the issues that cause concern. Additionally, these applications should be based on evidence and designed based on a theory or model such as AADE 7 self-care behaviours to cover all self-management tasks. Moreover, awareness of mobile applications needs to be raised for HCPs. Finally, feature research should explore diabetes mobile application features that are unavailable on the market and needed by HCPs.

CHAPTER 7:
General Discussion

1. Overview

This project aimed to explore the efficacy and availability of and perceptions towards using mobile applications in diabetes self-management in Saudi Arabia. Through five studies, several aims and objectives were set, and different methodologies were utilised with various results and implications. However, the integration of these studies' results gives a better understanding and makes the thesis coherent, so it provides a better explanation for its implications for practice, software development and research, and lessons were learned. Most studies have no geographical limitation except the last two studies, chapters 5 and 6. Even though the final two studies (Chapters 5 and 6) were conducted in Saudi Arabia, their generalisability could extend to other countries with similar demographic populations and levels of access to mobile devices. As with any research, this project had strengths and limitations, which will be discussed in this chapter in general terms; the details of the limitations are discussed separately in each chapter. Finally, the results, implications, limitations, and opportunities helped inform future research and draw a general conclusion.

2. A Summary of The Findings and Integration of The Results from All of The Studies

The first systematic review study aimed to explore the nature and effectiveness of mobile and web applications to support the self-management of type 1 and type 2 diabetes. Only 13 studies met the inclusion criteria(111–123), of which 11 RCTs and two were

observational studies. The general picture emerging from this study is that mobile and web applications that support diabetes self-management have various features. Classification of the intervention's features, according to the AADE 7 Self-care Behaviour® domains, showed that most of these applications support some diabetes self-care activities: healthy eating (77%), physical activity (61.5%), monitoring (77%), taking medications (38%), reducing risks (30%), and healthy coping (23%). None of the applications supported problem solving. More importantly, no application supports all self-care activities. In general, most applications support three to four domains only. It is worth highlighting that there may be various features within a domain itself. For example, monitoring could be blood glucose, lab results or clinical outcome monitoring. Thus, if two applications support monitoring does not mean they support the same self-care tasks. This may lead to a question of how these applications were developed. It is out of the scope of first systematic review to assess the quality of the used applications. However, design guidelines and application availability data were extracted. Only three applications were designed based on guidelines, theory or model (111,118,119). This may lead to a concern about the quality of the software used. In the same context, two studies developed applications for the research, and three gave no information, which not only led to concern about the quality but also to a question: are there any applications available to diabetes self-management? This question is not raised only from this fact but also from the low number of included studies.

Regarding the effect of the intervention, there is no conclusive evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and QoL. In 10 trials, these applications minimally affected or did

not affect HbA1c. The pooled HbA1c results for the three and six-month periods favoured the intervention, but they were statistically insignificant, with a mean difference of -0.11 [95% CI: -0.026–0.01] and -0.26 [95% CI: -0.59–0.07]. Most of the individual results from the trials favoured the intervention. However, not all the results were statistically significant. The intervention effect on the quality of life outcome is no different from HbA1c. Only five studies provided QoL data, but only one was statistically significant ($P < 0.05$). As these used different measurement tools, meta-analysis was not possible. In line with HbA1c, the data may suggest a limited effect on patients' quality of life.

Several reasons could explain why the effectiveness in improving HbA1c and QoL was small, as most of the included studies showed statistically insignificant effectiveness in favour of the mobile application. This may not be because the results are ineffective; instead, it could be due to several factors, such as the number of studies, the availability of applications, application design, and patient acceptance. First, the findings of this review show that only a few studies have been conducted on a limited number of mobile and web applications. Thus, it may not be enough to detect the difference. Second, some studies were conducted using apps designed specifically for research purposes that were unavailable to the public, so their quality could not be investigated. Third, our results showed that not all self-care activities were available within applications, which could reduce their efficacy and patient acceptance, as a patient needs to install several applications to cover all aspects of self-management. Finally, this review also showed that most applications were not designed based on any theory or model, such as AADE 7 Self-care Behaviour®. If all of these factors were considered, we could see more promising results and higher efficacy. Systematic reviews in mobile technology are

limited. There is no recent study specific to diabetes self-management mobile applications as this systematic review. Thus, it is not feasible to compare the results with previous literature. However, in a bigger image and comparing these results with systematic reviews in diabetes mobile technology in general. two studies conducted by Tao D et al., (63) and Greenwood et al., (34) explored all technologies used by patients, including SMS. Both of these studies show that mobile technology, in general, is effective, which is different from this systematic review finding. Another study by Heitkemper et al.,(64) found that educational diabetes mobile application has no effect different from education without technology. Another study by McMillan et al. found that very few studies examined the active lifestyle outcome. This systematic review aligns with this study that found that a limited number of studies examined HbA1c and Quality of life. This may suggest that, in general, a limited number of studies have been conducted on diabetes mobile applications. Comparing the first systematic review with mobile technologies for other diseases may help to put diabetes mobile applications in context. Several systematic reviews were conducted to explore the effectiveness of mobile technology on other diseases. This study is in line with the finding of these studies. A study conducted by Belisario et al., concluded that there is no positive evidence to support the use of mobile applications in the self-management of Asthma (162). Similarly, a study conducted by McCabe et.al, concluded that there is limited evidence supporting the use of mobile technology to support the self-management of chronic obstructive pulmonary disease (COPD)(163).

There is growing interest in qualitative evidence as a way to explain what works, for whom and in which context(165)(166). Thus, the second study conducted a qualitative

systematic review aimed to explore patients' and HCPs' perspectives on mobile and web applications that support the self-management of type 1 and type 2 diabetes by systemically reviewing qualitative evidence. Only eight studies met the inclusion criteria (62,169–175). Four themes resulted from the data synthesis: (A) factors affecting patients' acceptance and use of mobile apps; (B) factors affecting HCPs' acceptance, use and recommendation of mobile apps; (C) patients' experience and attitudes towards mobile apps; and (D) HCPs' experience and attitudes towards mobile apps. Additionally, ten sub-themes were also identified. The general results showed that patients and HCPs are not users, or limited users, of current diabetes self-management applications. They are looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications. In the first theme, most studies fit within the barrier sub-theme, and no study investigated facilitators, which may suggest that participants have barriers and not adapted to diabetes mobile applications. The most interesting barrier was the lack of awareness of the diabetes mobile application. This is in line with chapter one finding when there was a limited number of studies investigating the effectiveness of mobile applications, which led to a question: are there any applications available for diabetes self-management? Alternatively, the lack of awareness is also among researchers. Most patients' barriers mentioned across studies; are cost, lack of awareness, and app's reliability which is easy to address. Some studies reported; limited time, lack of internet, lack of smartphone, App use difficulty, no advice from HCP, and previous bad experiences, which also could be addressable. In the second theme, HCPs were similar to patients regarding barriers to using mobile applications; time limitation, app use difficulty and lack of awareness. Thus,

these data suggest that both patients and HCPs face the same barriers. Moreover, HCP show other barriers to recommending apps; apps have no effects, the effect is not evidence-based, or the government does not support apps. The previous systematic review would provide HCP with the evidence they need. The next chapter, Chapter 4, could address the lack of awareness. Third theme suggest that most patients require a tool that supports them in managing their diabetes to make their lives more comfortable. In most studies, the same features are repeated. Results showed a range of features that patients preferred in diabetes mobile applications. Moreover, glucose trackers, personalised education, personalised advice, and reminders are the most common in the studies. The final theme shows that HCPs share with the patient their lack of knowledge about diabetes mobile applications. However, they have a positive attitude towards the diabetes mobile applications. Across studies HCPs interested in two features; education and diaries. As mentioned previously, no systematic review has qualitatively explored the patients' and HCPs' perspectives on mobile applications on diabetes self-management, so comparing our findings to others is not feasible. However, to draw a general picture may be beneficial to compare these results with other diseases. One systematic review aiming to explore the acceptability and usefulness of mobile applications for self-management of cardiovascular disease by Coorey (176) has reported app features needed by patients. Some of these features align with this systematic review finding, including education, personalised, and customisable content. Thus, regardless of the type of digital health application, patients may need the same features that make them feel that these applications are designed for them, such as personalised

and customisable applications. The need for apps personalisation features is also seen in a study conducted by Giordan (177) regarding heart failure apps.

In the first study, we hypothesised several reasons for being no conclusive evidence about the effectiveness of mobile and web applications in the self-management of diabetes. This qualitative evidence offers a further explanation for why they are not effective. In combination, these two studies' results shaped the third study's aim and objectives and led to several questions: Are they not effective or is the number of studies insufficient? Does the limited number of applications result in a limit to the number of studies or are there no applications available for study or is there limited research on this area? Have the applications been designed in such a way that they are not effective in accomplishing their goal? Surprisingly, a very limited number of applications were investigated in the included studies. Some applications were designed specifically for research purposes and were not available on app stores. Therefore, it is unknown whether the inconclusive result was due to the lack of available software or simply that there has been insufficient research carried out on the available applications. Thus, the general aim of the third study was to explore the availability and features of diabetes self-management mobile applications in the Google Play Store® (Android™) for adults with type 1 and type 2 diabetes. Many objectives were driven from previous study results: (1) To explore and summarise available diabetes self-management mobile applications; (2) To explore diabetes self-management mobile application features and classify these features based on AADE 7 Self-Care Behaviours®; (3) To shed light on the specifics of these applications (such as missing common features and technical features); and (4) To provide an up-to-date overview for healthcare professionals (HCPs) and a

summary for patients. Other objectives were set to inform the next project' studies: (5) To compare the availability of applications in English and Arabic; and (6) To inform the next phase of this study's survey. These objectives were not only driven by our previous findings; however, in the scoping search of the literature, several studies have been conducted to investigate mobile applications in app stores to manage chronic diseases, such as hypertension, chronic kidney disease and heart failure.(178–182) Other studies have been carried out on medication management and adherence.(183) However, a limited number of studies have been conducted in the field of diabetes. These studies address a limited number of features(184,185) or are related to a specific country(186–188). Thus, it was necessary to conduct this study. This study resulted in 402 applications which is a vast number of applications. However, only 45 applications met the inclusion criteria and were included in the study. The findings suggest that there are many applications that patients and healthcare professionals may find overwhelming if there is no guidance or accreditation system in place. Healthcare professionals may find it challenging to look for an application and go through the same process that has been done in this study to find a good application for his/her patients without guidance and information. This assumption is supported by the previous chapter (Chapter 3) results, where HCPs stated that one of the barriers was that they did not know which application was useful and there was a lack of information. In the same context, patients may also have difficulties finding a good application from 402 applications, as previous chapter results showed that patients also have barriers as HCPs in terms of lack of knowledge and information about diabetes mobile applications. The first systematic review's results (chapter 2) helped to shape this study's aim as one of these questions we asked, after

having a few included research, are there any diabetes applications available? This finding helped to answer this question and show us that there are many applications. Moreover, it shows there is limited research done on these applications. Regarding AADE7 self-care behaviour, the included mobile applications in this study support different domains; they supported a range of self-care behaviours: 53% Healthy Eating, 42% Being Active, 96% Monitoring, 56% Taking Medication, 13% Problem Solving, 20% Reducing Risks, and 16% Healthy Coping; only two applications, namely One Drop® and Mazboot®, support at least one feature in each self-care domain. This result suggests that most available applications are electronic monitoring records and do not offer complete self-management of all tasks that diabetic patients must perform. This may lead a patient to install several applications to access all self-management tasks. Chapter 5 results confirmed that many participants installed more than one application. This is impractical for day-to-day diabetes management, not only for the patient but also for healthcare professionals, as they may need many apps to access patients' data and to be able to communicate with them. Needless to say, the importance of collaboration and integration between applications as installing many applications may not result in these applications collaborating with each other. – full discussion presented previously-. Moreover, as seen in qualitative systematic review results (chapter 3), patients do not know that diabetes mobile applications exist. Thus, the patient may not know about AADE 7 self-care behaviour and may not try to find applications. This suggestion is supported and confirmed by the results of the fourth study (chapter 5)- which will be discussed later in this chapter-. 'One app for all', 'one app to rule them all' or 'All-in-One mHealth Application' concepts have been used in literature in recent years (202,203).

The previous results show that the current status of diabetes mobile applications is far from achieving this concept. As one of the objectives was to compare what is available in English and Arabic, of included applications, only two applications were in Arabic and 43 were in English. Most importantly, the study sheds light on the Arabic application situation. So, the extra burden for an Arabic patient is learning English vocabulary to use an application in English. This is not the only extra burden; however, it may introduce a risk of misinterpretation of the application's messages and alerts. Moreover, the number of downloads may reflect the interest or usefulness of an application. The highest downloaded app on the included list was one million. One study conducted by A.D. Carlo et al., regarding behavioural health applications shows that the number of downloads ranged from 800K to 42M in the group of applications they investigated.(204) So here, there is a surprising question. Why do diabetes mobile applications have a limited number of end-users? Returning to previous chapter results (chapter 3) may help clarify why. The study found that both patients and HCP lack awareness that diabetes mobile applications exist in two included studies (62,170). Moreover, the fourth study in this project (chapter 5) confirmed this reason. This study shows that some applications request permission and access to mobile information when it is unnecessary. Also, the research update results showed that around 50% of applications were unavailable in app stores after two years. These results suggest that patients' awareness of security and suspicious app behaviour needs to increase and there is a need for an accreditation system. As mentioned previously, studies investigating diabetes mobile applications are limited. A study conducted by Brzan et al.,(184) included only nine applications with few features, and there is no model used. This study is explored diabetes applications in

depth and is guided by AADE 7 self-care model. Another study by Huang et.al (192) looked only at medication self-management and blood glucose logging features. However, this study covered all self-care tasks guided by AADE 7 self-care model with no limitation on features as long as the application was designed specifically for people with diabetes. More importantly, none of these studies explored the technical features of diabetes mobile applications as this study.

The findings of all three studies guided the final two studies in this project. The fourth study aimed to explore patients' beliefs, experiences, and knowledge of and attitudes towards using diabetes mobile applications in supporting diabetes self-management in the Saudi Arabian population. Also, the fifth study aimed to explore HCPs' beliefs, experiences, attitudes and knowledge regarding the use of mobile applications in supporting diabetes self-management by patients in the Saudi Arabian population. In these two studies, the aim was not to replicate what had been done in the studies included in the second systematic review. However, to build upon and advance the data collected based on these studies and the third study's outcomes on this project.

In the fourth study, 277 participated, only 179 were eligible and gave consent. The data about what daily tasks are performed by participants according to AADE 7 self-care domains shows that not all participant engages in all self-management tasks. However, the highest domain was monitoring (n= 92 participants). This result suggests that most of the used applications will also support monitoring. This may explain Chapter 4 results, where most of the applications support monitoring. The majority of patient participants (62%) had installed at least one application to help self-manage their diabetes, while 38%

had not installed any applications. These results are consistent with previously published studies (62,170) but are in conflict with other published studies (172); this study determined that most participants were unaware of diabetes mobile apps. Most participants were highly educated, and not being aware of diabetes apps may highlight the lack of awareness and education about diabetes mobile applications. Thus, it is not surprising that only 11% installed these apps following professional healthcare advice, while most reported various other advice sources. These figures suggest that mobile application users rely heavily on themselves rather than on professional advice. Moreover, the results from this study support our previous conclusion. In Chapter 4, we concluded that people with diabetes might need to install several applications to manage their diabetes on a daily basis. This study shows that people with diabetes installed several diabetes mobile applications, which is not practical for everyday use as discussed previously. Of the participants, 24.5% used mobile applications more than once a day. Mobile applications were used for longer than 12 months by 20% of participants. These results show adaptation in daily life for long term. Most application users faced issues while using applications, such as application crashes, inaccurate results and problems with units. Regardless of these issues, on a 5-point scale, the majority considered mobile applications to be very useful (mean 4.38 SD 0.84). These results are promising in that any effort spent on developing these applications will benefit people with diabetes. The participants gave many reasons for not using applications; however, most non-users were unaware that these applications existed. Most of these reasons are addressable, such as lack of awareness, availability of Arabic versions and high costs. Other reasons

include a lack of trust in the applications. Thus, it is necessary to develop evidence-based software. More importantly, there is a need for an accreditation system.

The participants of the patient survey gave many reasons for not using applications; however, most non-users were unaware that these applications existed. Combining this result with the fifth study, the results show that many reasons prevent HCPs from making recommendations. The top two reasons were that they had no information or were confused about which application was suitable. A lack of knowledge about diabetes mobile applications is apparent in people with diabetes and among HCPs. This led us to speculate about the first study's reasons behind why very few applications went in RCTs, that lack of knowledge may also be seen among researchers. Regardless of the issues faced by diabetes mobile application users and the lack of knowledge of diabetes mobile applications among application non-users, the usefulness of diabetes application features was high in general. The mean of the 5-Point Likert scale ranged from 2.5 to 4.4 for application users. These results are close to those of non-users, where the mean ranged from 3.17 to 4.4. The general view was that all participants believed that the presented features in this study were useful. According to the TAM model, usefulness affects adaption. Thus, the high perception that diabetes mobile applications are useful will affect adaption, which is encouraging. The majority of the participants said they found the application they used easy to learn. According to the 5-point Likert scale, the mean was 4.07 (SD 1.09). Most participants believed it was easy to navigate through the app, with a mean of 4.4 (SD 1.058). By referring to the second item of the TAM – ease of use-, these results are promising and predict future adaptation. These promising results are not only seen in people with diabetes. However, the final study, that was aiming to

explore HCPs' beliefs, experiences, attitudes and knowledge regarding the use of mobile applications in supporting diabetes self-management by patients, showed that HCPs' preferred diabetes mobile application features in the 5-Point Likert Scale (mean) and their perception of usefulness is high – at least 2.9 out of 5 for all of the 17 listed features. HCPs' attitudes towards diabetes mobile applications were positive. The highest preferred feature among HCPs is safety warning, the same as patient in both groups; user and non-users. As safety alerts may result in advice for dosing of high-alert medications, Thus, there is a need for applications designed based on evidence. The general impression that emerged from the last study is that only 30% of HCPs had recommended using a mobile app to their patients. There were several reasons behind the application recommendations: the apps are helpful for patients (46%), they make it easier for a patient to count carbohydrates and calculate their doses (27%), they're cost-free (18%), and make it possible to track patients' health (20%). The top reason' apps are helpful for patients' is supported by HCPs' preferred diabetes mobile application features in the 5-Point Likert Scale (mean) and their perception of usefulness, which was at least 2.9 out of 5 for all of the 17 listed features. The HCPs' attitudes towards diabetes mobile applications were positive and promising. However, many reasons prevented HCPs from making a recommendation. The top two reasons were that they either had no information or were confused about which application was suitable. These findings confirmed our results from a previous study (Chapter 4) in which we suggested that there was a very high number of applications that patients and HCPs may find overwhelming without guidance or an accreditation system in place. Additionally, reasons that prevent HCPs from recommending are in line with previously published studies(169,172). Finally,

the general view from these two studies was that diabetes mobile applications are useful and easy to use and may affect future adaption, according to the TAM model. However, there is a need for application that meet their expectations which designed based on evidence and cover all 7 self-care behaviour domains. More importantly, support Arabic.

As presented in the introduction and explored in depth in the qualitative systematic review in Chapter 3, there are a few studies comparable to patient study (169–171,174,175) and HCPs (62,172,173) . No study explored app features as this study does. However, the results of this study regarding barriers to using mobile applications show the same reasons. Lack of awareness that seen in most of the studies, was the primary reason for participants in this study not using an application (n=36). The need for personalised content and alerts that seen regarding diabetes mobile applications among patient participants was also seen in other diseases such as heart diseases (176,177). Surprisingly, HCPs in Saudi Arabia consider applications to be low cost in line with the previous studies. However, the patients in this study and other previous studies (169,170,172) consider the cost a barrier. This result may suggest that HCPs not aware of the actual cost in Saudi Arabia and other countries.

3. Implications for Practice

This thesis brings several implications into practice. However, the real implication for practice will come after the development of a mobile application based on the evidence in this thesis. The first study provided HCPs and decision-makers with evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and QoL. The project then attempted to explore the reasons behind

this, so that HCPs and decision-makers were aware of what people with diabetes need. Also, the comprehensive diabetes mobile application explored in Chapter 4 may offer a quick overview and guide to what is available, the app's features at a glance and how this might change over time. This may help decision-makers and offer guidance to software developers. So, the real implications for practice and for patients may come following the development of a mobile application based on the evidence in this thesis. Also, the finding of this thesis shows the need for an accreditation system for diabetes mobile applications.

4. Recommendations for Applications Developers and Decision Makers

This project shows promising results for current and future adaption. However, people with diabetes are still looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications. Based on the project's findings, the following recommendations are made for the further development of applications and for decision-makers:

- Most people with diabetes in Saudi Arabia use applications or are looking to use applications. However, they have not yet found an app that meet their expectations. Every effort should be made to provide an application that will at least include daily tasks.
- Diabetes self-management is a vast area; one single professional developer may not be able to design a high-quality application that meets end-users' needs. Professional companies that are looking to develop an application

would benefit from allowing integration with other software and devices through an application programming interface (API).

- Mobile apps that deal with diabetes are used by people with diabetes several times a day, thus the design should take the following into consideration: comfort, ease of use and practicality. They should also be customisable, based on the end-user's needs as discussed previously.
- Smart technologies such as Alexa, sound recognition and reading text may make an app easier to use; this kind of adaption may increase the end-user's comfort. From the authors' experience, receiving only a beep alert while driving may not be helpful.
- Integration with smart watches would ease the use of mobile application alerts. Also, it could be more comfortable for the user when they are asleep.
- Stakeholders of diabetes self-management software do not only include programmers and end-users. Many other stakeholders should be considered, such as HCPs, family members and regulatory agencies, who can all contribute to the success of an application.
- **Decision makers:** There are many applications that are of low quality; some triggered antivirus software while we were testing them, and others asked for unnecessary permission. Having an accreditation system will minimise the burden for HCPs and people with diabetes.

5. Implication for Research and Future Research

This project has several implications for research. Of the five studies on this project, each one identified a gap in knowledge. The project has filled some of these gaps and has built upon findings from other studies. However, to define the interventions, we suggest that future research follows the methods developed in this research, which will bring clarity to the research, ensure that results are comparable and to make it easy to conduct a meta-analysis by minimising study design heterogeneity. We would encourage researchers to examine the quality of diabetes mobile applications before conducting RCTs using tools such as MARS and develop a special tool for diabetes mobile applications. Their effectiveness may be predictable if the application is of very low quality. The question of why diabetes mobile applications have a limited number of end-users is partially answered by this thesis in relation to Saudi Arabia's population, but it may be beneficial if this is investigated using other countries and their populations. In Chapter 4, we analysed features that were available in apps already on the market and used these in Chapters 5 and 6. However, some features should be studied further to determine what people with diabetes need that is not already available, such as the integration of smart devices. Moreover, future research should allow online surveys to be saved by using cookies wherever possible and allowed by law. This may minimise partial responses. Finally, more RCTs need to be done to explore the efficacy of well-designed and accepted mobile apps.

6. Strengths and Limitations

Any project come with strength and limitation. Some of these strength and limitation are inherited from methodology and the intervention while others due to research or

researcher. In this project, every effort has been made to increase the strengths and minimise the effects of the limitations. The details of strengths and limitation are discussed in each chapter separately. However, the general strengths and limitations are presented here. The main strength of this project is that it focuses on one intervention. Also, a huge amount of time has been spent in defining the intervention and its specification – please see the next section-. Moreover, no studies were conducted without a proposal, because adherence to the highest possible academic and ethical practice was the main target for this entire project. This was not limited to the methodology – it extended to every part of the project, for example, using words that have positive impact on people with diabetes. The word choices related to diabetes follow the recommendations by the American Association of Diabetes Educators and the American Diabetes Association(4). More importantly, this project used several models and theories; MARS, TAM and AADE 7 self-care behaviours. However, there were some limitations. The general limitations were searching for literature written in the English language only and the budget. The researcher is bilingual and knows Arabic and English. Thus, accessing literature that was not translated into English was not feasible, which could have led to publication bias. Additionally, the research budget did not cover travelling to different parts of Saudi Arabia, as it is a very large country. However, an online survey helped the researcher access the wider national population, which turned the limitation into a strength. Moreover, most of the limitations' effect was minimised and may not affect the results. Thus, the strength of the evidence is believed to be high with low bias.

7. Lessons Learned

This research has several implications, not only in practice and research, but also for me as a researcher. Completing a PhD allowed me to learn new academic skills and practice them further. It was a challenge to start a project in two fields and in a language that was not my mother tongue. However, this advanced my organisation skills as it is easy focus only in one direction when working on a multidisciplinary project. My organisation helped establish my argument, which was the same across different studies throughout this project, and each phase confirmed the previous conclusion and my point of view. Regardless of my expertise in information technology, pharmacy and academia before starting my PhD, it was difficult to criticise other specialised authors. However, my tone and point of view developed over the four years. In clinical pharmacology, doing a systematic review on metformin, for example, deals with one intervention. However, when working in IT from a pharmacy point of view, it was challenging to define the intervention. Despite the fact that my project specialised in mobile applications, it offered different services; if using clinical terminology, we would say they have different mechanisms of action. Thus, in the previous metformin example, we have various interventions, which should have different chemical names. To fix this issue, in every study, I spent a huge amount of time defining a mobile application to make it comparable and to put the reader at the heart of the intervention. In Chapters 2, 3, and 4, all of the interventions that met the study's intervention definition were analysed further based on the services they offered, according to the AADE 7 Self-Care Behaviour domain. Taking this direction allowed me to see IT from a pharmacy and academic point of view, and pharmacy from an IT point of view. Thus, the PhD not only expanded my academic

skills and knowledge, but also expanded my ability to see the same things from different perspectives. I am grateful for this opportunity.

8. Conclusion

Dedicated four years of work have resulted in five studies that helped to shed light comprehensively on diabetes mobile applications for self-management in their nature, effectiveness, availability, features, and end user's attitude toward them. It also helped to identify the gap in the literature, applications and regulations. It provided patients, HCPs, decision-makers, researchers and software developers with a comprehensive guide. There is no conclusive evidence about the effectiveness of mobile and web applications in supporting diabetes self-management by improving HbA1c and QoL. So, there is no advice that could be made from these results to clinical practice. The lack of positive effects may not be due to their lack of effectiveness; it could be due to the limited number of studies conducted on a limited number of mobile apps. Also, some of the studies had been carried out using apps designed specifically for research purposes and were not available to the public; this could have led to further concern regarding how the apps were designed and tested, which may warrant further investigation and the need for more RCTs.

A limited number of qualitative studies investigated diabetes mobile applications end-users; However, qualitative evidence synthesis of these studies shows that patients and HCPs are not users, or limited users, of the currently available mobile diabetes self-management applications. They are looking for more sophisticated, interactive, smart, reliable, personalised, customisable, educational, easy-to-use and cost-effective applications. Surprisingly, some patients and HCPs lack knowledge about the existence of diabetes mobile applications, and there are many barriers to adaptation.

The number of available applications in the Google app store is high but applications are limited to supporting only some self-management tasks based on AADE 7 self-care behaviour. Patients are required to install a variety of tools to self-manage their diabetes. The findings also suggest that patients and HCPs may find such a large number of applications overwhelming if no guidance or accreditation system is in place. Future development should aim to develop a comprehensive evidence-based application to support tasks in all areas of self-care behaviours and provide these applications with the ability to collaborate with other applications and tools. More importantly, it should provide these applications with cutting-edge technologies like smart devices and the ability to be customisable to end-user needs.

In the Saudi Arabian population, most of the study participants used mobile applications and considered them to be very useful and easy to use, regardless of the issues that some of them faced. Also, non-user groups show the same interest. A limited number of HCPs recommend mobile applications for their patients, despite the belief that diabetes mobile applications are useful. The general view of the final two studies was that diabetes mobile applications are useful and easy to use. This may affect future adaption positively, according to the TAM model.

In future research, more RCTs need to be done to explore the efficacy of well-designed and accepted mobile apps. As this project explored diabetes mobile applications in google store depth. It is beneficial for future research to explore their quality, and then more RCTs need to be done to explore the efficacy of well-designed, evidence-based and accepted mobile apps that cover all AADE 7 self-care behaviours. Also, feature research should explore diabetes mobile application features that are unavailable on the market and needed by end-

users. Finally, research and practice may benefit from developing tools for diabetes self-management applications based on MARS.

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APPENDICES

CHAPTER 2 APPENDICES

Appendix 2.1: Systematic Reviews in Diabetes Management Technology (scope search)

Table A2.1 Summary of different trials on keywords search through PubMed.

Trial	Search Keywords	Filters	Results	Comment
1	(diabetes) AND technology	**Systematic Reviews**	**1093**	Too broad
2	Diabetes[MeSH Major Topic] and technology[MeSH Major Topic]	**Systematic Reviews** MeSH Major Topic	**10**	Too narrow
3	**Diabetes[MeSH Major Topic] and technology**	**Systematic Reviews** MeSH Major Topic	**444**	Test of MeSH filtration
4	((((diabetes management) OR diabetes self-management) OR diabetes education) OR diabetes self-management education) AND technology	---	**4489**	
		Systematic Reviews	**454**	
5	(((((diabetes management) OR diabetes self-management) OR diabetes education) OR diabetes self-management education) OR diabetes self-care) AND technology	---	**5082**	
		Systematic Reviews	**472**	18 paper more for the term "diabetes self-care"
		Manual Filtration (Titles)	100	Title has been flirted for relevance manually
		Manual Filtration (Abstract)	42	

Appendix 2.2: PRISMA-P Checklist (Protocol) for Chapters 2 and 3.

Table A2.2: Details of the protocol compliance with PRISMA-P Checklist. Adapted from Moher et al. (67)

	No	Item	Accomplishment	Section on the Protocol/Page No.
ADMINISTRATIVE INFORMATION				
Title: Identification	1a	Identify the report as a protocol of a systematic review	✓	Title page
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	NA	NA
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	✓	CRD42020140332
Authors: Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	✓	First Page
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review		
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	✓	Section 3 (Methods)
Support: Sources	5a	Indicate sources of financial or other support for the review	✓	First Page
Sponsor	5b	Provide name for the review funder and/or sponsor	✓	First Page
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	✓	First Page
INTRODUCTION				
Rationale	6	Describe the rationale for the review in the context of what is already known	✓	Section 1
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	✓	Section 2
METHODS				
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	✓	Section 3.2

Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	✓	Section 3 (Methods)
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	✓	Section 3.1 + Appendix 2
Study records: Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	✓	Section 3.5 (Software)
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	✓	Section 3.2
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	✓	Section 3.3
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	✓	Section 2
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	✓	Section 2
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	✓	Section 3.4
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	✓	Section 3.6
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)	✓	Section 3.6
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	✓	Section 3.4
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	✓	Section 3.4
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	✓	Section 3.4
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	✓	Section 3.4

Appendix 2.3: Search Strategy

Table A2.3: Search strategy for Embase® database through Ovid® platform.

	Embase	Note
	1. diabetes.mp. or exp diabetes mellitus/	989923
	2. self care.mp. or exp self care/	
	3. self-managment.mp.	
	4. self-monitoring.mp. or exp self monitoring/	
	5. **2 or 3 or 4**	88849
	6. 1 and 5	17112
	7. exp internet/	
	8. web-based.mp.	
	9. web.mp.	
	10. exp mobile application/ or Mobile App*.mp.	
	11. Mobile software.mp.	
	12. phone app*.mp.	
	13. computer program.mp. or exp software/	
	14. computer-based.mp.	
	15. mHealth.mp.	
	16. medical informatics.mp. or exp medical informatics/	
	17. digital health.mp.	
	18. Mobile technology.mp.	
	19. Mobile-based technology.mp.	
	20. Mobile health.mp.	
	21. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20	496289
	22. 6 and 21	1493
	23. limit 22 to last 10 years	**1291**

Table A2.5: Search strategy for Medline® database through Ovid® platform.

	Medline	Note
	1. exp Diabetes Mellitus, Type 2/ or exp DIABETES MELLITUS/ or Diabetes.mp. or exp Diabetes Mellitus, Type 1/	586631
	2. Self care.mp. or exp Self Care/	
	3. self-management.mp. or exp Self-Management/	
	4. blood glucose self-monitoring.mp. or exp Blood Glucose Self-Monitoring/	

	5. self-monitoring.mp.	
	6. 2 or 3 or 4 or 5	70926
	7. 1 and 6	15214
	8. Internet.mp. or exp INTERNET/	
	9. web.mp.	
	10. web-based.mp.	
	11. mobile application.mp. or exp Mobile Applications/	
	12. mobile app*.mp.	
	13. mobile software.mp.	
	14. phone app*.mp.	
	15. computer program.mp.	
	16. software.mp. or exp SOFTWARE/	
	17. computer-based.mp.	
	18. mHealth.mp.	
	19. medical informatics.mp. or exp Medical Informatics/	
	20. digital health.mp.	
	21. mobile technology.mp.	
	22. mobile-based technology.mp.	
	23. mobile health.mp.	
	24. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23	759200
	25. 7 and 24	1708
	26. limit 25 to last 10 years	1327

Appendix 2.4: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Chapter 2
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Chapter 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Section 1
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Section 2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Section 3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Section 2 & Section 3.2
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Section 3.1
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Section 3.1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Section 3.2
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Section 3.3

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Section 3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Section 3.4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Section 3.5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Section 3.5
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Section 3.4
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Not Applicable
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Section 4.1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Section 4.1.2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Section 4.2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Section 4.3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Section 4.3
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Section 4.2 & Section 5.2
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Not Applicable
DISCUSSION			
Summary of evidence	24	Summarise the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Section 5.1

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Section 5.3
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Section 5.4
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Chapter 2 Abstract

Adapted From: Moher D et. al, (219)

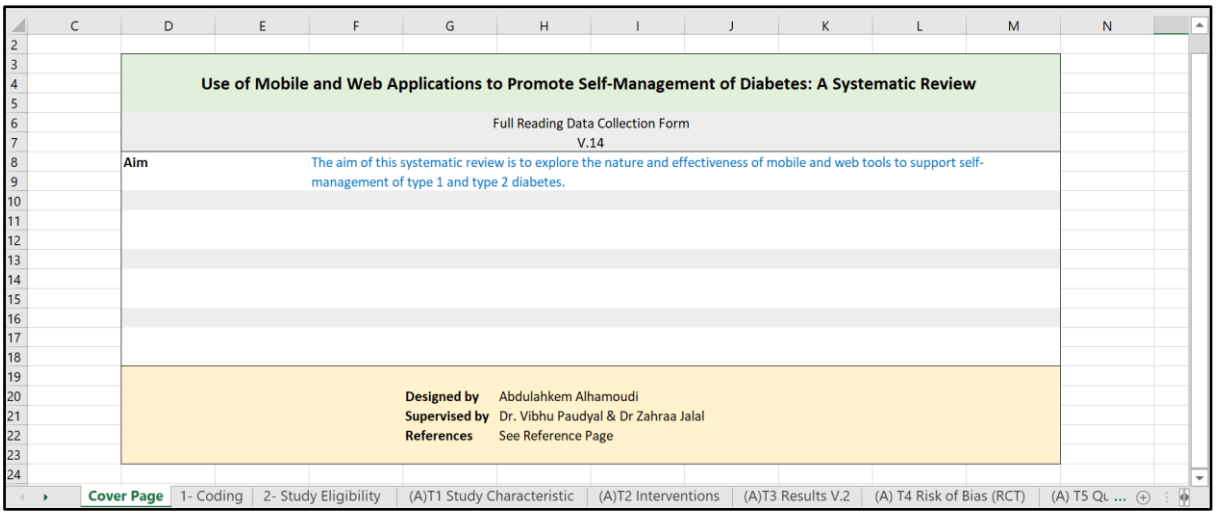
Appendix 2.5: PRISMA for Abstracts Checklist

TITLE	CHECKLIST ITEM	REPORTED ON PAGE #
1. Title:	Identify the report as a systematic review, meta-analysis, or both.	☑
BACKGROUND		
2. Objectives:	The research question including components such as participants, interventions, comparators, and outcomes.	☑
METHODS		
3. Eligibility criteria:	Study and report characteristics used as criteria for inclusion.	☑
4. Information sources:	Key databases searched and search dates.	☑
5. Risk of bias:	Methods of assessing risk of bias.	☒
RESULTS		
6. Included studies:	Number and type of included studies and participants and relevant characteristics of studies.	☑
7. Synthesis of results:	Results for main outcomes (benefits and harms), preferably indicating the number of studies and participants for each. If meta-analysis was done, include summary measures and confidence intervals.	☑
8. Description of the effect:	Direction of the effect (i.e. which group is favoured) and size of the effect in terms meaningful to clinicians and patients.	☑
DISCUSSION		
9. Strengths and Limitations of evidence:	Brief summary of strengths and limitations of evidence (e.g. inconsistency, imprecision, indirectness, or risk of bias, other supporting or conflicting evidence)	☒
10. Interpretation:	General interpretation of the results and important implications	☑
OTHER		
11. Funding:	Primary source of funding for the review.	☑
12. Registration:	Registration number and registry name.	☑

Adapted From Page et al. 2021 (68)

Appendix 2.6: Data Extraction Form

Excel data extraction from that developed and used for data collection which is adapted from data collection from by The Cochrane Collaboration.



Use of Mobile and Web Applications to Promote Self-Management of Diabetes: A Systematic Review

Full Reading Data Collection Form
V.14

Aim The aim of this systematic review is to explore the nature and effectiveness of mobile and web tools to support self-management of type 1 and type 2 diabetes.

Designed by Abdulahkem Alhamoudi
Supervised by Dr. Vibhu Paudyal & Dr Zahraa Jalal
References See Reference Page

Cover Page | 1- Coding | 2- Study Eligibility | (A)T1 Study Characteristic | (A)T2 Interventions | (A)T3 Results V.2 | (A) T4 Risk of Bias (RCT) | (A) T5 Qu ...

Appendix 2.7: Comparison Between Systematic Review Software.

Criteria	Covidence™	Ryyan™	EPPI-Reviewer 4™	DistillerSR™	SRDB.PRO™
Separate section for each systematic review step	✓	×	NOT TESTED	×	×
Ability to see progress for each step	✓	×	NOT TESTED	✓	×
Ability to track changes	✓	×	NOT TESTED	?	×
Facilitate collaboration	✓	✓	NOT TESTED	NO calibration for student's account	✓
Import and export references	✓	✓	NOT TESTED	✓	✓
Cloud	✓	✓	✓ BETA, not stable.	✓	×
Country	Australia	Qatar	University of London, UK	Canada	UK

(Source: Personal collection)

CHAPTER 3 APPENDICES

Appendix 3.1: PRISMA for Abstracts Checklist for the Second Systematic Review

TITLE	CHECKLIST ITEM	REPORTED ON PAGE #
1. Title:	Identify the report as a systematic review, meta-analysis, or both.	Page 3
BACKGROUND		
2. Objectives:	The research question including components such as participants, interventions, comparators, and outcomes.	Page 3
METHODS		
3. Eligibility criteria:	Study and report characteristics used as criteria for inclusion.	Page 3
4. Information sources:	Key databases searched and search dates.	Page 3
5. Risk of bias:	Methods of assessing risk of bias.	☒
RESULTS		
6. Included studies:	Number and type of included studies and participants and relevant characteristics of studies.	Page 3
7. Synthesis of results:	Results for main outcomes (benefits and harms), preferably indicating the number of studies and participants for each. If meta-analysis was done, include summary measures and confidence intervals.	Page 3
8. Description of the effect:	Direction of the effect (i.e. which group is favoured) and size of the effect in terms meaningful to clinicians and patients.	Page 3
DISCUSSION		
9. Strengths and Limitations of evidence:	Brief summary of strengths and limitations of evidence (e.g. inconsistency, imprecision, indirectness, or risk of bias, other supporting or conflicting evidence)	☒
10. Interpretation:	General interpretation of the results and important implications	Page 3
OTHER		
11. Funding:	Primary source of funding for the review.	Page 3
12. Registration:	Registration number and registry name.	Page 3

Adapted From Page et al. 2021 (68)

Appendix 3.2: PRISMA Checklist for the Second Systematic Review

Section/topic	#	Checklist item	Reported on page #
TITLE			Page
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Chapter 3
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Chapter 3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Section 4.2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Section 4.2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Section 4.3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Section 4.3.2
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Section 4.3.1
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Section 4.3.1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Section 4.3.2

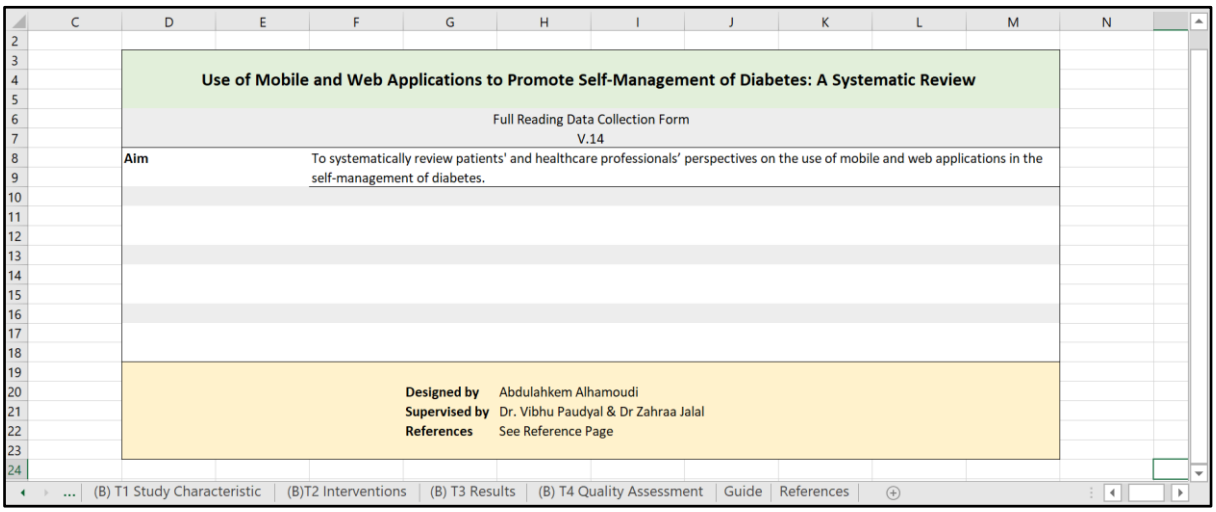
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Section 4.3.3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Sections 4.2 & 4.3.2.1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Section 4.3.4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Section 4.3.3
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Section 4.5.4
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Section 4.4
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Section 4.4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Section 4.4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Section 4.4
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Section 4.4
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Section 4.4
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses,	NA

		meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarise the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Section 4.5
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Section 4.5
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Section 4.5
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Chapter 3

Adapted From: Moher D et. al, (219)

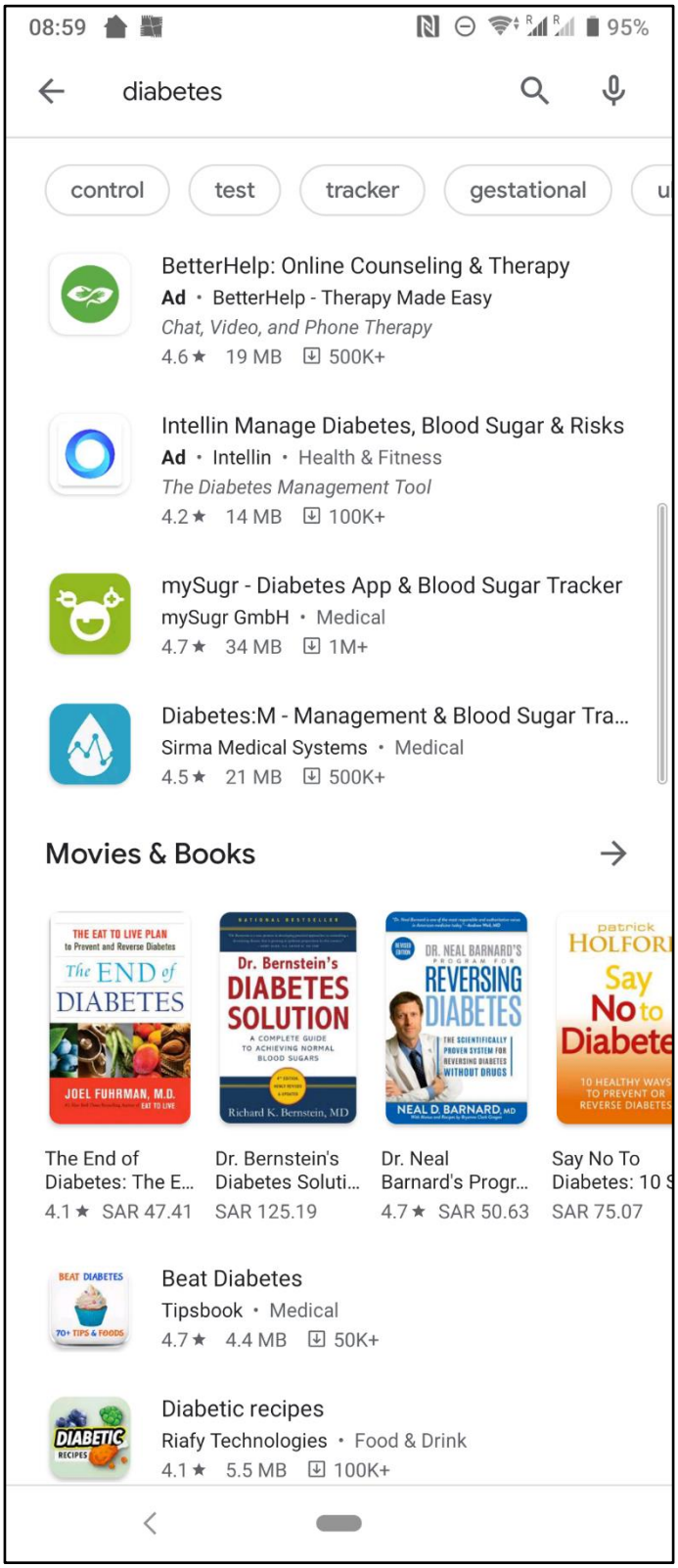
Appendix 3.3: Data Extraction Form for Qualitative data Synthesis

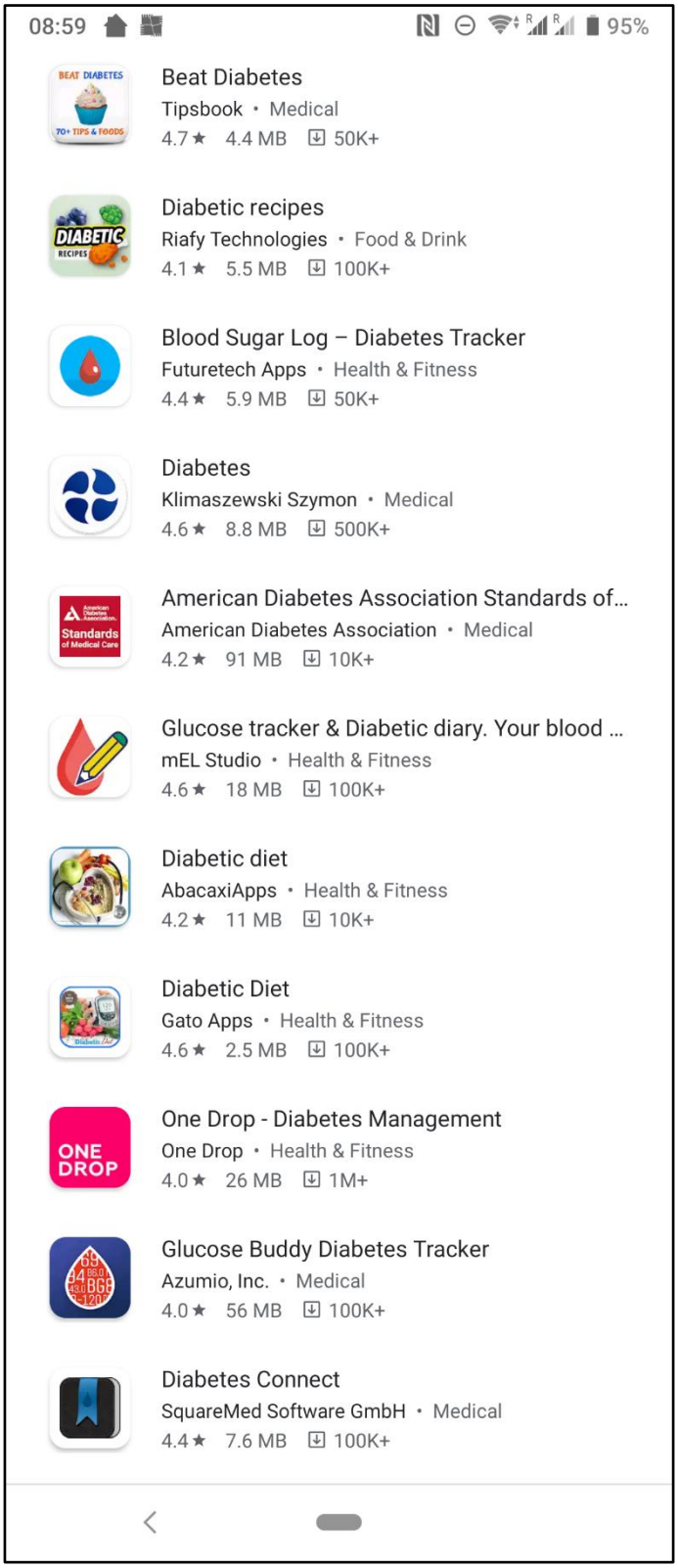
Excel data extraction from that developed and used for data collection which is adapted from data collection from by The Cochrane Collaboration.

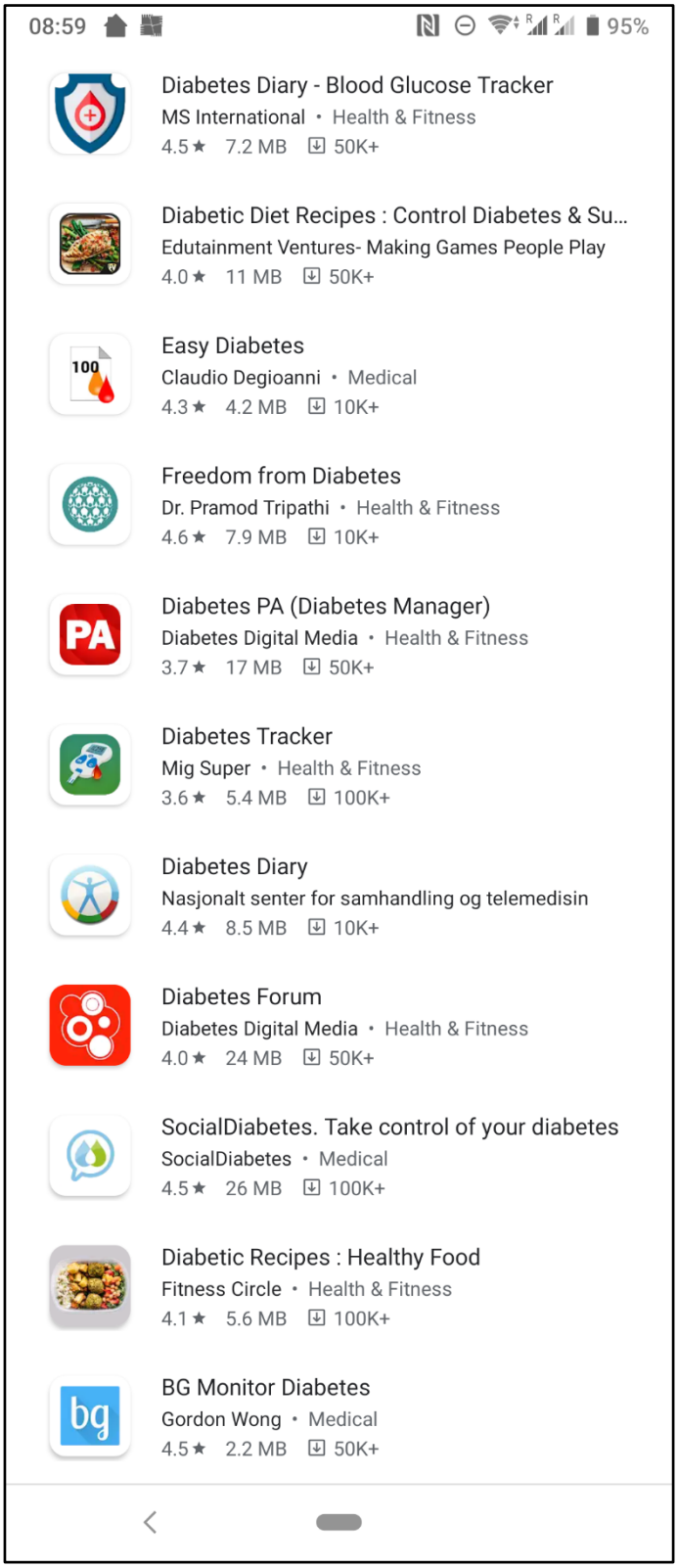


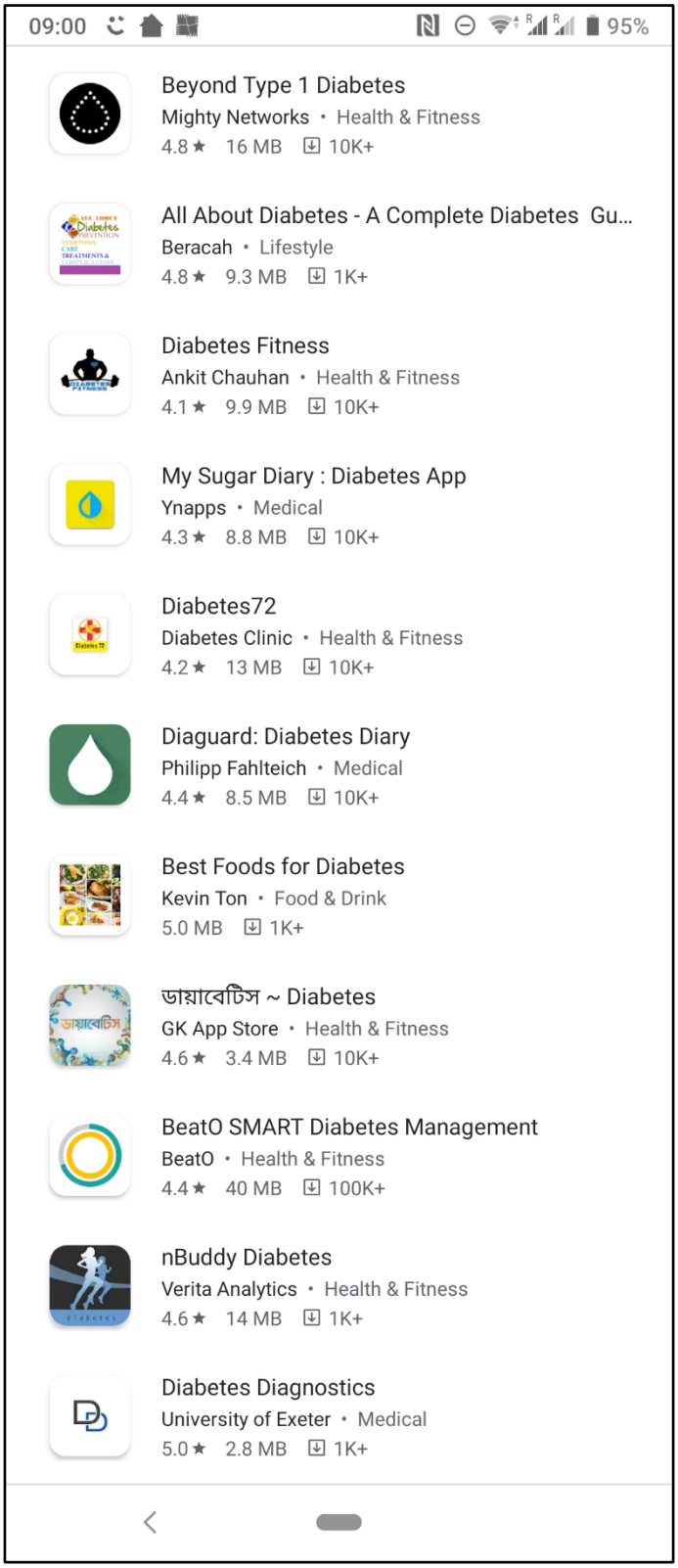
CHAPTER 4 APPENDICES

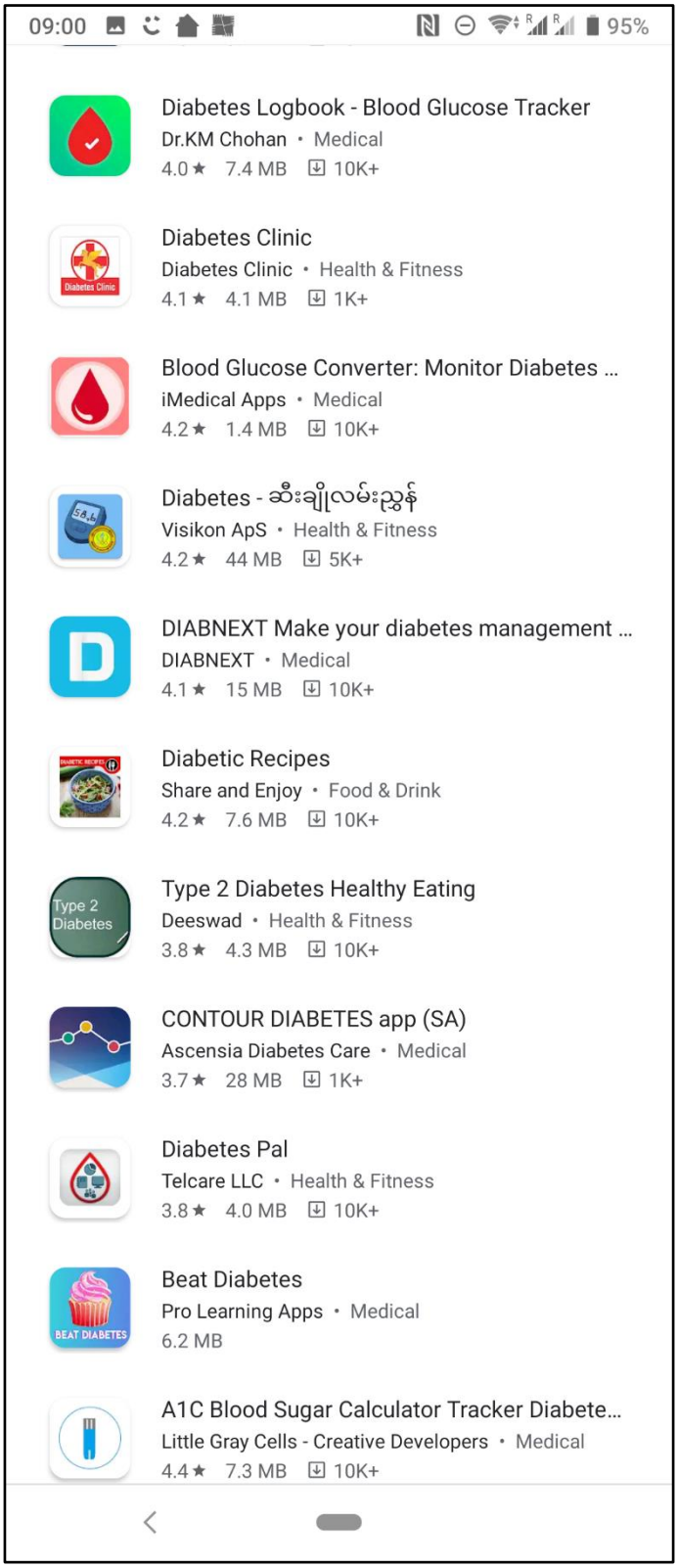
Appendix 4.1: Chapter 4 Scoping Search




08:59
95%
Beat Diabetes
Tipsbook • Medical
4.7★ 4.4 MB 50K+
Diabetic recipes
Riafy Technologies • Food & Drink
4.1★ 5.5 MB 100K+
Blood Sugar Log – Diabetes Tracker
Futuretech Apps • Health & Fitness
4.4★ 5.9 MB 50K+
Diabetes
Klimaszewski Szymon • Medical
4.6★ 8.8 MB 500K+
American Diabetes Association Standards of...
American Diabetes Association • Medical
4.2★ 91 MB 10K+
Glucose tracker & Diabetic diary. Your blood ...
mEL Studio • Health & Fitness
4.6★ 18 MB 100K+
Diabetic diet
AbacaxiApps • Health & Fitness
4.2★ 11 MB 10K+
Diabetic Diet
Gato Apps • Health & Fitness
4.6★ 2.5 MB 100K+
One Drop - Diabetes Management
One Drop • Health & Fitness
4.0★ 26 MB 1M+
Glucose Buddy Diabetes Tracker
Azumio, Inc. • Medical
4.0★ 56 MB 100K+
Diabetes Connect
SquareMed Software GmbH • Medical
4.4★ 7.6 MB 100K+


08:59
95%
Diabetes Diary - Blood Glucose Tracker
MS International • Health & Fitness
4.5★ 7.2 MB 50K+
Diabetic Diet Recipes : Control Diabetes & Su...
Edutainment Ventures- Making Games People Play
4.0★ 11 MB 50K+
Easy Diabetes
Claudio Degioanni • Medical
4.3★ 4.2 MB 10K+
Freedom from Diabetes
Dr. Pramod Tripathi • Health & Fitness
4.6★ 7.9 MB 10K+
Diabetes PA (Diabetes Manager)
Diabetes Digital Media • Health & Fitness
3.7★ 17 MB 50K+
Diabetes Tracker
Mig Super • Health & Fitness
3.6★ 5.4 MB 100K+
Diabetes Diary
Nasjonalt senter for samhandling og telemedisin
4.4★ 8.5 MB 10K+
Diabetes Forum
Diabetes Digital Media • Health & Fitness
4.0★ 24 MB 50K+
SocialDiabetes. Take control of your diabetes
SocialDiabetes • Medical
4.5★ 26 MB 100K+
Diabetic Recipes : Healthy Food
Fitness Circle • Health & Fitness
4.1★ 5.6 MB 100K+
BG Monitor Diabetes
Gordon Wong • Medical
4.5★ 2.2 MB 50K+


09:00
95%
Beyond Type 1 Diabetes
Mighty Networks • Health & Fitness
4.8★ 16 MB 10K+
All About Diabetes - A Complete Diabetes Gu...
Beracah • Lifestyle
4.8★ 9.3 MB 1K+
Diabetes Fitness
Ankit Chauhan • Health & Fitness
4.1★ 9.9 MB 10K+
My Sugar Diary : Diabetes App
Ynapps • Medical
4.3★ 8.8 MB 10K+
Diabetes72
Diabetes Clinic • Health & Fitness
4.2★ 13 MB 10K+
Diaguard: Diabetes Diary
Philipp Fahlteich • Medical
4.4★ 8.5 MB 10K+
Best Foods for Diabetes
Kevin Ton • Food & Drink
5.0 MB 1K+
ডায়াবেটিস ~ Diabetes
GK App Store • Health & Fitness
4.6★ 3.4 MB 10K+
BeatO SMART Diabetes Management
BeatO • Health & Fitness
4.4★ 40 MB 100K+
nBuddy Diabetes
Verita Analytics • Health & Fitness
4.6★ 14 MB 1K+
Diabetes Diagnostics
University of Exeter • Medical
5.0★ 2.8 MB 1K+


09:00
95%
Diabetes Logbook - Blood Glucose Tracker
Dr.KM Chohan • Medical
4.0★ 7.4 MB 10K+
Diabetes Clinic
Diabetes Clinic • Health & Fitness
4.1★ 4.1 MB 1K+
Blood Glucose Converter: Monitor Diabetes ...
iMedical Apps • Medical
4.2★ 1.4 MB 10K+
Diabetes - ဆီးချိုလမ်းညွှန်
Visikon ApS • Health & Fitness
4.2★ 44 MB 5K+
DIABNEXT Make your diabetes management ...
DIABNEXT • Medical
4.1★ 15 MB 10K+
Diabetic Recipes
Share and Enjoy • Food & Drink
4.2★ 7.6 MB 10K+
Type 2 Diabetes
Type 2 Diabetes Healthy Eating
Deeswad • Health & Fitness
3.8★ 4.3 MB 10K+
CONTOUR DIABETES app (SA)
Ascensia Diabetes Care • Medical
3.7★ 28 MB 1K+
Diabetes Pal
Telcare LLC • Health & Fitness
3.8★ 4.0 MB 10K+
BEAT DIABETES
Beat Diabetes
Pro Learning Apps • Medical
6.2 MB
A1C Blood Sugar Calculator Tracker Diabete...
Little Gray Cells - Creative Developers • Medical
4.4★ 7.3 MB 10K+

Appendix 4.2: List of Excluded Apps

	App Name
1.	10 Best Foods for You
2.	100+ Diabetes Recipes
3.	200 Delicious and Simple Type 2 Diabetic Recipes
4.	200 Easy Delicious Insulin Resistance Recipes
5.	310 Diabetes Type 2 Quick Recipes
6.	350 Diabetes Type-2 Quick & Easy DiabeticRecipes
7.	5-Ingredient Diabetes Pressure Cooker Recipes
8.	7 Day Diabetic Diet Plan: Diabetic Patients Diet
9.	7 Day Diabetic Meal Plan
10.	7 Day Diabetic Meal Plan & Diabetic Diet Recipes
11.	A1CVD Pro
12.	ADA Books
13.	All About Diabetes - A Complete Diabetes Guide
14.	American Diabetes Association
15.	American Diabetes Association Standards of Care
16.	ApolloSugar - Health Coach
17.	AQR - Diabetic Foot
18.	Arogya Diabetes
19.	BC-ADM Diabetes Management Exam Prep
20.	Beat Diabetes
21.	Beat Diabetes
22.	BEAT Diabetes & Prediabetes
23.	Beat Diabetes Pro - Ad Free
24.	BeatO SMART Diabetes Management
25.	Best food for diabetes
26.	Betes - Your Diabetes Diary
27.	Beyond Type 1 Diabetes
28.	BG Monitor Diabetes Pro
29.	Blood Glucose Tracker
30.	Blood Glucose Tracker - Track your blood Glucose
31.	Blood Glucose Tracker (Diabetes Tracker)
32.	Blood Pressure Checker Diary -BP Info - BP Tracker
33.	Blood Pressure Diary
34.	Blood Sugar Calculator, Info, Dairy, Log History
35.	Blood Sugar Checker : Blood Glucose Diabetes Level
36.	Blood Sugar Checker Diary : Track Glucose History
37.	Blood Sugar Diary : Glucose Record History Journal
38.	Blood Sugar Diary : Glucose Record History Journal
39.	Blood Sugar Diet
40.	Blood Sugar Glucose Journal: Records History Diary
41.	Blood Sugar Infos and Tracker
42.	Blood Sugar Level Converter
43.	Blood Sugar Test Checker : Glucose Convert Tracker
44.	Blood Sugar Test Info and Advice
45.	Blood Sugar Tracker: Blood Glucose History Checker
46.	Blue Circle Diabetes
47.	Calorie Counter - MyNetDiary, Food Diary Tracker
48.	Calories in food

49.	Carb Calc
50.	Carb Manager: Keto Diet Tracker & Macros Counter
51.	Carbohydrate Counter Diabetic Diary Insulin Calc
52.	Carbohydrates Calculator
53.	C-Diabetes
54.	CGH Diabetes Diary
55.	Clinical Practice Guidelines
56.	CONTOUR DIABETES app (SA)
57.	Control:Diabetes
58.	Daily Health Tips
59.	Delicious Diabetes recipes
60.	Dexcom CLARITY
61.	Diabcura: Personalised Diabetes Management
62.	Diabete Gourmand
63.	diabetes
64.	Diabetes
65.	Diabetes - Control y Manejo
66.	Diabetes - Diabetes Diet Tips
67.	Diabetes - ဆီးချိုလမ်းညွှန်
68.	Diabetes & Diet Tracker
69.	Diabetes a la carta
70.	Diabetes Academy
71.	Diabetes and Fast Food
72.	Diabetes App
73.	Diabetes App 1
74.	Diabetes App 2
75.	Diabetes Cálculo de Hidratos
76.	Diabetes Canada Guidelines
77.	Diabetes Care
78.	Diabetes Care Diet & Nutrition
79.	Diabetes Clinic
80.	Diabetes Coach
81.	Diabetes Coach
82.	Diabetes Connections
83.	Diabetes Control Tips
84.	Diabetes Control Tips
85.	Diabetes Cookbook
86.	Diabetes cookbook
87.	Diabetes Cookbook
88.	DIABETES CURE
89.	Diabetes Diagnostics
90.	Diabetes Diary
91.	Diabetes Diary 2
92.	Diabetes diary. Carbs Insulin and glucose charts
93.	Diabetes Diet and Management
94.	Diabetes Food Recipes
95.	Diabetes Forecast®
96.	Diabetes Forum
97.	Diabetes Healthy Meal Plan Diet
98.	Diabetes Hub - Diabetics foods, Tips & and Forum
99.	Diabetes Info
100.	Diabetes Journey

101.	Diabetes Logs
102.	Diabetes M & Treatment
103.	Diabetes Management
104.	Diabetes Management System
105.	Diabetes Meal Plan
106.	Diabetes Mellitus
107.	Diabetes Mellitus
108.	Diabetes Mellitus pocket
109.	Diabetes Nature Cure
110.	Diabetes Normal Sugar Level Control Tips Malayalam
111.	Diabetes og kulhydrattælling
112.	Diabetes Pharma
113.	Diabetes Plus Type2
114.	Diabetes Prevent
115.	Diabetes Recipe (gujarati)
116.	Diabetes Recipes
117.	Diabetes Risk Assessment Tool
118.	Diabetes risk calculator
119.	Diabetes Self-Management
120.	Diabetes Solution Center (DSC)
121.	Diabetes Store
122.	Diabetes symptoms
123.	Diabetes Symptoms
124.	Diabetes Symptoms Causes
125.	Diabetes T2 Reversal
126.	Diabetes tipo 1
127.	Diabetes Tracker
128.	Diabetes Tracker App: Blood Glucose & Cholesterol
129.	Diabetes Treatment
130.	DIABETES TREATMENT App
131.	Diabetes Type 1
132.	Diabetes Type 1
133.	Diabetes type 1 and 2 Cure Check Up Monitor App
134.	Diabetes Type 2
135.	Diabetes Type 2
136.	Diabetes UK Events
137.	Diabetes Words
138.	Diabetes Yoga Therapy at Home - Diet for low Sugar
139.	Diabetes का घरेलू इलाज Hindi Health Tips
140.	Diabetes የስኳር ህመም መረጃ
141.	Diabetes.AC noticias y recetas para diabéticos
142.	Diabetes: Type 1&2
143.	Diabetes72
144.	DiabetesCare-Tamil
145.	Diabetic Calculator Full
146.	Diabetic Cookbook & Meal Plan for Newly Diagnosed
147.	Diabetic diet
148.	Diabetic Diet
149.	Diabetic Diet
150.	Diabetic Diet
151.	Diabetic Diet & Symptoms of diabetes - Diabetes Go
152.	Diabetic Diet Plan

153.	Diabetic Diet Plan
154.	Diabetic Diet Plan Chart
155.	Diabetic Diet Plan Chart
156.	Diabetic Diet Plan(Diet Information)
157.	Diabetic Diet Recipes
158.	Diabetic Diet Recipes : Control Diabetes & Sugar
159.	Diabetic Food
160.	Diabetic Living Australia
161.	Diabetic Living India
162.	Diabetic Medicine
163.	Diabetic Protocols
164.	Diabetic recipe
165.	Diabetic recipes
166.	Diabetic Recipes
167.	Diabetic Recipes
168.	Diabetic Recipes – Healthy
169.	Diabetic Recipes : Healthy Food
170.	Diabetic Recipes for Free
171.	Diabetic recipes for free app offline with photo
172.	Diabetic Recipes free
173.	Diabetic Recipes: Best Diabetes Recipes App Free
174.	Diabetic Recipes: Great recipes for diabetics
175.	Diabetic Warehouse
176.	Diabeting
177.	Diabits | #1 Diabetes Management and Predictions
178.	Diet For Diabetes
179.	Diet to Reverse of Diabetes type 2
180.	Dieta Para Diabéticos
181.	Diseases Treatments Dictionary
182.	Doc's Diabetes Diary
183.	Doctor Support Diabetes Mellitus
184.	Easy Diabetic Recipes
185.	Eat This Much - Meal Planner
186.	Food for Diabetics
187.	Free Type 1 Diabetes News
188.	Free Type 2 Diabetes News
189.	Freedom from Diabetes
190.	Gadge Diabetes Care
191.	gestational diabetes
192.	Gestational Diabetes
193.	Gestational Diabetes Diet
194.	Gestational Diabetes Health Tips and Care
195.	Gestational Diabetes Meal
196.	Gestational Diabetes Stress Scale
197.	GI and glycemic load Lite
198.	Glink Diabetes
199.	GlucoNightWatch Blu
200.	GlucosApp
201.	Glucose Buddy Diabetes Tracker
202.	glucose levels
203.	GLUCOSEZONE
204.	Glycemic Index of Products

205.	Guide Diabetic Diet Plan
206.	guide Le Diabéte
207.	Habits: Diabetes Coach
208.	HALT Diabetes
209.	HC And - Diabetes type 1
210.	Health Diet Foods Fitness Help
211.	Healthy Cook Diabetics Diet Friendly Recipes
212.	Healthy Diabetic Recipes Indian Dishes Diabetics
213.	Healthy Diet - Best Diet Plan, Calorie Counter
214.	Help My Diabetes
215.	Herbal Concoctions For Diabetes
216.	Home Remedies For Diabetes
217.	How To Cure Diabetes
218.	How to Lower Blood Sugar
219.	How to Prevent Diabetes
220.	How to Prevent Diabetes
221.	How to Reduce Fasting Blood Sugar
222.	How To Reverse Type 2 Diabetes
223.	How to treat diabetes
224.	Hypo Program
225.	Insulin Calculator
226.	Insulin Dose Calculator and timer for diabetes
227.	Jerry the Bear
228.	Jugos Para Diabeticos
229.	KetoDiet: Keto Diet App Tracker, Planner & Recipes
230.	kNOw Diabetes
231.	LibreLinkUp
232.	Life with Diabetes
233.	Lifesum: Food Diary, Meal Planner & Diet Tracker
234.	LinkBluCon
235.	Low Carb Program
236.	Low Glycemic Diet Plan
237.	MedM Diabetes
238.	Medworks - Management of Diabetes the Smart Way
239.	mHealthGate -managing Diabetes
240.	My Diet Coach - Weight Loss Motivation & Tracker
241.	MyDiabetes - Food For diabetics app
242.	MyDiabetes - Personal Diabetes Reversing Assistant
243.	nBuddy Diabetes
244.	Novi-Chek : diabète de type 1
245.	Novique
246.	NutriBullet Recipes - Smoothie Recipes (Diabetics)
247.	Nutrition Diabetes
248.	On Call Mini Diabetes Manager
249.	OneTouch Reveal Plus
250.	OneTouch Reveal® mobile app for Diabetes
251.	PredictBGL for Diabetic Pets
252.	Pregnant with diabetes
253.	Prevent diabetes
254.	Quick Medical Diagnosis & Treatment
255.	Recetas Para Diabeticos Con Diabetes Tipo 2
256.	Recetas para diabéticos en español gratis.

257.	Recette Diabétique Gratuite 2019
258.	Recette pour diabétique Facile 2018
259.	Recipes For Diabetic
260.	régime diabétique
261.	Remedy to cure diabetes
262.	Renal-diabetes-diet
263.	RetinaRisk
264.	RVC Pet Diabetes App
265.	Safe Med Sensor
266.	Signs & Symptoms Diabetes
267.	Simple Diabetes Tracker - Track Blood Sugar
268.	Smart Sugar Scanner
269.	Sugar Control - Diabetes management
270.	Sugar ka illaj
271.	Sukar - Glucose & Diabetes Tracker
272.	Symptom Tracker & Medicine, Health Symptoms Diary
273.	T1Exercise
274.	T2D Healthline
275.	Teman Diabetes
276.	Terapias de Insulina en UCI
277.	The 7-Day Diabetes Meal Plan
278.	Tidepool Mobile
279.	Todo sobre la diabetes - Control y recetas
280.	Type 1 Diabetes
281.	Type 1 Diabetes Info
282.	Type 2 Diabetes
283.	Type 2 Diabetes
284.	Type 2 diabetes
285.	Type 2 Diabetes
286.	Type 2 Diabetes Crock-Pot Cookbook
287.	Type 2 Diabetes Diet Plan
288.	Type 2 Diabetes Diet Plan
289.	Type 2 Diabetes Healthy Eating
290.	Type 2 Diabetes Healthy Eating
291.	Type 2 Diabetes Support
292.	Type II Diabetes Mellitus
293.	Vedique Diet –Dr Shikha NutriHealth Free Diet Plan
294.	WeCheck -Diabetes lifelog, Blood Glucose Level
295.	World Diabetes Day
296.	X-PERT Diabetes Digital
297.	YogaPlus - Diabetes, Stress, Weight loss workouts
298.	أحسب جرعتك - جرعة الأنسولين
299.	إدارة السكري
300.	Diabetes Managementإدارة السكري -
301.	أطعمة سحرية لعلاج السكري
302.	أكلات و تغذية مرضى السكري
303.	تتبع مرض السكري
304.	تغذية مرضى السكري
305.	دايت كلينيك - رجيم الوزن المثالي
306.	دليل السكر الطبيعي
307.	سكري الأطفال
308.	العلاج بالفاكهة

309.	علاج مرض السكري .. الوقاية خيرٌ من العلاج
310.	غير جرعة الانسولين بامان
311.	متجر مريض السكري
312.	مفكرة السكري
313.	نظام غذائي لمرضى السكر
314.	وصفات العلاج بالأعشاب بدون انترنت
315.	بدون نتوصفات لعلاج مرض السكري
316.	मधुमेह जानकारी और उपाए
317.	मधुमेह लक्षण और उपचार ~ madhumeh ka ilaj
318.	ডায়াবেটিস ~ Diabetes
319.	ডায়াবেটিস নিয়ন্ত্রণের উপায়
320.	ডায়বেটিস এর A to Z~ডায়াবেটিস নিয়ন্ত্রণ~Diabetes
321.	ডায়াবেটিস ডাক্তার
322.	GBDiabetes Test App

Appendix 4.3: Final Included and Excluded List After Download and Investigation with Reasons

	App Name	Language	Company	Decision	Note
46.	A1C Blood Sugar Calculator Tracker Diabetes app	English	Little Gray Cells - Creative Developers	Included	
47.	Apollo Sugar	English/Arabic/Multilanguage	Apollo Diabetes Care Management	Included	
48.	BeatO SMART Diabetes Management	English/Indian	BeatO	Included	
49.	BG Monitor Diabetes	English	Gordon Wong	Excluded	Outdated
50.	BG Monitor Diabetes PRO	English	Gordon Wong	Excluded	Outdated
51.	Blood Glucose Monitor | Sugar Test Converter	English	Micromeriasoft	Included	
52.	Blood Glucose Tracker	English	Little Bytes Software	Excluded	Outdated
53.	Blood Glucose Tracker - Monitor, Levels & Test	English	Vive Apps Studio	Included	
54.	Blood Sugar Checker / Blood Glucose Tracker	English	Rockstar Status	Included	
55.	Blood Sugar Checker Diary: Track Glucose History	English	Health Therapy Fitbot	Included	
56.	Blood Sugar Converter	English	jacdebug	Excluded	Not for Self-management, Just Calculation tool
57.	Blood Sugar Diary	English	Interactive Specialized Software	Excluded	Outdated
58.	Blood Sugar Diary - Health Tracker	English	Visionary Labs	Included	
59.	Blood sugar diary App – Insulin	English	F. Zander	Included	
60.	Blood Sugar Log	English	mallikarjunudu chittari	Excluded	Outdated
61.	Blood Sugar Log	English	Frank'sApps	Excluded	Outdated
62.	Blood Sugar Log – Diabetes Tracker	English	Futuretech Apps	Included	
63.	Blood Sugar Test By Finger Info	English	Rean Apps	Included	
64.	Blood Sugar Test Tracker and Info	English	Chriscatstudio	Included	
65.	Blood Sugar Tracker: Glucose Diary Average Records	English	Digital Health Fitness Log	Included	
66.	Carb Calc	English	Bee's Apps	Included	
67.	Diabetes	English	Hint Solutions	Included	
68.	Diabetes	English/Arabic/ Multilanguage	Klimaszewski Szymon	Included	
69.	Diabetes Connect	English	SquareMed Software GmbH	Included	
70.	Diabetes Diary	English	Nasjonalt senter for e-helseforskning	Included	
71.	Diabetes Diary - Blood Glucose Tracker	English	MS International	Included	
72.	Diabetes Easy	English	DerKeiler GmbH	Excluded	Outdated
73.	Diabetes Fitness	English	Ankit Chauhan	Excluded	Outdated

74.	Diabetes Journal	English	Suderman Solutions	Excluded	Outdated
75.	Diabetes Logbook - Blood Glucose Tracker	English	Dr.KM Chohan	Included	
76.	Diabetes Monitor	English	HuanNguyen	Excluded	Outdated
77.	Diabetes PA (Diabetes Manager)	English	Diabetes Digital Media	Excluded	Outdated
78.	Diabetes Pal	English	Telcare LLC	Excluded	Outdated
79.	Diabetes Plus	English	SquareMed Software GmbH	Excluded	Outdated
80.	Diabetes Tracker	English	Mig Super	Excluded	Outdated
81.	Diabetes Tracker Free	English	Pragma Infotech	Included	
82.	Diabetes:M - Management & Blood Sugar Tracker App	English	Sirma Medical Systems	Included	
83.	Diabetic Calculator	English	Jake2701	Included	
84.	Diabetic Diet Plan	English	Slay In Vogue Apps	Excluded	Educational & Outdated
85.	Diabetic's Logbook	English	Ivan Vladimirov Ivanov	Excluded	Outdated
86.	DIABNEXT Make your diabetes management easy	English	DIABNEXT	Included	
87.	Diacomp (diabetes diary)	English	Nikita Bosik	Included	
88.	Diaguard: Diabetes Diary	English	Philipp Fahlteich	Included	
89.	Diasend	English	Glooko AB	Included	
90.	Dottli : Diabetes Made Simple	English	Dottli	Included	
91.	Easy Diabetes	English	Claudio Degioanni	Excluded	Outdated
92.	forDiabetes: diabetes self-management app	English/ Multilanguage	Tessera Multimedia	Included	
93.	Glimp	English	CTAPP Software	Excluded	Outdated
94.	Glucool Diabetes	English	3qubits	Excluded	Outdated
95.	Glucose Buddy Diabetes Tracker	English	Azumio, Inc.	Included	
96.	Glucose Control	English	Lehreer	Included	
97.	Glucose tracker & Diabetic diary. Your blood sugar	English	mEL Studio	Included	
98.	Glycemic Index Load – net carbs keto diet tracker	English	cream.software	Excluded	Not Design specifically for self-management
99.	Habits: Diabetes Coach	English	Jana Care	Included	
100.	iFORA Diabetes Manager	English	ForaCare	Excluded	Outdated
101.	InCalc: Insulin Calculator	English	Digitally Smarter	Excluded	Outdated
102.	Intellin Diabetes Manager. Blood Sugar Tracker.	English	Intellin	Included	
103.	Jade Insulin Dose Calculator	English	Jade Diabetes	Included	
104.	Life in Control Diabetes Coach	English	Life in Control	Excluded	Outdated
105.	Mazboot: Personal Assistant for Diabetes & High BP	Arabic	Mazboot LLC	Included	
106.	MedM Diabetes	English	MedM Inc	Included	
107.	My Glycemia : Diabete tracker	English	InSyncApp	Excluded	Outdated
108.	My Sugar Diary : Diabetes App	English	Yogesh Sanwal	Excluded	Outdated
109.	myDiabby	English	myDiabby Healthcare	Excluded	Not in English
110.	mySugr - Diabetes App & Blood Sugar Tracker	English	mySugr GmbH	Included	
111.	One Drop	English	One Drop	Included	

112.	OneTouch Reveal	English	LifeScan Europe GmbH	Included	
113.	OnTrack Diabetes	English	Vertical Health	Excluded	Outdated
114.	RT Diabetes	English	Raneem Technologies	Included	
115.	SiDiary Diabetes Management	English	SINOVO GmbH & Co. KG	Excluded	Outdated
116.	SmartLog	English	i-SENS,Inc.	Included	
117.	SocialDiabetes. Take control of your diabetes	English	SocialDiabetes	Included	
118.	Sugar Checking App	English	JSS APP STUDIO	Excluded	Outdated
119.	Sugar Test by Finger Reports	English	Mayur App Studio	Excluded	Outdated
120.	Sugar Tester App Info	English	BFF APPS STUDIO	Included	
121.	سكري (Sokary)	Arabic	Hussain Albar	Included	

CHAPTER 5 APPENDICES

Appendix 5.1 Patient Survey – English Version

Diabetic Patients' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications in supporting diabetes self-management in Saudi Arabia.

Thank you for taking part in this questionnaire. This questionnaire has 26 questions or less and needs approximately 10 minutes to be completed.

This study aims to explore adult diabetes patient' beliefs, experiences, attitudes and knowledge of using diabetes mobile applications in supporting diabetes self-management in Saudi Arabia.

Your privacy is important; no question will be asked that identifies you (e.g., email or mobile number). The collected data will keep you anonymous.

Please share this questionnaire with any adult with diabetes. Thanks for your support!

If you have any question regarding this survey or need any assistance, please contact the researcher. If you have any issues or problems, you can also contact the lead supervisor.

Contact details:

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Important Information

(1) What do we mean by mobile application for diabetes?

Any mobile app which helps in daily diabetes self-management activities and explicitly designed for people with diabetes (e.g. glucose tracking apps). Any apps that are not designed specifically for people with diabetes are not included, such as sport activities apps.

- **Please note: once the questionnaire has been submitted, data cannot be withdrawn.**

- **You are eligible to participate if you are:**
  - An adult patient (≥18 years) diagnosed with Type I or Type II diabetes.
  - An Arabic speaker as a native or as a second language.
  - Familiar with mobile devices by knowing at least one mobile platform (Windows mobile, Android or iOS) for at least 3 months.
  - Resident in Saudi Arabia.

1. **Do you give consent to participate in this research?**
   - ☐ Yes
   - ☐ No

2. **Do you have a smartphone or tablet?**
   - ☐ Yes
   - ☐ No

3. **What type of diabetes do you have?**
   - ☐ Type one
   - ☐ Type two
   - ☐ Other
   - ☐ Unsure
   - ☐ I do not have diabetes

4. **What is your age group?**
   - ☐ 18-25 years
   - ☐ 26-35 years
   - ☐ 36-45 years
   - ☐ 46-55 years
   - ☐ 56 – 65 years
   - ☐ >65 years

5. **What is your highest education level?**
   - ☐ No formal education
   - ☐ Primary
   - ☐ Secondary
   - ☐ Tertiary
   - ☐ Diploma
   - ☐ Bachelor's degree
   - ☐ Postgraduate degree

6. **If you have concerns regarding your diabetes management, where do you go first for assistance?**
   - ☐ Your GP
   - ☐ Specialised diabetes clinic

- ☐ Pharmacist
- ☐ Diabetes dietician
- ☐ Your family and friends
- ☐ Internet
- ☐ Mobile applications
- ☐ Other, specify _____

7. In the last 2 years or since your first diagnosis of diabetes, how often have you visited a hospital or diabetes clinic to check your diabetes?

- ☐ Once every month
- ☐ Once every 3 months
- ☐ Once every 6 months
- ☐ Once every one-year
- ☐ No specific time
- ☐ Other, specify _____

8. What is your HBA1c?

- ☐ Less than 6
- ☐ 7.1-8
- ☐ 8.1-9
- ☐ 9.1-10
- ☐ 10.1-11
- ☐ 11.1-12
- ☐ Equal or more than 12.1
- ☐ I do not know

9. How confident do you feel in your ability to manage your diabetes?

- ☐ Not confident at all; I always need help in making a decision
- ☐ Somewhat confident; I need help in making decision most of the time.
- ☐ Neutral; I need help in making decision sometime.
- ☐ Confident; I am dependent in making decision most of the time
- ☐ Very confident; I rarely need a help in making decisions.

10. What area of self-management do you work on a regular basis? (Please tick all that applies to you)

- ☐ Managing my food intake (e.g., organise my meal, calculate my carbohydrates, record my foot intake)
- ☐ Activity and Sport (e.g., keep following my doctor advice for change my health life style, record my sport activities)

- ☐ Monitoring (blood glucose monitoring) (e.g., check my blood regularly, record my hypo/hyper episodes)
- ☐ Taking Medication (e.g., taking your medications, calculate insulin dose)
- ☐ Solve diabetes problems (e.g., contact your GP or family member regarding your diabetes, using mobile application for solve problems)
- ☐ Reducing risk of diabetes (e.g., doing actions to reduce diabetes risk such as visiting eye clinic, foot clinic)
- ☐ Your health in general (e.g.,) (e.g., doing any activity to support your health such as taking medication for hypertension)
- ☐ None of Above

11. Have you installed any mobile applications for self-management of diabetes on your phone? If yes, how many applications have you installed to manage your diabetes?

- ☐ N/A
- ☐ 1 app
- ☐ 2 apps
- ☐ 3 apps
- ☐ 4 or more apps

12. What was the source of recommendation for you to install App/s for self-management of diabetes? *(Please tick all that applies to you)*

- ☐ I like to use mobile apps in general.
- ☐ I sought an app for my mobile myself without anyone advising me.
- ☐ Advice from a friend or family.
- ☐ Advice from a health care provider.
- ☐ Read about it in social media.
- ☐ Read about it in Newspaper, newsletters or promotion materials.
- ☐ Other, specify _____

13. What is the language of your installed apps?

- ☐ Arabic Only
- ☐ English Only
- ☐ Arabic and English
- ☐ Other language, specify _____

14. Regarding mobile apps for self-management of diabetes, which of the following behavioural statements applicable to you? *(Please tick all that applies to you)*

- ☐ I have sufficient technological skills to use apps.

- ☐ I believe that apps help achieve my diabetes management goals.
- ☐ I am motivated to use apps to have more control on my diabetes.
- ☐ I feel I am an organised person that enables me to plan the use of mobile apps.
- ☐ I believe that there is sufficient evidence from science to suggest apps can help.

15. Regarding mobile apps use in general, how do you classify yourself?

- ☐ Innovative adopter; *You buy into a new product's concepts very early in its life cycle and you rely on your own intuition and vision in buying decision.*
- ☐ Early majority; *you are driven by a strong sense of practicality. So, you wait and see how other people are making out before you buy in yourself.*
- ☐ Late majority; *You do not buy unless comfortable with your ability to use the technology. So, you wait until something has become an established standard.*
- ☐ Laggards; *You are very cautious about new technology and only purchase when you feel it has become a necessity.*

16. How often do you use your diabetes self-management App?

- ☐ Every time you eat or take medications/insulin
- ☐ Daily
- ☐ A few days per week
- ☐ Weekly
- ☐ Monthly
- ☐ Only when needing guidance
- ☐ Never (just installed the App)

17. For how long do you use diabetes self-management App?

- ☐ Less than 1 month
- ☐ 2-6 months
- ☐ 7-11 months
- ☐ 12 months or more

18. What is the name of the App(s) you have installed? You may select multiple Apps.

- ☐ سكري (Sokary)
- ☐ Mazboot
- ☐ FreeStyle LibreLink
- ☐ Dexcom G6

- ☐ Diabetes:M - Management & Blood Sugar Tracker App
- ☐ mySugr - Diabetes App & Blood Sugar Tracker
- ☐ One Drop
- ☐ OneTouch Reveal
- ☐ Other (Specify) _____
- ☐ N/A

19. Which other features available/not available in your App? (if you have more than one App, please answer based on your main App)

Features	**Available**	**Not available**
Diary of meals and carbohydrate intake		
Carbohydrate's calculator		
Dietary advice and food database for carbohydrates		
Diary of blood glucose levels and HbA1c		
Reminders to check blood glucose levels		
Estimated HbA1c		
Log Blood Pressure, body weight, lab results		
Record notes		
Diary of medication intake		
Calculation device to determine insulin dose		
Medication Reminder		
Recommendation based on your glucose level		
Set and Track Goals		
Safety warnings		
Coaching connects with HCP		
Social (e.g., Chat with diabetes patients)		
Health and community news		
Contact details for your diabetes team, GP		
Calendar of diabetes related appointments		

20. Which of the following features would you find useful in a mobile application for diabetes self-management?

Features	Not at all Useful	Slightly useful	Moderately useful	Very useful	Extremely useful	N/A	Do not know
Diary of meals and carbohydrate intake							
Carbohydrate's calculator							
Dietary advice and food database for carbohydrates							
Diary of blood glucose levels and HbA1c							
Reminders to check blood glucose levels							
Estimated HbA1c							
Log Blood Pressure, body weight, lab results							

Record notes (e.g., about your diabetes, your mood)							
Diary of medication intake							
Calculation device to determine insulin dose							
Medication Reminder							
Recommendation based on your glucose level							
Set and Track Goals							
Safety warnings (e.g., high glucose level)							
Coaching connects with healthcare professionals (e.g., doctors or pharmacist)							
Social (e.g., Chat with diabetes patients)							
Health and community news							
Contact details for your diabetes team, GP							
Calendar of diabetes related appointments							

21. In General, how useful do you find your App/Apps?

- ☐ Not at all useful; just wasted my time with no benefits
- ☐ Not very useful; there is a little benefit
- ☐ Somewhat useful; it is having some benefit
- ☐ Very useful; it has a lot of benefit
- ☐ Extremely useful; It is part of my everyday life, I could not live without it

22. Have you encountered any of the following problems with your diabetes Apps?
(Select as many that apply)

- ☐ Crashing of software
- ☐ Inconsistency in results
- ☐ Problems with units
- ☐ Difficulty understanding advice given
- ☐ Results that do not align with other medical advice you have been given
- ☐ No problems
- ☐ Other, (Specify) _____

23. How accurately/fast do the app features (functions) and components (buttons/menus) work?

- ☐ App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.
- ☐ Some functions work, but lagging or contains major technical problems

- ☐ App works overall. Some technical problems need fixing/Slow at times
- ☐ Mostly functional with minor/negligible problems
- ☐ Perfect/timely response; no technical bugs found

24. How easy is it to learn how to use the app?

- ☐ No/limited instructions; menu labels/icons are confusing; complicated
- ☐ Useable after a lot of time/effort
- ☐ Useable after some time/effort
- ☐ Easy to learn how to use the app (or has clear instructions)
- ☐ Able to use app immediately; intuitive; simple

25. How easy is it to navigate through your App?

- ☐ Different sections within the App are disconnected and random
- ☐ Usable after a lot of time/effort
- ☐ Usable after some time/effort
- ☐ Easy to use but missing a negligible links
- ☐ Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

26. If you do not use a mobile App, what is/are the reason(s) you don't have an App? (This question appears only for non-users of mobile apps)

- ☐ Didn't know they existed
- ☐ They do not work on my mobile phone
- ☐ Cost; I am not willing to pay for an app.
- ☐ Feel confident without one
- ☐ Have tried one before and didn't like it
- ☐ The effectiveness of the apps is not evidence-based
- ☐ No app available in Arabic
- ☐ Other, specify _____

27. Would you be interested in the future in using a Smartphone Application to assist with your diabetes management? (This question appears only for non-users of mobile apps)

- ☐ Yes
- ☐ No
- ☐ Unsure

28. If you had an App, which features would you find useful? (This question appears only for non-users of mobile apps)

Features	Not at all Useful	Slightly useful	Moderately useful	Very useful	Extremely useful	N/A	Do not know
Diary of meals and carbohydrate intake							
Carbohydrate's calculator							
Dietary advice and food database for carbohydrates							
Diary of blood glucose levels and HbA1c							
Reminders to check blood glucose levels							
Estimated HbA1c							
Log Blood Pressure, body weight, lab results							
Record notes (e.g., about your diabetes, your mood)							
Diary of medication intake							
Calculation device to determine insulin dose							
Medication Reminder							
Recommendation based on your glucose level							
Set and Track Goals							
Safety warnings (e.g., high glucose level)							
Coaching connects with healthcare professionals (e.g., doctors or pharmacist)							
Social (e.g., Chat with diabetes patients)							
Health and community news							
Contact details for your diabetes team, GP							
Calendar of diabetes related appointments							

29. Do you have any comments to add about mobile apps for diabetes self-management?

Many thanks for your time.

By click a submit button, you are giving a CONSENT to participate on this questionnaire

Appendix 5.2 Patient Survey – Arabic Version

معتقدات وخبرات وانطباعات ومعرفة المصابين بالسكري عن استخدام برامج الجوال لدعم الإدارة الذاتية للسكري في السعودية

شكراً لمشاركتك في هذا الإستبيان. يحتوي هذا الإستبيان على 26 سؤال أو أقل وتحتاج تقريباً 10 دقائق من وقتك.

هذه الدراسة تهدف إلى استكشاف معتقدات وخبرات وانطباعات ومعرفة المصابين بالسكري عن استخدام برامج الجوال لدعم الإدارة الذاتية للسكري في المملكة العربية السعودية.

خصوصيتك مهمة ، لن يتم سؤالك عن أي سؤال شخصي يتم من خلاله التعرف عليك (مثل بريدك الإلكتروني أو رقم هاتفك). البيانات المجموعة في هذا الإستبيان ستبقي هويتك مجهولة.

الرجاء مشاركة هذا الإستبيان مع الأشخاص الذين تعرفهم ولديهم سكري. شكراً لمساعدتك!

إذا كان لديك أي سؤال بخصوص هذا الإستبيان أو تحتاج أي مساعدة لإكماله ، الرجاء التواصل مع الباحث. إذا كان لديك أي مشاكل يمكنك أيضاً التواصل مع المشرف الرئيسي على البحث.

معلومات الإتصال :

الباحث :

معلومات مهمة قبل البدء بالإستبيان

- ماذا نقصد ببرنامج الجوال لإدارة مرض السكري ؟
أي برنامج تستخدمه ليساعدك في الإدارة اليومية للسكري ، والذي صمم خصيصاً للمصابين بالسكري (مثل تتبع قياسات السكر ، تتبع الرياضة) ، لذلك ، أي برنامج أخر لم يصمم خصيصاً للمصابين بالسكري غير مهم في هذا البحث حتى وإن كان يساعدك في الإدارة (مثلاً البرامج الرياضية)

- الرجاء ملاحظة أنه عندما يتم إرسال هذا الإستبيان ، لا يمكن الإنسحاب من الدراسة لاحقاً.

- أنت مؤهل للمشاركة في هذا الإستبيان إذا كنت:
  - بالغ (18 سنة أو أكبر) مشخص بالسكري من النوع الأول أو الثاني
  - تجيد العربية كناطق أصلي أو كلغة ثانية
  - لديك خبرة بأجهزة الجوال بمعرفة على الأقل نظام تشغل واحد (أبل ، أندرويد أو ويندوز) لفترة لا تقل عن 3 شهور.
  - مقيم في المملكة العربية السعودية

1. **هل أنت موافق على المشاركة في هذا البحث ؟**
   - ☐ نعم
   - ☐ لا

2. **هل لديك جوال ذكي أو كمبيوتر لوحي (تابلت) ؟**
   - ☐ نعم
   - ☐ لا

3. **ماهو نوع السكري الذي لديك ؟**
   - ☐ سكري من النوع الأول (المعتمد على الانسولين)
   - ☐ سكري من النوع الثاني (الغير معتمد على الانسولين)
   - ☐ نوع آخر
   - ☐ لست متأكد
   - ☐ ليس لدي سكري

4. **ماهي فئتك العمرية ؟**
   - ☐ 18-25 سنة
   - ☐ 26-35 سنة
   - ☐ 36-45 سنة
   - ☐ 46-55 سنة
   - ☐ 56 – 65 سنة
   - ☐ 65< سنة

5. **ماهي أعلى درجة علمية حصلت عليها ؟**
   - ☐ غير متعلم
   - ☐ إبتدائي
   - ☐ متوسط
   - ☐ ثانوي
   - ☐ دبلوم
   - ☐ بكالوريوس
   - ☐ دراسات عليا

6. **عندما تواجه مشكلة في إدارتك لمرض السكري ، ماهو أول خيار تلجأ إليه للمساعدة ؟**
   - ☐ مركز الرعاية الأولية
   - ☐ عيادة متخصصة للسكري
   - ☐ الصيدلي
   - ☐ أخصائي تغذية السكري
   - ☐ الأهل والأصدقاء
   - ☐ الإنترنت
   - ☐ برامج الجوال
   - ☐ أخرى ، الرجاء كتابتها _____

7. في آخر سنتين أو منذ تشخيصك بالسكري ، كل كم تقوم بمراجعة المستشفى أو عيادة السكري للفحص؟

- ☐ مرة كل شهر
- ☐ مرة كل ثلاث أشهر
- ☐ مرة كل ست شهور
- ☐ مرة بالسنة
- ☐ لا يوجد وقت محدد
- ☐ أخرى ، الرجاء كتابتها _____

8. ماهو معدل سكرك التراكمي HBA1c ؟

- ☐ يساوي أو أقل من 6
- ☐ 6.1-7
- ☐ 7.1-8
- ☐ 8.1-9
- ☐ 9.1-10
- ☐ 10.1-11
- ☐ 11.1-12
- ☐ أكثر من 12
- ☐ لا أعرف

9. كيف تشعر وتثق بقدرتك في إدارة مرض السكري ؟

- ☐ غير واثق على الإطلاق ، أنا دائماً أحتاج للمساعدة عن أي قرار
- ☐ واثق نوعا ما ، أنا أحتاج مساعدة في اتخاذ قرار أغلب الوقت
- ☐ عادي ، أنا أحتاج للمساعدة في اتخاذ قرار بعض الأحيان
- ☐ واثق ، أنا مستقل في اتخاذ القرار أغلب الوقت
- ☐ واثق جداً ، نادراً ما أحتاج المساعدة في اتخاذ القرار

10. ماهي المهام التي تقوم بها بشكل منتظم لإدارة السكري ؟ *(اختر جميع ماينطبق عليك)*

- ☐ إدارة الأكل بشكل يومي (مثلاً تنظيم الوجبات ، أو حساب السعرات الحرارية ، أو تسجيل الوجبات الغذائية)
- ☐ النشاط والرياضة (مثلا ، أتبع إرشادات الطبيب لتغيير نمط حياتي ، أو أقوم بتسجيل نشاطاتي الرياضية)
- ☐ مراقبة مستوى السكر (مثلاً فحص مستوى السكر بشكل منتظم ، تسجيل القراءات ، تسجيل حالات ارتفاع أو انخفاض السكر)
- ☐ متابعة تناول الدواء (مثلاً أخذ الدواء ، حساب جرعة الأنسولين)
- ☐ حل المشاكل المرتبطة بالسكري (مثلاً ، التواصل مع الطبيب أو أحد افراد العائلة لأي مشكلة متعلقة بالسكري ، أو استخدام برامج الجوال لحل المشاكل)
- ☐ تقليل مخاطر السكري (مثلاً الزيارة المنتظمة لعيادة السكري ، أو فحص العيون ، أو فحص القدم)
- ☐ متابعة الحالة الصحية بشكل عام (القيام بنشاط للإهتمام بصحتك بشكل عام ، مثلاً أخذ أدوية لإرتفاع ضغط الدم)
- ☐ لا شيء مما سبق

11. هل قمت بتركيب برامج جوال متخصصة في المساعدة للإدارة الذاتية لمرض السكري في جوالك ؟ إذا كان الجواب نعم كم عدد البرامج التي ركبتها في جوالك للمساعدة في الإدارة الذاتية لمرض السكري

- ☐ لم أقم بتحميل أي برنامج للسكري
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 أو أكثر

12. ما هو مصدر التوصية لتحميلك برامج للإدارة الذاتية للسكري ؟ *(اختر جميع ماينطبق عليك)*

- ☐ أحب استخدام برامج الجوال بشكل عام
- ☐ بحثت عن البرنامج بنفسي بدون أي نصيحة من أحد
- ☐ نصيحة من صديق أو العائلة
- ☐ نصيحة من طبيب أو صيدلي أو أحد مقدمي خدمات الرعاية الصحية
- ☐ قرأت عن البرنامج في وسائل التواصل الإجتماعي
- ☐ قرأت عن البرنامج في جريدة أو مجلة أو نشرة دعائية
- ☐ أخرى ، الرجاء كتابتها _____

13. **ماهي اللغة التي حملت البرنامج/ البرامج بها ؟**

- ☐ بالعربية فقط
- ☐ بالإنجليزية فقط
- ☐ باللغة العربية أو الإنجليزية
- ☐ لغة أخرى ، الرجاء كتابتها _____

14. فيما يتعلق ببرامج الجوال للإدارة الذاتية لمرض السكري ، أياً ممايلي من العبارات السلوكية تنطبق عليك ؟

- ☐ لدي المعلومات التقنية الكافية لإستخدام البرامج
- ☐ أعتقد أن البرامج تساعدني لتحقيق أهدافي لإدارة السكري
- ☐ أنا متحمس لإستخدام البرامج لأتمكن من التحكم بالسكري أكثر
- ☐ أنا أشعر أنني شخص منظم وأتمكن من التخطيط لإستخدام برامج الجوال.
- ☐ أنا أعتقد أنه هناك دليل علمي كافي تدعم أن البرامج يمكن أن تساعد.

15. فيما يتعلق ببرامج الجوال بشكل عام ، كيف تصنف نفسك ؟

- ☐ متبني الإبتكارات ، تقوم بشراء منتج جديد فور طرحه ، وتعتمد على نفسك ورؤيتك بقرار الشراء.
- ☐ الأغلبية المبكرة ، مدفوع بشعور قوي للإحساس بفاعلية المنتج ، لذلك تنتظر وتنظر للناس قبل أن تقوم بالشراء.
- ☐ الأغلبية المتاخرة ، لا تقوم بالشراء إلا إذا كنت مرتاح من قدرتك في استخدام التقنية ، لذلك تنتظر حتى أن يكون المنتج معياراً مقبولاً.
- ☐ غير مهتم بالتقنية ، أنت حذر جداً من أي تقنية جديدة ، وتشتري فقط في حالة شعورك أنها أصبحت ضرورية.

16. كم مرة تستخدم برنامجك لإدارة مرض السكري ؟

- ☐ أكثر من مرة باليوم (مثلاً في كل مرة أكل أو أخذ الدواء)
- ☐ بشكل يومي
- ☐ بعض أيام الأسبوع
- ☐ بشكل أسبوعي
- ☐ بشكل شهري
- ☐ فقط عندما أحتاج للمساعدة
- ☐ لا استخدمه نهائياً ، فقط قمت بتحميله

17. منذ متى وانت تستخدم برامج الجوال للإدارة الذاتية لمرض السكري ؟

- ☐ أقل من شهر
- ☐ 2-6 شهور
- ☐ 7-11 شهر
- ☐ أكثر من 12 شهر

18. **ماهو اسم البرنامج الذي تستخدمه لإدارة مرض السكري** (من الممكن أن تختار أكثر من خيار)

- ☐ برنامج سكري
- ☐ برنامج مضبوط
- ☐ برنامج فري ستايل ليبري لنك
- ☐ برنامج Dexcom G6
- ☐ برنامج Diabetes:M
- ☐ برنامج mySugr
- ☐ برنامج One Drop
- ☐ برنامج OneTouch Reveal
- ☐ أخرى ، الرجاء كتابتها .....
- ☐ ليس مماسبق

19. **ماهي المميزات المتوفرة بالبرنامج الذي تستخدمه حالياً** *(إذا كنت تستخدم أكثر من برنامج ، الرجاء تسجيل كل المميزات المتوفرة بكل البرامج)*

الميزة	متوفرة	غير متوفرة
مفكرة لتسجيل الوجبات والسعرات الحرارية		
حاسبة للسعرات الحرارية		
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية		
مفكرة لتسجيل مستويات السكر والسكر التراكمي		

منبه للتذكير بقياس مستوى السكر		
حساب السكر التراكمي التقريبي		
تسجيل بياناتي الصحية (الضغط ، الوزن ، نتائج المختبر)		
تسجيل ملاحظات		
مفكرة لتسجيل تناول الأدوية		
آلة حاسبة لجرعة الأنسولين		
منبه لتناول الأدوية		
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك		
تحديد وتتبع أهدافك للسكري		
تنبيهات في حالة الخطر		
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج		
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)		
أخبار صحية ومجتمعية		
معلومات التواصل مع الطاقم الطبي		
تقويم للمواعيد المرتبطة بالسكري		

20. ماهي أهمية المميزات التالية في برامج السكري بالنسبة لك *(بشكل عام : سواء كانت متوفرة ببرنامجك المستخدم أم لا)*

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							
تسجيل بياناتي الصحية (الضغط ، الوزن ، نتائج المختبر)							

تسجيل ملاحظات (مثلاً حول سكرك ، مزاجك)							
مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							
تقويم للمواعيد المرتبطة بالسكري							

21. بشكل عام ، ماهو تقييمك لفائدة البرنامج الذي تستخدمه لإدارة السكري ؟

- ☐ غير مفيد نهائياً ، فقط ضياع لوقتي بدون فائدة
- ☐ غير مفيد نوعا ما ، يوجد فائدة قليلة
- ☐ مفيد بعض الشيء ، يوجد بعض الفائدة
- ☐ مفيد ، يوجد فائدة كبيرة
- ☐ مفيد جداً ، هو جزء من حياتي اليومية ، لا يمكن الإستغناء عنه

22. هل واجهت أي مشاكل في البرنامج الذي تستخدمه حالياً لإدارة السكري ؟ *(الرجاء اختيار كل مانيطبق)*

- ☐ تعطل البرنامج

- ☐ نتائج غير دقيقة
- ☐ مشاكل في وحدات القياس
- ☐ صعوبة في فهم النصائح المعطاة
- ☐ النتائج لا تتفق مع النصائح الطبية المقدمة لك
- ☐ لا يوجد مشاكل
- ☐ أخرى ، الرجاء كتابتها _____

23. **مامدى دقة / سرعة مميزات البرنامج (الوظائف) و المحتويات (الأزرار والقوائم) الذي تستخدمه ؟** *(الرجاء اختيار إجابة واحدة)*

- ☐ البرنامج لا يعمل ، لايوجد استجابة / استجابة غير كافية / استجابة غير دقيقة (مثلاً توقف البرنامج أو المشاكل أو المميزات لا تعمل .. إلخ)
- ☐ بعض الوظائف تعمل ولكنها بطيئة أو بها مشاكل فنية كبيرة
- ☐ بشكل عام البرنامج يعمل ولكن يوجد بعض المشاكل الفنية بعض الأوقات
- ☐ يعمل بشكل جيد مع بعض المشاكل الصغيرة
- ☐ يعمل بشكل رائع بدون أي مشاكل فنية

24. **مامدى سهولة تعلم البرنامج ؟**

- ☐ لا يوجد أي تعليمات أو تعليمات غير واضحة ، القوائم والأيقونات معقدة .
- ☐ ممكن استخدامه ولكن بعد الكثير من الجهد والوقت
- ☐ ممكن استخدامه ولكن بعد بعض الجهد والوقت
- ☐ سهل التعلم والإستخدام والتعليمات واضحة
- ☐ سهل الإستخدام بشكل مباشرة وبسيط ولا يحتاج إلى تعلم

25. **مامدى سهولة التنقل والتعامل مع البرنامج**

- ☐ أقسام البرنامج عشوائية وغير مترابطة وعشوائية
- ☐ ممكن استخدامه ولكن بعد الكثير من الجهد والوقت
- ☐ ممكن استخدامه ولكن بعد بعض الجهد والوقت
- ☐ سهل ولكن بعض الروابط لا تعمل
- ☐ منطقي وسهل وواضح بشكل رائع ، ترابط الشاشات منطقي ويوجد اختصارات

26. **إذا كنت لا تستخدم برامج الجوال ، ماهو السبب الرئيسي لعدم استخدامك برنامج لإدارة السكري ؟**

- ☐ لا أعلم أنه يوجد برنامج متوفرة.
- ☐ لا تعمل على جهاز الجوال الخاص بي
- ☐ التكلفة ، ليس لدي الإستعداد للدفع من أجل برنامج
- ☐ أشعر بالثقة بدون برامج
- ☐ قمت بتجربة برنامج بالسابق ولكن لم يعجبني
- ☐ فعالية هذه البرامج غير مدعومة بدليل علمي

- ☐ لا يوجد برنامج متوفر باللغة العربية
- ☐ أخرى ، الرجاء كتابتها .....

27. هل أنت مهتم بإستخدام برنامج في جوالك لمساعدتك في إدارة السكري بالمستقبل ؟

- ☐ نعم
- ☐ لا
- ☐ غير متأكد

28. لو كنت تستخدم برنامج ، ماهي أهمية المميزات التالية في برامج السكري بالنسبة لك ؟

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							
تسجيل بياناتي الصحة (الضغط ، الوزن ، نتائج المختبر)							
تسجيل ملاحظات (مثلا حول سكرك ، مزاجك)							
مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							

نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							
تقويم للمواعيد المرتبطة بالسكري							

29. هل لديك أي تعليقات لتضيفها فيما يتخص برامج الجوال لإدارة مرض السكري ؟

شكراً لوقتك.

بالضغط على **زر إرسال** ، أنت تعطي الموافقة للمشاركة في هذا الإستبيان

Appendix 5.3 Patient Survey – Certified Back Translation

WORD360

Declaration

Word360 Limited certifies that the enclosed translation in the English language is a true and accurate translation of the enclosed document, written in Arabic.

A copy of the source document is identified herewith as W360/ARA and its respective translation as W360/ENG.

02/02/2022

[redacted]

Amy Coburn
Translation Project Manager
Word360 Ltd

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WORD360/ENG

Patient Survey – English Version

The beliefs, experiences, impressions, and knowledge of diabetics on using mobile applications to support self-management of diabetes in Saudi Arabia

Thank you for participating in this survey. This survey contains 26 questions or less and takes approximately 10 minutes of your time to complete.

This study aims at exploring the beliefs, experiences, impressions, and knowledge of diabetics on using mobile applications to support self-management of diabetes in the Kingdom of Saudi Arabia.

Your privacy is important to us. You will not be asked any personal questions by which you might be identified, such as your email address or phone number. The data collected in this survey will remain anonymous.

Please share this survey with people you know who have diabetes.

Thank you for your help!

If you have any questions regarding this survey or need any assistance in completing it, please contact the researcher. If you have any problems, you can contact the supervisor who supervises this research.

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Important information before starting the survey

- **What do we mean by diabetes management mobile applications?** Any application that patients use to help them in the daily management of diabetes, which is designed specifically for diabetics (such as tracking blood sugar levels and physical exercise). Accordingly, any other application that was not designed specifically for diabetics is of no value to this research - even if it helps patients in the management of diabetes (for example, applications for physical exercise).

- Please note that once this survey is submitted, you cannot withdraw from this study.

- You are eligible to participate in this survey if you are:
  - An adult (18 years old or more) diagnosed with type 1 or type 2 diabetes
  - Fluent in Arabic (whether native or as a second language)
  - Experienced in using mobile devices and at least one operating system (Apple, Android or Windows) for a period of min. 3 months
  - A resident in the Kingdom of Saudi Arabia



1. **Do you give your consent to participate in this research?**
   - ☐ Yes
   - ☐ No

2. **Do you have a smart phone or tablet?**
   - ☐ Yes
   - ☐ No

3. **What type of diabetes do you have?**
   - ☐ Type 1 diabetes (insulin dependent)
   - ☐ Type 2 diabetes (non-insulin dependent)
   - ☐ Other
   - ☐ Not sure
   - ☐ I do not have diabetes

4. **What is your age group?**
   - ☐ 18-25
   - ☐ 26-35
   - ☐ 36-45
   - ☐ 46-55
   - ☐ 56-65
   - ☐ >65

5. **What is the highest academic degree that you hold?**
   - ☐ Illiterate
   - ☐ Primary
   - ☐ Intermediate
   - ☐ Secondary
   - ☐ Diploma
   - ☐ Undergraduate
   - ☐ Postgraduate

6. **When you have trouble managing your diabetes, what is your first choice for help?**
   - ☐ Primary care centre
   - ☐ Specialised diabetes clinic
   - ☐ Pharmacist
   - ☐ Diabetes dietitian
   - ☐ Family and friends
   - ☐ Internet
   - ☐ Mobile applications
   - ☐ Other, please mention: _____



7. **In the last two years or since you were diagnosed with diabetes, how often do you visit hospital or diabetes clinic for tests?**

- ☐ Once a month
- ☐ Once every three months
- ☐ Once every six months
- ☐ Once a year
- ☐ There is no set time
- ☐ Other, please mmention: _____

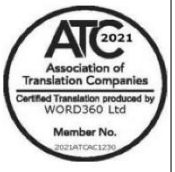
8. **What is your HbA1c level?**
   - ☐ ≤ 6
   - ☐ 6-7
   - ☐ 7-8
   - ☐ 9-10
   - ☐ 11-12
   - ☐ ≥ 13
   - ☐ I do not know

9. **How confident are you about your ability to manage your diabetes?**

☐ Not at all confident (I always need help with making any decision)
☐ Somewhat confident (I need help with making decisions most of the time)
☐ Average (I need help with making decisions sometimes)
☐ Confident (I am independent with making decisions most of the time)
☐ Very confident (I rarely need help with making decisions)

10. **What regular tasks do you follow to manage your diabetes? (Select all that applies to you)**

- ☐ Managing diet on a daily basis (for example, organising meals, counting calories, or recording meals)
- ☐ Physical activities and exercise (for example, following the doctor's instructions on changing your lifestyle, or recording your physical activities)
- ☐ Monitoring sugar levels (for example, checking your sugar level regularly, recording readings, or recording cases of high and low levels)
- ☐ Keeping track of medication intake (for example, taking medication, or calculating insulin dose)
- ☐ Solving problems related to diabetes (for example, informing your doctor or a family member of any problems related to diabetes, or using mobile applications to solve problems)
- ☐ Reducing diabetes risk (for example, regular visit to a diabetes clinic, eyes test, or foot examination)
- ☐ Maintaining general health (for example, participating in physical activities to stay healthy, or taking medications for high blood pressure)
- ☐ None of the above



11. **Did you install any diabetes self-management applications on your mobile phone? If the answer is yes, how many applications have you installed on your phone to help you manage diabetes?**

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 or more

12. **Who recommended installing diabetes self-management application(s)? (Select all that applies to you)**
    - ☐ I like mobile applications in general
    - ☐ I looked for applications myself without any advice from anyone
    - ☐ Advice from a friend or family
    - ☐ Advice from a doctor, Pharmacist, or healthcare provider
    - ☐ I read about the application in a newspaper, magazine, flyer etc.
    - ☐ Other, please mention: _____

13. **What is the language of the application(s)?**
    - ☐ Arabic
    - ☐ English
    - ☐ Arabic and English
    - ☐ Other language(s), please mention: _____

14. **Regarding diabetes self-management applications, which of the following behavioural statements apply to you?**
    - ☐ I have enough technical knowledge to use applications
    - ☐ I believe that applications help me achieve my goals in managing diabetes
    - ☐ I am excited about using applications to be able to control my diabetes more
    - ☐ I feel that I am well organised and can plan using mobile applications
    - ☐ I believe that there is enough scientific evidence supporting the benefits of mobile applications

15. **Regarding mobile applications in general, how would you classify yourself?**
    - ☐ Innovator (you buy a new product as soon as it is launched and rely on yourself and your vision to make the purchase decision)
    - ☐ Early Majority (you are driven by a strong sense of product efficacy. You wait and observe other people before you make a purchase)
    - ☐ Late Majority (you only buy if you are comfortable with your ability to use the technology. You wait until the product has an acceptable standard)
    - ☐ Laggard (you are very wary of any new technology and only buy if you feel that it has become necessary)

16. **How often do you use your diabetes management application?**
    - ☐ More than once a day (for example, every time I eat or take my medication)
    - ☐ Daily



- ☐ Few days a week
- ☐ Weekly
- ☐ Monthly
- ☐ Only when I need assistance
- ☐ I only installed it and do not use it at all

17. **How long have you been using diabetes self-management applications?**
    - ☐ Less than a month
    - ☐ 2-6 months
    - ☐ 7-11 months
    - ☐ More than 12 months

18. **What is the name of the application you use to manage diabetes? (You can select more than one option)**
    - ☐ سكري
    - ☐ مضبوط
    - ☐ Freestyle LibreLink
    - ☐ Dexcom G6
    - ☐ Diabetes:M
    - ☐ mySugr
    - ☐ One Drop
    - ☐ OneTouch Reveal
    - ☐ Other, please mention: .....
    - ☐ None of the above

19. **What are the available features in the application that you are currently using? (If you are using more than one application, please select all the available features in all the applications)**

Feature	Available	Not available
Diet and calories diary		
Calorie calculator		
Nutrition advice and carbs amount in food		
Cumulative sugar and sugar levels diary		
Sugar level measurement reminder		
Approximate cumulative sugar calculator		
Health data (blood pressure, weight, lab results)		
Adding notes		
Medication diary		
Insulin dose calculator		
Medication reminder		
Tips based on your diabetes level		
Set and track your diabetes goals		
Alerts in case of danger		
Contacting a medical provider via application		
Social (e.g. discussions with other diabetics)		
Health and community news		
Medical staff contact details		
Diabetes-related appointments calendar		

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20. **What is the importance of the following diabetes applications features to you in general? (Whether they are available in your application or not)**

Feature	Not important	Somewhat important	Important	Very Important	Extremely Important	Never Used	Not Sure
Diet and calories diary							
Caloric calculator							
Nutrition advice and carbs amount in food							
Cumulative sugar and sugar levels diary							
Sugar level measurement reminder							
Approximate cumulative sugar calculator							
Health data (blood pressure, weight, lab results)							
Adding notes (such as your sugar or mood)							
Medication diary							
Insulin dose calculator							
Medication reminder							
Tips based on your diabetes level							
Set and track your diabetes goals							
Alerts in case of danger (e.g. high blood sugar)							
Contacting a medical provider via application							
Social (e.g. discussions with other diabetics)							
Health and community news							
Medical staff contact details							
Diabetes-related appointments calendar							

21. **In general, how would you rate the benefits of the application you are using to manage diabetes?**
- ☐ Completely useless – a waste of time and without any benefits
- ☐ Not very useful – there are little benefits
- ☐ Somewhat useful – there are some benefits
- ☐ Useful – there are great benefits
- ☐ Very useful – it is indispensable and part of my daily life

22. **Have you encountered any problems with the application you are currently using to manage diabetes? (Please select all that applies)**
- ☐ The application crashes
- ☐ Inaccurate results
- ☐ Problems with measurement units
- ☐ Difficulty understanding the advice given
- ☐ The results do not correspond to the medical advice given to you
- ☐ No problems
- ☐ Other, please mention: _____

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23. **How accurate/fast are the application features (functions) and contents (buttons and menus) you are using? (Please select one answer)**
- ☐ The application does not work, not responsive / insufficient response / inaccurate response (for example, the application froze, features do not work etc.)
- ☐ Some functions work but are slow or have major technical problems
- ☐ Works in general with some technical problems sometimes
- ☐ Works fine with small issues
- ☐ Works great without any technical issues

24. **How easy it is to learn how to use the application?**
- ☐ No instructions / unclear instructions and menus are complicated
- ☐ Requires a lot of effort and time
- ☐ Requires some effort and time
- ☐ Easy to learn and use and instructions are clear
- ☐ Very easy to use, simple and requires no learning

25. **How easy it is to navigate the application?**
- ☐ Sections are random and unrelated
- ☐ Requires a lot of effort and time
- ☐ Requires some effort and time
- ☐ Easy to navigate but some links do not work
- ☐ Easy, clear, screens are logically connected and have shortcuts

26. **Even if you do not use any mobile applications, what is the main reason that stops you from using diabetes management applications?**
- ☐ I did not know there were applications available
- ☐ Applications do not work on my mobile phone
- ☐ Cost – I am not willing to pay for an application
- ☐ I feel confident without using any applications
- ☐ I used an application before, but I did not like it
- ☐ The effectiveness of these applications is not supported by scientific evidence
- ☐ No applications are available in Arabic
- ☐ Other, please mention: .....

27. **Would you be interested in using a mobile applications to help you manage your diabetes in the future?**
- ☐ Yes
- ☐ No
- ☐ Not sure



28. **If you are using an application, how important are the following features of diabetes applications to you?**

Feature	Not important	Somewhat important	Important	Very Important	Extremely Important	Never Used	Not Sure
Diet and calories diary							
Caloric calculator							

Nutrition advice and carbs amount in food							
Cumulative sugar and sugar levels diary							
Sugar level measurement reminder							
Approximate cumulative sugar calculator							
Health data (blood pressure, weight, lab results)							
Adding notes (such as your sugar or mood)							
Medication diary							
Insulin dose calculator							
Medication reminder							
Tips based on your diabetes level							
Set and track your diabetes goals							
Alerts in case of danger (e.g. high blood sugar)							
Contacting a medical provider via application							
Social (e.g. discussions with other diabetics)							
Health and community news							
Medical staff contact details							
Diabetes-related appointments calendar							

29. **Do you have any comments on mobile applications for diabetes management?**

Thank you for your time.

By clicking on the submit button, you give consent to participate in this survey.

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Patient Survey – Arabic Version

معتقدات وخبرات وانطباعات ومعرفة المصابين بالسكري عن استخدام برامج الجوال لدعم الإدارة الذاتية للسكري في السعودية

شكراً لمشاركتك في هذا الإستبيان.. يحتوي هذا الإستبيان على 26 سؤال أو أقل وتحتاج تقريباً 10 دقائق من وقتك.

هذه الدراسة تهدف إلى استكشاف معتقدات وخبرات وانطباعات ومعرفة المصابين بالسكري عن استخدام برامج الجوال لدعم الإدارة الذاتية للسكري في السعودية في المملكة العربية السعودية.

خصوصيتك مهمة ، لن يتم سؤالك عن أي سؤال شخصي يتم من خلاله التعرف عليك (مثل بريدك الإلكتروني أو رقم هاتفك). البيانات المجموعة في هذا الإستبيان ستبقي هويتك مجهولة.

الرجاء مشاركة هذا الإستبيان مع الأشخاص الذين تعرفهم ولديهم سكري. شكراً لمساعدتك!

إذا كان لديك أي سؤال بخصوص هذا الإستبيان أو تحتاج أي مساعدة لإكماله ، الرجاء التواصل مع الباحث. إذا كان لديك أي مشاكل يمكنك أيضاً التواصل مع المشرف الرئيسي على البحث.

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معلومات مهمة قبل البدء بالإستبيان

- ماذا نقصد ببرنامج الجوال لإدارة مرض السكري ؟
أي برنامج تستخدمه ليساعدك في الإدارة اليومية للسكري ، والذي صمم خصيصاً للمصابين بالسكري (مثل تتبع قياسات السكر ، تتبع الرياضة) ، لذلك ، أي برنامج آخر لم يصمم خصيصاً للمصابين بالسكري غير مهم في هذا البحث حتى وإن كان يساعدك في الإدارة (مثلاً البرامج الرياضية)

- الرجاء ملاحظة أنه عندما يتم إرسال هذا الإستبيان ، لا يمكن الإنسحاب من الدراسة لاحقاً.

- أنت مؤهل للمشاركة في هذا الإستبيان إذا كنت:
  - بالغ (18 سنة أو أكبر) مشخص بالسكري من النوع الأول أو الثاني
  - تجيد العربية كناطق أصلي أو كلغة ثانية
  - لديك خبرة بأجهزة الجوال بمعرفة على الأقل نظام تشغل واحد (أبل ، أندرويد أو ويندوز) لفترة لا تقل عن 3 شهور.
  - مقيم في المملكة العربية السعودية

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1. **هل أنت موافق على المشاركة في هذا البحث ؟**
   - ☐ نعم
   - ☐ لا

2. **هل لديك جوال ذكي أو كمبيوتر لوحي (تابلت) ؟**
   - ☐ نعم
   - ☐ لا

3. **ماهو نوع السكري الذي لديك ؟**
   - ☐ سكري من النوع الأول (المعتمد على الانسولين)
   - ☐ سكري من النوع الثاني (الغير معتمد على الانسولين)
   - ☐ نوع آخر
   - ☐ لست متأكد
   - ☐ ليس لدي سكري

4. **ماهي فئتك العمرية ؟**
   - ☐ 18-25 سنة
   - ☐ 26-35 سنة
   - ☐ 36-45 سنة
   - ☐ 46-55 سنة
   - ☐ 56 – 65 سنة
   - ☐ 65< سنة

5. **ماهي أعلى درجة علمية حصلت عليها ؟**
   - ☐ غير متعلم
   - ☐ إبتدائي
   - ☐ متوسط
   - ☐ ثانوي
   - ☐ دبلوم
   - ☐ بكالوريوس
   - ☐ دراسات عليا

6. **عندما تواجه مشكلة في إدارتك لمرض السكري ، ماهو أول خيار تلجأ إليه للمساعدة ؟**
   - ☐ مركز الرعاية الأولية
   - ☐ عيادة متخصصة للسكري
   - ☐ الصيدلي
   - ☐ أخصائي تغذية السكري
   - ☐ الأهل والأصدقاء
   - ☐ الإنترنت
   - ☐ برامج الجوال
   - ☐ أخرى ، الرجاء كتابتها _____

7. **في آخر سنتين أو منذ تشخيصك بالسكري ، كل كم تقوم بمراجعة المستشفى أو عيادة السكري للفحص؟**
   - ☐ مرة كل شهر
   - ☐ مرة كل ثلاث أشهر

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- ☐ مرة كل ست شهور
- ☐ مرة بالسنة
- ☐ لا يوجد وقت محدد
- ☐ أخرى ، الرجاء كتابتها _____

8. ماهو معدل سكرك التراكمي HBA1c ؟

- ☐ يساوي أو أقل من 6
- ☐ 6-7
- ☐ 8-7
- ☐ 10-9
- ☐ 12-11
- ☐ مساوي أو أكثر من 13
- ☐ لا أعرف

9. كيف تشعر وتثق بقدرتك في إدارة مرض السكري ؟

- ☐ غير واثق على الإطلاق ، أنا دائماً أحتاج للمساعدة عن أي قرار
- ☐ واثق نوعا ما ، أنا أحتاج مساعدة في اتخاذ قرار أغلب الوقت
- ☐ عادي ، أنا أحتاج للمساعدة في اتخاذ قرار بعض الأحيان
- ☐ واثق ، أنا مستقل في اتخاذ القرار أغلب الوقت
- ☐ واثق جداً ، نادراً ما أحتاج المساعدة في اتخاذ القرار

10. ماهي المهام التي تقوم بها بشكل منتظم لإدارة السكري ؟ *(اختر جميع مانيطبق عليك)*

- ☐ إدارة الأكل بشكل يومي (مثلاً تنظيم الوجبات ، أو حساب السعرات الحرارية ، أو تسجيل الوجبات الغذائية)
- ☐ النشاط والرياضة (مثلا ، أتبع إرشادات الطبيب لتغير نمط حياتي ، أو أقوم بتسجيل نشاطاتي الرياضية)
- ☐ مراقبة مستوى السكر (مثلاً فحص مستوى السكر بشكل منتظم ، تسجيل القراءات ، تسجيل حالات ارتفاع أو انخفاض السكر)
- ☐ متابعة تناول الدواء (مثلاً أخذ الدواء ، حساب جرعة الأنسولين)
- ☐ حل المشاكل المرتبطة بالسكري (مثلاً ، التواصل مع الطبيب أو أحد افراد العائلة لأي مشكلة متعلقة بالسكري ، أو استخدام برامج الجوال لحل المشاكل)
- ☐ تقليل مخاطر السكري (مثلاً الزيارة المنتظمة لعيادة السكري ، أو فحص العيون ، أو فحص القدم)
- ☐ متابعة الحالة الصحية بشكل عام (القيام بنشاط للإهتمام بصحتك بشكل عام ، مثلاً أخذ أدوية لإرتفاع ضغط الدم)
- ☐ لا شيء مما سبق

11. هل قمت بتركيب برامج جوال متخصصة في المساعدة للإدارة الذاتية لمرض السكري في جوالك ؟ إذا كان الجوال نعم كم عدد البرامج اللتي ركبتها في جوالك للمساعدة في لإدارة الذاتية لمرض السكري

- ☐ لم أقم بتحميل أي برنامج للسكري
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 أو أكثر

12. ما هو مصدر التوصية لتحميلك برامج للإدارة الذاتية للسكري ؟ *(اختر جميع مانيطبق عليك)*

- ☐ أحب استخدام برامج الجوال بشكل عام

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- ☐ بحثت عن البرنامج بنفسي بدون أي نصيحة من أحد
- ☐ نصيحة من صديق أو العائلة
- ☐ نصيحة من طبيب أو صيدلي أو أحد مقدمي خدمات الرعاية الصحية
- ☐ قراءت عن البرنامج في جريدة أو مجلة أو نشرة دعائية
- ☐ أخرى ، الرجاء كتابتها _____

13. **ماهي اللغة التي حملت البرنامج/ البرامج بها ؟**
- ☐ بالعربية فقط
- ☐ بالإنجليزية فقط
- ☐ باللغة العربية أو الإنجليزية
- ☐ لغة أخرى ، الرجاء كتابتها _____

14. **فيما يتعلق ببرامج الجوال للإدارة الذاتية لمرض السكري ، أياً ممايلي من العبارات السلوكية تنطبق عليك ؟**
- ☐ لدي المعلومات التقنية الكافية لإستخدام البرامج
- ☐ أعتقد أن البرامج تساعدني لتحقيق أهدافي لإدارة السكري
- ☐ أنا متحمس لإستخدام البرامج لأتمكن من التحكم بالسكري أكثر
- ☐ أنا أشعر أنني شخص منظم وأتمكن من التخطيط لإستخدام برامج الجوال.؟
- ☐ أنا أعتقد أنه هناك دليل علمي كافي تدعم أن البرامج يمكن أن تساعد.

15. **فيما يتعلق ببرامج الجوال لشكل عام ، كيف تصنف نفسك ؟**
- ☐ متبني الإبتكارات ، تقوم بشراء منتج جديد فور طرحه ، وتعتمد على نفسك ورؤيتك بقرار الشراء.
- ☐ الأغلبية المبكرة ، مدفوع بشعور قوي للإحساس بفاعلية المنتج ، لذلك تنتظر وتنظر للناس قبل أن تقوم بالشراء.
- ☐ الأغلبية المتاخرة ، لا تقوم بالشراء إلا إذا كنت مرتاح من قدرتك في استخدام التقنية ، لذلك تنتظر حتى أن يكون المنتج معياراً مقبولاً.
- ☐ غير مهتم بالتقنية ، أنت حذر جداً من أي تقتنية جديدة ، وتشتري فقط في حالة شعورك أنها أصبحت ضرورية.

16. **كم مرة تستخدم برنامجك لإدارة مرض السكري ؟**
- ☐ أكثر من مرة باليوم (مثلاً في كل مرة أكل أو أخذ الدواء)
- ☐ بشكل يومي
- ☐ بعض أيام الأسبوع
- ☐ بشكل أسبوعي
- ☐ بشكل شهري
- ☐ فقط عندما أحتاج للمساعدة
- ☐ لا استخدمه نهائياً ، فقط قمت بتحميله

17. **منذ متى وانت تستخدم برامج الجوال للإدارة الذاتية لمرض السكري ؟**
- ☐ أقل من شهر
- ☐ 2-6 شهور
- ☐ 7-11 شهر
- ☐ أكثر من 12 شهر

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18. **ماهو اسم البرنامج الذي تستخدمه لإدارة مرض السكري** (من الممكن أن تختار أكثر من خيار)

- ☐ برنامج سكري
- ☐ برنامج مضبوط
- ☐ برنامج فري ستايل ليبري لنك
- ☐ برنامج Dexcom G6
- ☐ برنامج Diabetes:M
- ☐ برنامج mySugr
- ☐ برنامج One Drop
- ☐ برنامج OneTouch Reveal
- ☐ أخرى ، الرجاء كتابتها .....
- ☐ ليس مماسبق

19. **ماهي المميزات المتوفرة بالبرنامج الذي تستخدمه حالياً** *(إذا كنت تستخدم أكثر من برنامج ، الرجاء تسجيل كل المميزات المتوفرة بكل البرامج)*

الميزة	متوفرة	غير متوفرة
مفكرة لتسجيل الوجبات والسعرات الحرارية		
حاسبة للسعرات الحرارية		
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية		
مفكرة لتسجيل مستويات السكر والسكر التراكمي		
منبه للتذكير بقياس مستوى السكر		
حساب السكر التراكمي التقريبي		
تسجيل بياناتي الصحة (الضغط ، الوزن ، نتائج المختبر)		
تسجيل ملاحظات		
مفكرة لتسجيل تناول الأدوية		
آلة حاسبة لجرعة الأنسولين		
منبه لتناول الأدوية		
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك		
تحديد وتتبع أهدافك للسكري		
تنبيهات في حالة الخطر		
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج		
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)		
أخبار صحية ومجتمعية		
معلومات التواصل مع الطاقم الطبي		
تقويم للمواعيد المرتبطة بالسكري		

20. **ماهي أهمية المميزات التالية في برامج السكري بالنسبة لك** *(بشكل عام : سواء كانت متوفرة ببرنامجك المستخدم أم لا)*

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							

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تسجيل بياناتي الصحة (الضغط ، الوزن ، نتائج المختبر)							
تسجيل ملاحظات (مثلاً حول سكرك ، مزاجك)							
مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							
تقويم للمواعيد المرتبطة بالسكري							

21. بشكل عام ، ماهو تقييمك لفائدة البرنامج الذي تستخدمه لإدارة السكري ؟

- ☐ غير مفيد نهائياً ، فقط ضياع لوقتي بدون فائدة
- ☐ غير مفيد نوعا ما ، يوجد فائدة قليلة
- ☐ مفيد بعض الشيء ، يوجد بعض الفائدة
- ☐ مفيد ، يوجد فائدة كبيرة
- ☐ مفيد جداً ، هو جزء من حياتي اليومية ، لا يمكن الإستغناء عنه

22. هل واجهت أي مشاكل في البرنامج الذي تستخدمه حالياً لإدارة السكري ؟ *(الرجاء اختيار كل ماينطبق)*

- ☐ تعطل البرنامج
- ☐ نتائج غير دقيقة
- ☐ مشاكل في وحدات القياس
- ☐ صعوبة في فهم النصائح المعطاة
- ☐ النتائج لا تتفق مع النصائح الطبية المقدمة لك
- ☐ لا يوجد مشاكل
- ☐ أخرى ، الرجاء كتابتها _____

23. **مامدى دقة / سرعة مميزات البرنامج (الوظائف) و المحتويات (الأزرار والقوائم) الذي تستخدمه ؟** *(الرجاء اختيار إجابة واحدة)*

- ☐ البرنامج لا يعمل ، لايوجد استجابة / استجابة غير كافية / استجابة غير دقيقة (مثلاً توقف البرنامج أو المشاكل أو المميزات لا تعمل .. إلخ)
- ☐ بعض الوظائف تعمل ولكنها بطيئة أو بها مشاكل فنية كبيرة
- ☐ بشكل عام البرنامج يعمل ولكن يوجد بعض المشاكل الفنية بعض الأوقات
- ☐ يعمل بشكل جيد مع بعض المشاكل الصغيرة
- ☐ يعمل بشكل رائع بدون أي مشاكل فنية

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24. مامدى سهولة تعلم البرنامج ؟

- ☐ لا يوجد أي تعليمات أو تعليمات غير واضحة ، القوائم والأيقونات معقدة .
- ☐ ممكن استخدامه ولكن بعد الكثير من الجهد والوقت
- ☐ ممكن استخدامه ولكن بعد بعض الجهد والوقت
- ☐ سهل التعلم والإستخدام والتعليمات واضحة
- ☐ سهل الإستخدام بشكل مباشرة وبسيط ولا يحتاج إلى تعلم

25. مامدى سهولة التنقل والتعامل مع البرنامج

- ☐ أقسام البرنامج عشوائية وغير مترابطة وعشوائية
- ☐ ممكن استخدامه ولكن بعد الكثير من الجهد والوقت
- ☐ ممكن استخدامه ولكن بعد بعض الجهد والوقت
- ☐ سهل ولكن بعض الروابط لا تعمل
- ☐ منطقي وسهل وواضح بشكل رائع ، ترابط الشاشات منطقي ويوجد اختصارات

26. إذا كنت لا تستخدم برامج الجوال ، ماهو السبب الرئيسي لعدم استخدامك برنامج لإدارة السكري ؟

- ☐ لا أعلم أنه يوجد برنامج متوفرة.
- ☐ لا تعمل على جهاز الجوال الخاص بي
- ☐ التكلفة ، ليس لدي الإستعداد للدفع من أجل برنامج
- ☐ أشعر بالثقة بدون برامج
- ☐ قمت بتجربة برنامج بالسابق ولكن لم يعجبني
- ☐ فعالية هذه البرامج غير مدعومة بدليل علمي
- ☐ لا يوجد برنامج متوفر باللغة العربية
- ☐ أخرى ، الرجاء كتابتها .....

27. هل أنت مهتم بإستخدام برنامج في جوالك لمساعدتك في إدارة السكري بالمستقبل ؟

- ☐ نعم
- ☐ لا
- ☐ غير متأكد

28. لو كنت تستخدم برنامج ، ماهي أهمية المميزات التالية في برامج السكري بالنسبة لك ؟

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							
تسجيل بياناتي الصحة (الضغط ، الوزن ، نتائج المختبر)							
تسجيل ملاحظات (مثلا حول سكرك ، مزاجك)							

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مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							
تقويم للمواعيد المرتبطة بالسكري							

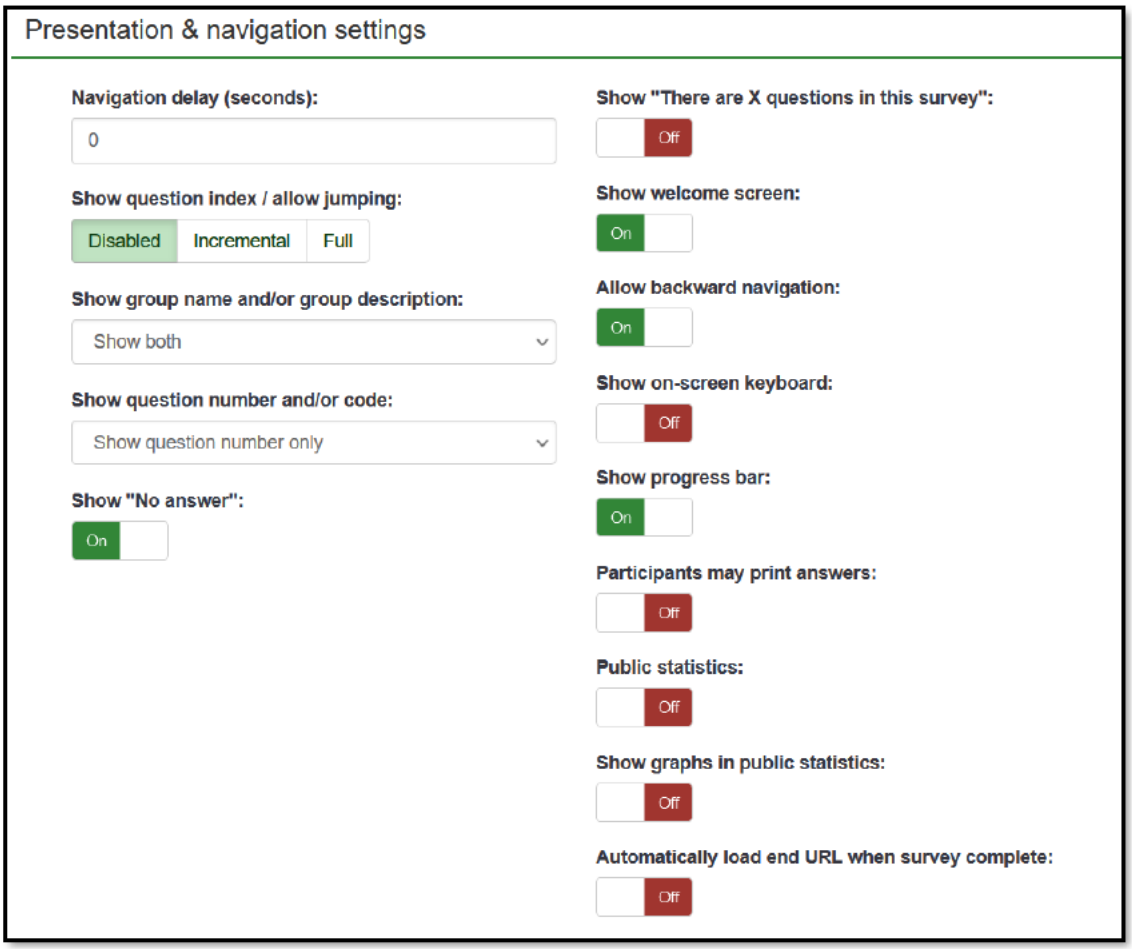
29. هل لديك أي تعليقات لتضيفها فيما يتخص برامج الجوال لإدارة مرض السكري ؟

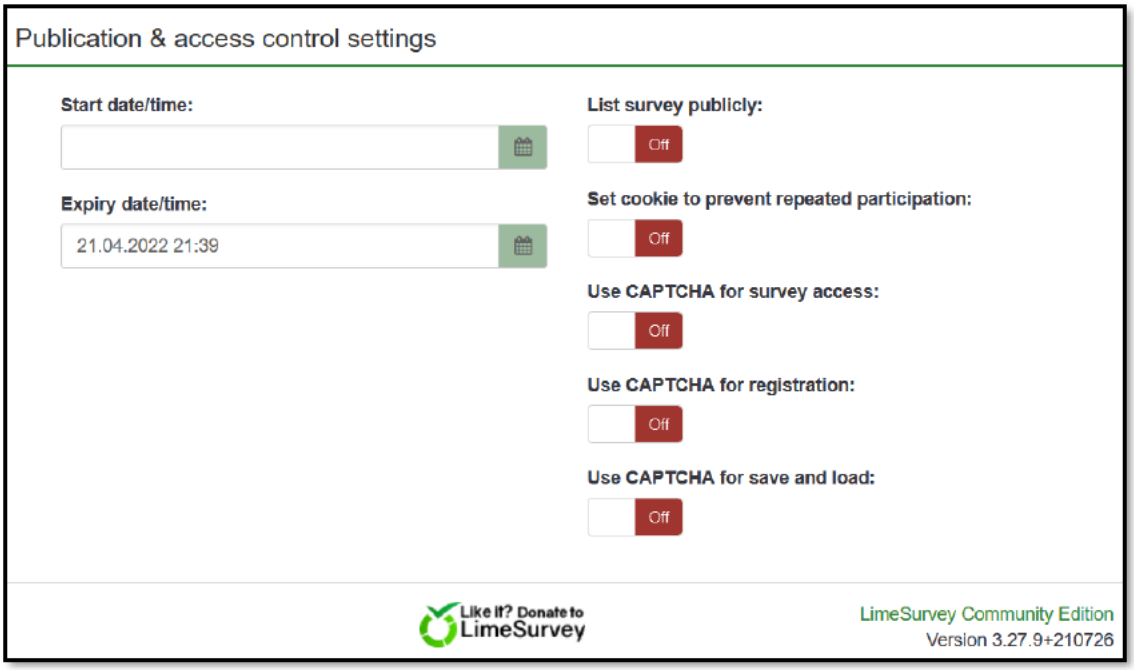
شكراً لوقتك.

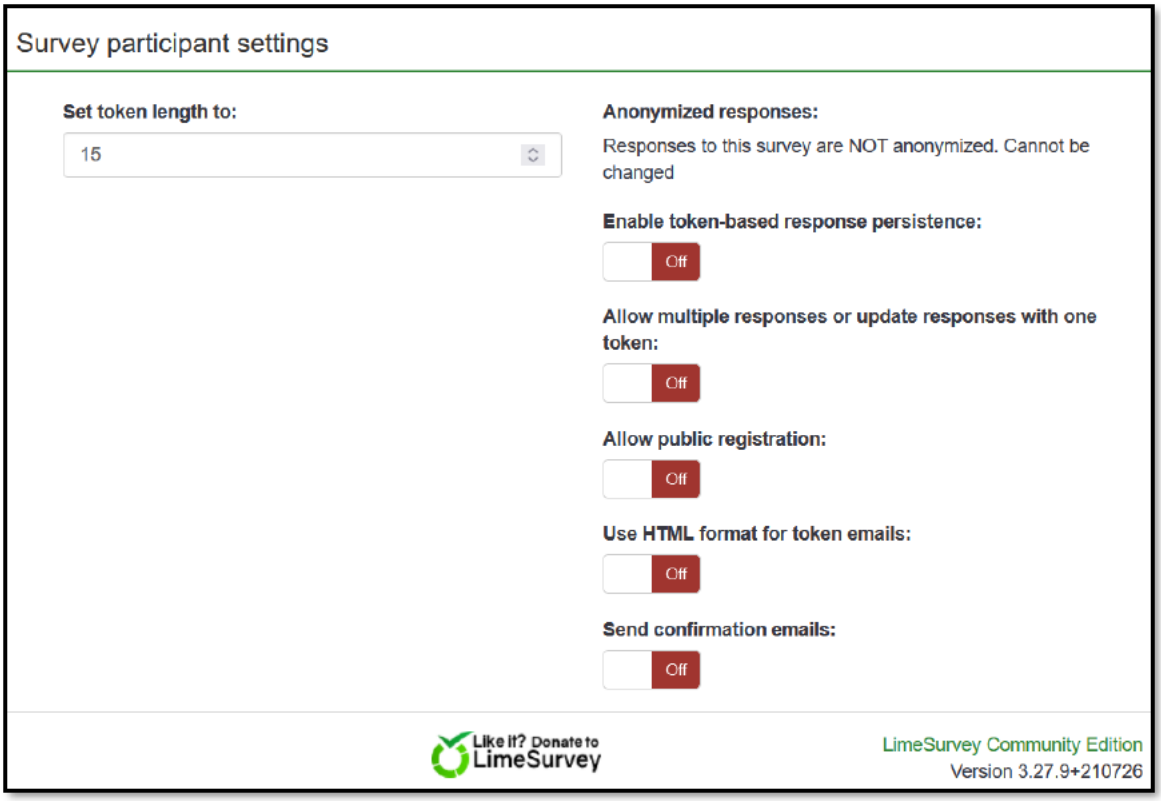
بالضغط على **زر إرسال** ، أنت تعطي الموافقة للمشاركة في هذا الإستبيان

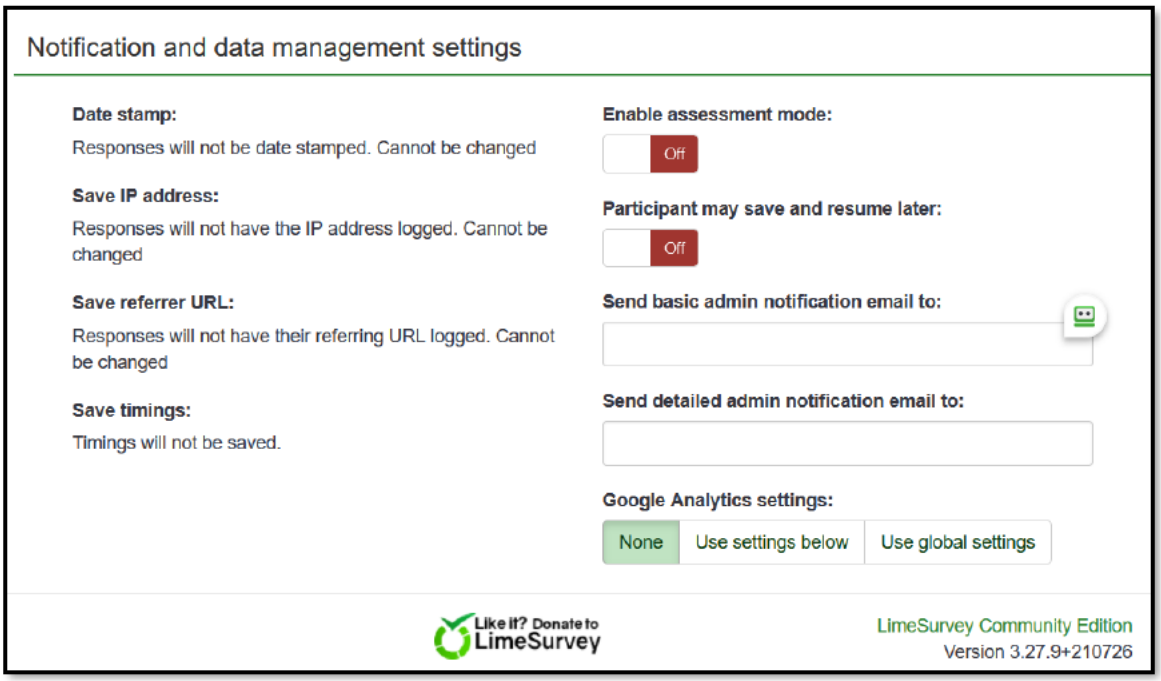


Appendix 5.4: LimeSurvey Settings






Survey participant settings
Set token length to:
15
Anonymized responses:
Responses to this survey are NOT anonymized. Cannot be changed
Enable token-based response persistence:
Off
Allow multiple responses or update responses with one token:
Off
Allow public registration:
Off
Use HTML format for token emails:
Off
Send confirmation emails:
Off
Like it? Donate to LimeSurvey
LimeSurvey Community Edition
Version 3.27.9+210726


Notification and data management settings
Date stamp:
Responses will not be date stamped. Cannot be changed
Save IP address:
Responses will not have the IP address logged. Cannot be changed
Save referrer URL:
Responses will not have their referring URL logged. Cannot be changed
Save timings:
Timings will not be saved.
Enable assessment mode:
Off
Participant may save and resume later:
Off
Send basic admin notification email to:
Send detailed admin notification email to:
Google Analytics settings:
None
Use settings below
Use global settings
Like it? Donate to LimeSurvey
LimeSurvey Community Edition
Version 3.27.9+210726

CHAPTER 6 APPENDICES

Appendix 6.1 Healthcare Professionals Survey – English Version

Healthcare professionals' beliefs, experience, attitude and knowledge in regard to the use of mobile applications in supporting diabetes self-management by patients in Saudi Arabia

Thank you for taking part in this questionnaire. This questionnaire is easy to complete; it has 13 questions and needs approximately 6 minutes to be completed.

This study aims to explore healthcare professionals' beliefs, experience, attitude and knowledge in regard to the use of mobile applications in supporting diabetes self-management by patients in Saudi Arabian population.

Your privacy is important; no private question will be asked or questions that identifies you (e.g., email or mobile number). The collected data will keep you anonymous.

Please share this questionnaire with any healthcare provider. Thanks for your support!

If you have any questions regarding this survey or need any assistance, please contact the researcher. If you have any issues or problems, you can also contact the lead supervisor.

Contact details:

Researcher:
Abdulhakem Alhamoudi
School of Pharmacy
University of Birmingham, UK
University of Albaha, SA
Mobile
WhatsApp

Lead supervisor:
Dr Vibhu Paudyal
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School of Pharmacy
University of Birmingham

Email:

Important Information

- **What do we mean by mobile application for diabetes?**

Any mobile app which helps in daily diabetes self-management activities and explicitly designed for people with diabetes (e.g. glucose tracking apps). Any apps that are not designed specifically for people with diabetes are not included, such as sport activities apps.

- **What do we mean by healthcare professionals?**

Any healthcare professionals who help you manage your diabetes, such as your physician, pharmacist or diabetes dietician, is a health care provider.

- **Please note: once the questionnaire has been submitted, data cannot be withdrawn.**

- **You are eligible to participate if you are:**

  - Works directly with a diabetic patient of type I or type II either by treatment, providing advice or education this includes physicians, pharmacists, dieticians and educators.
  - An Arabic speaker as a native or as a second language.
  - Familiar with mobile devices by using at least one mobile platform (Windows mobile, Android or iOS) for more than 3 months.

Resident in Saudi Arabia.

1. **Do you give consent to participate in this research?**
   - ☐ Yes
   - ☐ No

2. **Do you own a smartphone?**
   - ☐ Yes
   - ☐ No

3. **Do you support diabetic patients in your practice?**
   - ☐ Yes
   - ☐ No

4. **What is your profession?**
   - ☐ Doctor
   - ☐ Pharmacist
   - ☐ Nurse
   - ☐ Dietician
   - ☐ Diabetes Educator
   - ☐ Other, please specify: _____

5. **What is your age group?**
   - ☐ 26-35 years
   - ☐ 36-45 years
   - ☐ 46-55 years
   - ☐ 56 – 65 years
   - ☐ >65 years

6. **How many years has your professional role focused on people with diabetes?**
   - ☐ < 1 Year
   - ☐ 2-5 years
   - ☐ 6-10 years
   - ☐ >10

7. **Have you ever recommended a smartphone application (App) to a patient for diabetes self-management?**

☐ Yes. If yes, which smartphone app(s) did you recommend? _____

☐ No

8. What are the main reasons for you to recommend an application to patients?

- ☐ Helpful for patients
- ☐ Easier for accomplish complicated tasks such as carbohydrate counting or dose calculations
- ☐ No cost for patients
- ☐ I can track my patients' diabetes management online
- ☐ Other, please specify _____

9. What are the main reasons for you not to recommend an application?

- ☐ Apps have no effect on patients' clinical outcomes
- ☐ I have no information about diabetes apps
- ☐ The effectiveness of the apps is not evidence-based
- ☐ Busy and have no time for a recommendation
- ☐ Apps are numerous; I do not know which one is suitable.
- ☐ Other, please specify _____

10. Would you recommend others to use the below-stated categories of mobile apps for diabetes self-management??

Apps	I wouldn't recommend at all	Slightly recommend	Moderate recommend	Very recommend	Highly recommend
Diabetes App for food diaries and carbohydrate calculations					
Diabetes App for tracking sport and activates					
Blood glucose diaries and trackers					
Apps with reminders for glucose tracking					
Insulin calculation apps					
Apps with reminders for medication					
Diabetes education apps					

11. Have you ever contacted your patient or saw their data through a smartphone application (App) for diabetes self-management (e.g. FreeStyle LibreLink or Dexcom CLARITY)?

- ☐ Yes. If yes, which smartphone app(s) did you recommend? _____
- ☐ No
- ☐ I do not know about these apps

12. Please rate how useful you think these diabetes app features are for people with diabetes to enhance their diabetes self-management.

Features	Not at all Useful	Slightly useful	Moderately useful	Very useful	Extremely useful	N/A	Do not know
Diary of meals and carbohydrate intake							
Carbohydrate's calculator							
Dietary advice and food database for carbohydrates							
Diary of blood glucose levels and HbA1c							
Reminders to check blood glucose levels							
Estimated HbA1c							
Log Blood Pressure, body weight, lab results							
Record notes							
Diary of medication intake							
Calculation device to determine insulin dose							
Medication Reminder							
Recommendation based on your glucose level							
Set and Track Goals							
Safety warnings (e.g., high glucose level)							
Coaching connects with healthcare professionals (e.g., doctors or pharmacist)							
Social (e.g., Chat with diabetes patients)							
Health and community news							
Contact details for your diabetes team, GP							
Calendar of diabetes related appointments							

13. Do you have any comments to add about mobile apps for diabetes self-management?

Many thanks for your time.

By click a submit button, you are giving a CONSENT to participate on this questionnaire.

Appendix 6.2 Healthcare Professionals Survey – Arabic Version

معتقدات و خبرات وانطباعات و معرفة الطاقم الطبي فيما يتعلق باستخدام برامج الجوال في دعم الإدارة الذاتية للسكري من قبل المرضى في السعودية

شكراً لمشاركتك في هذا الإستبيان. تعبئة هذا الإستبيان سهلة. يحتوي الإستبيان على 13 سؤال وتحتاج تقريباً 6 دقائق لإكمالها.

هذه الدراسة تهدف إلى استكشاف معتقدات و خبرات وانطباعات و معرفة الطاقم الطبي فيما يتعلق باستخدام برامج الجوال في دعم الإدارة الذاتية للسكري من قبل المرضى في المملكة العربية السعودية.

خصوصيتك مهمة ، لن يتم سؤالك عن أي سؤال شخصي يتم من خلاله التعرف عليك (مثل بريدك الإلكتروني أو رقم هاتفك). جميع البيانات المجموعة في هذا الإستبيان ستكون مجهولة المصدر ولن يتم التعرف عليك.

الرجاء مشاركة هذا الإستبيان مع الأشخاص الذين تعرفهم من الطاقم الطبي. شكراً لمساعدتك!

إذا كان لديك أي سؤال بخصوص هذا الإستبيان أو تحتاج أي مساعدة لإكماله ، الرجاء التواصل مع الباحث. إذا كان لديك أي مشاكل يمكنك أيضاً التواصل مع المشرف الرئيسي على البحث.

معلومات الإتصال :

الباحث :





معلومات مهمة قبل البدء بالإستبيان

- **ماذا نقصد ببرنامج إدارة مرض السكري ؟**

أي برنامج يستخدمه المريض ليساعده في الإدارة اليومية للسكري ، والذي صمم خصيصاً للمصابين بالسكري (مثل تتبع قياسات السكر ، تتبع الرياضة) ، أي برنامج أخر لم يصمم خصيصاً للمصابين بالسكري غير مهم في هذا البحث حتى وإن كان يساعد المريض في الإدارة (مثلاً البرامج الرياضية)

- **ماذا نقصد بأخصائي الرعاية الطبية ؟**

أي مختص بتقديم الرعاية الطبية لمرضى السكري مثل الأطباء والصيادلة والتغذية.

- الرجاء ملاحظة أنه عندما يتم إرسال هذا الإستبيان ، لا يمكن الإنسحاب من الدراسة لاحقاً.

- أنت مؤهل للمشاركة إذا كنت :
  - يعملون بشكل مباشر مع مرضى السكري النوع الأول والثاني سواء بالعلاج أو تقديم نصائح أو تعليم ، وهذا يشمل الأطباء والصيادلة وأخصائي التغذية والتعليم.
  - يجيد العربية كناطق أصلي أو كلغة ثانية
  - لديك خبرة بأجهزة الجوال بمعرفة على الأقل نظام تشغل واحد (أبل ، أندرويد أو ويندوز) لفترة لا تقل عن 3 شهور.
  - مقيم في المملكة العربية السعودية

30. هل أنت موافق على المشاركة في هذا البحث ؟

☐ نعم
☐ لا

31. هل لديك جوال ذكي أو كمبيوتر لوحي (تابلت) ؟

☐ نعم
☐ لا

32. هل تتعامل مع وتدعم المصابين بالسكري في عملك ؟

☐ نعم
☐ لا

33. ماهي مهنتك ؟

☐ طبيب
☐ صيدلي
☐ ممرض
☐ أخصائي تغذية
☐ مثقف مرض السكري
☐ أخرى ، الرجاء كتابتها _____

34. ماهي فئتك العمرية ؟

☐ 26-35 سنة
☐ 36-45 سنة
☐ 46-55 سنة
☐ 56 – 65 سنة
☐ 65< سنة

35. كم عدد السنوات التي قضيتها في عملك بالتعامل مع المصابين بالسكري ؟

☐ سنة أو أقل
☐ 2-5 سنوات
☐ 6-10 سنوات
☐ أكثر من 10 سنوات

36. هل سبق وأن قمت بتوصية أي مريض باستخدام برنامج لمتابعة إدارة السكري ؟

☐ نعم ، إذا كانت الإجابة بنعم ماهو البرنامج الذي تنصح به المرضى _____
☐ لا

37. ماهي الأسباب الرئيسية لتوصية المريض بإستخدام برنامج ؟

☐ مفيدة للمرضى
☐ أسهل لحساب الكربوهيدرات وجرعات الأنسولين

- ☐ لا يوجد لها تكلفة
- ☐ أستطيع تتبع المرضى أون لاين وعن طريق البرامج
- ☐ أخرى ، الرجاء كتابتها _____

38. ماهي الأسباب الرئيسية التي تمنعك من توصية المريض بإستخدام برنامج ؟

- ☐ البرامج المتوفرة ليس لها تأثير على المخرجات الإكلينيكية للمريض
- ☐ لا يوجد عندي أي معلومات عن البرامج المتوفرة للسكري
- ☐ فاعليتها وفائدتها غير مثبته بالبراهين
- ☐ مشغول وليس عندي وقت للتوصية
- ☐ البرامج كثيرة ولا أعرف أيها الأفضل
- ☐ أخرى ، الرجاء كتابتها _____

39. ماهي درجة ثقتك لتوصية المرضى في هذه النوعية من برامج إدارة مرض السكري ؟

الفئة	لا أوصي على الإطلاق	أوصي قليلاً	أوصي بشكل متوسط	أوصي بها جداً	أوصي بها بشدة
برامج السكري التي تتبع الأكل وتساعد في حاسب الكربوهيدرات					
برامج السكري التي تتبع وتساعد في الأنشطة الرياضية					
برامج السكري التي تتبع وتساعد في مراقبة مستوى السكر بالدم					
برامج السكري التي تنبه المريض لمراقبة مستوى السكر					
برامج السكري التي تساعد في حساب جرعات الأدوية (حاسبة الأنسولين)					
برامج السكري التي تنبه المريض لأخذ الأدوية					
برامج السكري التعليمية والتثقيفية					

40. هل سبق لك وأن تواصلت مع مرضى أو أطلعت على بياناتهم الطبية عن طريق برنامج جوال لإدارة مرض السكري (مثلاً برنامج فريستايل أو ديكسكم كلاريتي) ؟

- ☐ نعم ، إذا اخترت هذا الجواب ، ماهو البرنامج الذي استخدمته ؟ _____
- ☐ لا
- ☐ لا أعرف هذه البرامج

41. ماهي المميزات التالية في برامج إدارة السكري التي تعتقد أنها ستساعد المريض في إدارته لمرض السكري ؟

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							
تسجيل البيانات الصحية (الضغط ، الوزن ، نتائج المختبر)							
تسجيل ملاحظات							
مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							
التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							

تقويم للمواعيد المرتبطة بالسكري							

42. هل لديك أي تعليقات لتضيفها فيما يخص برامج الجوال لإدارة مرض السكري ؟

شكراً لوقتك.

بالضغط على **زر إرسال** ، أنت تعطي الموافقة للمشاركة في هذا الإستبيان

Appendix 6.3: Healthcare Professionals Survey – Certified Back Translation

WORD360/ENG

The beliefs, experiences, impressions, and knowledge of medical staff on diabetes self-management mobile applications in Saudi Arabia

Thank you for your participation in this survey. Completing this questionnaire is easy. The questionnaire contains 13 questions and takes approximately 6 minutes to complete.

This study aims at exploring the beliefs, experiences, impressions, and knowledge of medical staff on the use of mobile applications to support diabetes self-management in the Kingdom of Saudi Arabia.

Your privacy is important to us. You will not be asked any personal questions by which you might be identified, such as your email address or phone number. The data collected in this survey will remain anonymous.

Please share this survey with the medical staff you know.

Thank you for your help!

If you have any questions regarding this survey or need any assistance in completing it, please contact the researcher. If you have any problems, you can contact the supervisor who supervises this research.

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Important information before starting

the survey

- **What do we mean by diabetes management mobile applications?**
  Any application that patients use to help them in the daily management of diabetes, which is designed specifically for diabetics (such as tracking blood sugar levels and physical exercise). Accordingly, any other application that was not designed specifically for diabetics is of no value for this research - even if it helps patients in the management of diabetes (for example, applications for physical exercise).

- **What do we mean by medical care specialist?**
  Any specialist who provides medical care to diabetics, such as doctors, pharmacists, and nutritionists.

- Please note that once this survey is submitted, you cannot withdraw from this study.

- You are eligible to participate in this survey if you are:
  - Working directly with patients with type 1 and 2 diabetes, whether in treatment, consultation, or education. This includes doctors, pharmacists, nutritionists, and educators
  - Fluent in Arabic (whether native or as a second language)
  - Experienced in using mobile devices and at least one operating system (Apple, Android or Windows) for a period of min. 3 months
  - A resident of the Kingdom of Saudi Arabia



1. **Do you give your consent to participate in this research?**
☐ Yes
☐ No

2. **Do you have a smart phone or tablet?**
☐ Yes
☐ No

3. **Do you work with and support people with diabetes?**
☐ Yes
☐ No

4. **What is your occupation?**
☐ Doctor
☐ Pharmacist
☐ Nurse
☐ Nutritionist
☐ Educator
☐ Other, please mention: _____

5. **What is your age group?**
☐ 26-35
☐ 36-45
☐ 46-55
☐ 56-65
☐ >65

6. **How many years have you been working with diabetics?**
☐ Less than a year
☐ 1-2 years
☐ 2-5 years
☐ 6-10 years
☐ More than 10 years

7. **Have you ever recommended to any patient to use a diabetes management application?**
☐ Yes. The application I recommend to patients is: _____
☐ No

8. **What is the main reason for recommending the use of applications to patients?**
☐ Useful for patients
☐ Easier to calculate carbs and insulin doses
☐ Cost effective
☐ Patients can be tracked online via applications
☐ Other, please mention: _____



9. **What is the main reason that prevents you from recommending the use of applications to patients?**

- ☐ Available applications have no effect on the patient's clinical outcomes
- ☐ I do not know much about the available diabetes applications
- ☐ There is no evidence to prove their efficiency and usefulness
- ☐ Busy and have no time to give recommendations
- ☐ There are many applications, and I do not know which one is the best
- ☐ Other, please mention: _____

10. **How confident are you in recommending the following types of diabetes management applications?**

Type	Do not recommend at all	Somewhat recommend	Recommend	Highly recommend	Extremely recommend
Applications that manage diet and calculate carbs					
Applications that track and assist with physical activities					
Applications that track and help monitor blood sugar levels					
Applications that remind patients to monitor the level of sugar					
Applications that help in calculating medication doses (insulin calculator)					
Applications that remind patients to take medication					
Educational and awareness applications					

11. **Have you ever communicated with patients or viewed their medical data via a diabetes management application (for example, Freestyle or Dexcom Clarity)?**

- ☐ Yes. The application I used is: _____
- ☐ No
- ☐ I do not know these applications

12. **What are the following features of diabetes management applications that you think will help the patient in managing diabetes?**

Feature	Not important	Somewhat important	Important	Very Important	Extremely Important	Never Used	Not Sure
Diet and calories diary							
Caloric calculator							
Nutrition advice and carbs amount in food							
Cumulative sugar and sugar levels diary							
Sugar level measurement reminder							
Approximate cumulative sugar calculator							
Health data (blood pressure, weight, lab results)							
Adding notes							
Medication diary							
Insulin dose calculator							
Medication reminder							
Tips based on your diabetes level							
Set and track your diabetes goals							
Alerts in case of danger (e.g. high blood sugar)							
Contacting a medical provider via application							
Social (e.g. discussions with other diabetics)							

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Health and community news							
Medical staff contact dctails							
Diabetes-related appointments calendar							

13. **Do you have any comments on mobile applications for diabetes management?**

Thank you for your time.

By clicking on the submit button, you give consent to participate in this survey.

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معتقدات و خبرات وانطباعات و معرفة الطاقم الطبي فيما يتعلق باستخدام برامج الجوال في دعم الإدارة الذاتية للسكري من قبل المرضى في السعودية

شكراً لمشاركتك في هذا الإستبيان. تعبئة هذا الإستبيان سهلة. يحتوي الإستبيان على 13 سؤال وتحتاج تقريباً 6 دقائق لإكمالها.

هذه الدراسة تهدف إلى استكشاف معتقدات و خبرات وانطباعات و معرفة الطاقم الطبي فيما يتعلق باستخدام برامج الجوال في دعم الإدارة الذاتية للسكري من قبل المرضى في السعودية في المملكة العربية السعودية.

خصوصيتك مهمة ، لن يتم سؤالك عن أي سؤال شخصي يتم من خلاله التعرف عليك (مثل بريدك الإلكتروني أو رقم هاتفك). جميع البيانات المجموعة في هذا الإستبيان ستكون مجهولة المصدر ولن يتم التعرف عليك.

الرجاء مشاركة هذا الإستبيان مع الأشخاص الذين تعرفهم من الطاقم الطبي. شكراً لمساعدتك!

إذا كان لديك أي سؤال بخصوص هذا الإستبيان أو تحتاج أي مساعدة لإكماله ، الرجاء التواصل مع الباحث. إذا كان لديك أي مشاكل يمكنك أيضاً التواصل مع المشرف الرئيسي على البحث.

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معلومات مهمة قبل البدء بالإستبيان

- **ماذا نقصد ببرنامج إدارة مرض السكري ؟**

أي برنامج يستخدمه المريض ليساعده في الإدارة اليومية للسكري ، والذي صمم خصيصاً للمصابين بالسكري (مثل تتبع قياسات السكر ، تتبع الرياضة) ، أي برنامج أخر لم يصمم خصيصاً للمصابين بالسكري غير مهم في هذا البحث حتى وإن كان المريض في الإدارة (مثلاً البرامج الرياضية)

- **ماذا نقصد بأخصائي الرعاية الطبية ؟**

أي مختص بتقديم الرعاية الطبية لمرضى السكري مثل الأطباء والصيادلة والتغذية.

- الرجاء ملاحظة أنه عندما يتم إرسال هذا الإستبيان ، لا يمكن الإنسحاب من الدراسة لاحقاً.

- أنت مؤهل للمشاركة إذا كنت :
  - يعملون بشكل مباشر مع مرضى السكري النوع الأول والثاني سواء بالعلاج أو تقديم نصائح أو تعليم ، وهذا يشمل الأطباء والصيادلة وأخصائي التغذية والتعليم.
  - يجيد العربية كناطق أصلي أو كلغة ثانية
  - لديك خبرة بأجهزة الجوال بمعرفة على الأقل نظام تشغل واحد (أبل ، أندرويد أو ويندوز) لفترة لا تقل عن 3 شهور.
  - مقيم في المملكة العربية السعودية

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1. **هل أنت موافق على المشاركة في هذا البحث ؟**
   - ☐ نعم
   - ☐ لا

2. **هل لديك جوال ذكي أو كمبيوتر لوحي (تابلت) ؟**
   - ☐ نعم
   - ☐ لا

3. **هل تتعمل مع وتدعم المصابين بالسكري في عملك ؟**
   - ☐ نعم
   - ☐ لا

4. **ماهي مهنتك ؟**
   - ☐ طبيب
   - ☐ صيدلي
   - ☐ ممرض
   - ☐ أخصائي تغذية
   - ☐ مثقف مرض السكري
   - ☐ أخرى ، الرجاء كتابتها _____

5. **ماهي فئتك العمرية ؟**
   - ☐ 26-35 سنة
   - ☐ 36-45 سنة
   - ☐ 46-55 سنة
   - ☐ 56 – 65 سنة
   - ☐ 65< سنة

6. **كم عدد السنوات التي قضيتها في عملك بالتعامل مع المصابين بالسكري ؟**
   - ☐ أقل من سنة
   - ☐ 1-2 سنوات
   - ☐ 2-5 سنوات
   - ☐ 6-10 سنوات
   - ☐ أكثر من 10 سنوات

7. **هل سبق وأن قمت بتوصية أي مريض باستخدام برنامج لمتابعة إدارة السكري ؟**
   - ☐ نعم ، إذا كانت الإجابة بنعم ماهو البرنامج الذي تنصح به المرضى _____
   - ☐ لا

8. **ماهو السبب الرئسي لتوصية المريض بإستخدام برنامج ؟**
   - ☐ مفيدة للمرضى
   - ☐ أسهل لحساب الكربوهيدرات وجرعات الأنسولين
   - ☐ لا يوجد لها تكلفة
   - ☐ أستطيع بتتبع المرضى أون لاين وعن طريق البرامج
   - ☐ أخرى ، الرجاء كتابتها _____

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9. ماهو السبب الرئسي الذي يمنعك كم توصية المريض بإستخدام برنامج ؟

- ☐ البرامج المتوفرة ليس لها تأثير على المخرجات الإكلينيكية للمريض
- ☐ لا يوجد عندي أي معلومات عن البرامج المتوفرة للسكري
- ☐ فاعليتها وفائدتها غير مثبته بالبراهين
- ☐ مشغول وليس عندي وقت للتوصية
- ☐ البرامج كثيرة ولا أعرف أيها الأفضل
- ☐ أخرى ، الرجاء كتابتها _____

10. ماهي درجة ثقتك لتوصية المرضى في هذه النوعية من برامج إدارة مرض السكري ؟

الفئة	لا أوصي على الإطلاق	أوصي قليلاً	أوصي بشكل متوسط	أوصي بها جداً	أوصي بها بشدة
برامج السكري التي تتبع الأكل وتساعد في حاسب الكربوهيدرات					
برامج السكري التي تتبع وتساعد في الأنشطة الرياضية					
برامج السكري التي تتبع وتساعد في مراقبة مستوى السكر بالدم					
برامج السكري التي تنبه المريض لمراقبة مستوى السكر					
برامج السكري التي تساعد في حساب جرعات الأدوية (حسابة الأنسلين)					
برامج السكري التي تنبه المريض لأخذ الأدوية					
برامج السكري التعليمية والتثقيفية					

11. هل سبق لك وأن تواصلت مع مرض أو أطلعت على بياناتهم الطبية عن طريق برنامج جوال لإدارة مرض السكري (مثلاً برنامج فريستايل أو ديكسكم كلاريتي) ؟

- ☐ نعم ، إذا اخترت هذا الجواب ، ماهو البرنامج الذي استخدمته ؟ _____
- ☐ لا
- ☐ لا أعرف هذه البرامحج

12. ماهي المميزات التالية في برامج إدارة السكري التي تعتقد أنها ستساعد المريض في إدارته لمرض السكري ؟

الميزة	غير مهمة نهائياً	مهمة نوع ما	متوسطة الأهمية	عالية الأهمية	مهمة جداً	لم أجربها	لا أعرف
مفكرة لتسجيل **الوجبات** والسعرات الحرارية							
حاسبة للسعرات الحرارية							
نصائح غذائية و بيانات عن عدد الكربوهيدرات في الأغذية							
مفكرة لتسجيل مستويات السكر والسكر التراكمي							
منبه للتذكير بقياس مستوى السكر							
حساب السكر التراكمي التقريبي بشكل آلي							
تسجيل بياناتي الصحة (الضغط ، الوزن ، نتائج المختبر)							
تسجيل ملاحظات							
مفكرة لتسجيل تناول الأدوية							
آلة حاسبة لجرعة الأنسولين							
منبه لتناول الأدوية							
نصائح وتوجيهات بناء على مستوى السكري بالنسبة لك							
تحديد وتتبع أهدافك للسكري							
تنبيهات في حالة الخطر (مثلاً ارتفاع مستوى السكر)							

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التواصل مع مقدم الرعاية الطبية عن طريق البرنامج							
إجتماعي (مثلاً التواصل مع المصابين بالسكري والنقاش معهم)							
أخبار صحية ومجتمعية							
معلومات التواصل مع الطاقم الطبي							
تقويم للمواعيد المرتبطة بالسكري							

13. هل لديك أي تعليقات لتضيفها فيما يتخص برامج الجوال لإدارة مرض السكري ؟

شكراً لوقتك.

بالضغط على **زر إرسال** ، أنت تعطي الموافقة للمشاركة في هذا الإستبيان

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