

**Effective Message Strategies for Mobile Text Messaging Interventions Targeting Type 2  
Diabetes Self-Management**

by

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B. A., Anadolu University, 1991  
M.A., Marquette University, 1995  
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A Dissertation Submitted in Partial Fulfillment  
of the Requirements for the Degree of

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University of Victoria

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## **Abstract**

Type 2 diabetes is a life-threatening condition, and it is rapidly growing in the world. If patients receive adequate education and support, they can manage their diabetes-related tasks effectively and reduce the severe complications of this disease. However, traditional self-management education and practices were not very effective in stimulating behaviour change and addressing patients' diversified needs and expectations. Mobile text messaging is a promising method for type 2 diabetes self-management as it can provide continuous and customized support to these patients. However, there is a lack of knowledge about the optimal approach to designing and delivering mobile text messages. Hence, this dissertation aimed to define effective message strategies for mobile text messaging interventions targeting type 2 diabetes self-management. This manuscript-based dissertation consists of three complementary studies. The first manuscript includes a systematic review and a meta-analysis of tailored mobile text messaging interventions on type 2 diabetes self-management. It examines the tailoring strategies, message content, and structure and identifies the moderators of effectiveness in these interventions. The second manuscript includes a systematic review and a meta-synthesis of qualitative evidence on patients' experiences and perspectives of mobile text messaging studies. The third manuscript consists of a prospective qualitative study to explore the text messaging design and delivery preferences of patients.

In the first and second studies, the comprehensive search strategy included major electronic databases, key journal searches, and hand searches of the reference lists of related systematic reviews and meta-analyses. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and Cochrane Collaboration's guidelines and recommended tools were used for data extraction, risk of bias and critical appraisal assessments,

data analysis and reporting. Within a social marketing framework, the third study included semi-structured interviews and a thematic analysis of the main findings.

In the first manuscript, 13 eligible trials were included for the systematic review and 11 eligible trials were further analyzed in the meta-analysis. This study concluded that tailored mobile text messaging interventions could improve glycemic control in patients with type 2 diabetes. The subgroup analyses revealed the importance of some moderators such as message delivery, message direction, message frequency, and using multi-modalities.

In the second manuscript, the systematic review included 14 eligible studies, and the thematic synthesis included 13 eligible studies. Patients emphasized the importance of tailored text message design and delivery. They felt “supported” by using text messaging and improved their communication with family/friends and care providers. Mobile text messaging increased patients’ self-awareness, knowledge and control of diabetes.

The third study explored that mobile text messages could be more effective if they are gain-framed and written in a standard format. Patients favoured the text messages that included simple and direct tone and provided statistical evidence. The findings demonstrated patients’ needs and expectations for advanced tailoring strategies in both message content and delivery.

Together, the manuscripts fill a significant gap and inform research and practice for the development of more effective message strategies that could lead to reducing the spread of type 2 diabetes worldwide.

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**Dedication**

This dissertation is dedicated to my father, who passed away at the same age as I am now.

## **Preface**

This dissertation is an original intellectual product of the author, Cigdem Sahin. Chapters 2-4 of this dissertation are anticipated to be stand-alone manuscripts in the peer-reviewed academic literature in the future.

The manuscript described in Chapter 2 was published in the Digital Health Journal of Sage Publications on April 22, 2019. As lead author, I designed the study with the recommendations from the other authors (my supervisory committee), Dr. Courtney, Dr. Naylor, and Dr. Rhodes. Following the Cochrane Collaboration's guidelines, I worked with two reviewers independently to make decisions regarding study inclusion, data extraction, and the risk of bias assessment. I analyzed the data and drafted the manuscript and submitted it to the other authors for review. All authors reviewed and edited the manuscript and approved its final version.

In the manuscript described in Chapter 3, I followed a similar procedure and applied Cochrane Collaboration's guidelines. I worked with a reviewer independently to make decisions about study inclusion, data extraction, and critical appraisal and coding processes. I analyzed the data and prepared the manuscript. My supervisory committee reviewed and edited the manuscript and approved the final version. This manuscript will be submitted to a peer-reviewed journal with a focus on health promotion and health communication technologies.

My third manuscript, described in Chapter 4, involves a qualitative study and received the Human Research Ethics Board approval from the University of Victoria and Island Health Authority. As the principal investigator, Dr. Courtney led the ethics approval process and guided me for the necessary documentation. Under the supervision of my committee, I completed the recruitment, data collection, and data analysis stages of the study, and prepared my manuscript. My supervisory committee reviewed and edited the manuscript and approved the final version.

This manuscript will be submitted to a peer-reviewed journal with a focus on health communication and health promotion.

## **Chapter 1: Introduction**

The overarching purpose of this research was to define effective message strategies for mobile text messaging interventions targeting Type 2 diabetes self-management using a multi-phase mixed methods design. This manuscript-based dissertation includes the three complementary research studies conducted to achieve the purpose: 1) A systematic review and a meta-analysis of tailored mobile text messaging interventions on type 2 diabetes self-management, 2) A systematic review and a meta-synthesis of qualitative evidence on patients' experiences and perspectives of mobile text messaging studies, and 3) A prospective qualitative study to explore text messaging preferences of patients to design more effective interventions for type 2 diabetes self-management. These studies were explained in the following chapters consecutively.

### **1.1 Background**

The rapid growth of Type 2 diabetes is a serious global health concern. Approximately 463 million adults (20-79 years) live with diabetes, which equals 1 in 11 of the world's adult population, and this figure is expected to rise to 700 million adults by 2045 (International Diabetes Federation, 2019). Type 2 diabetes is the most prevalent form of diabetes and constitutes nearly 90% of all diabetes cases. Although this disease is often associated with older adults, it has been increasingly observed in children and young adults in recent years (diabetes.co.uk, 2019).

Type 2 diabetes is a progressive life-long condition that can cause serious complications, such as blindness, heart disease, kidney problems, nerve damage, which make its management

more challenging over time. The complex and multifaceted characteristics of the disease require patients' strong commitment to its treatment and the provision of individualized support. Regular monitoring of blood glucose levels and adopting appropriate lifestyle changes can help patients to achieve better glycemic control and decrease the threats of diabetes (Diabetes Canada, 2020). Therefore, increasing awareness and knowledge about Type 2 diabetes and enhancing the self-management skills of patients is highly critical (Sherifali, Berard, Gucciardi, MacDonald, & MacNeill, 2018).

Traditional nurse-led self-management programs were not very successful in reaching people at risk and preventing the progression of the disease (Chen et al., 2013; Krosel, Svegl, Vidmar, & Dinevski, 2016; Torjesen, 2012; Song, Xu, & Sun, 2014). Patients have been facing difficulties adopting and maintaining lifestyle changes recommended by these programs; therefore, new and innovative approaches should be considered (Spruijt-Metz, O'Reilly, Cook, Page, & Quinn, 2014; Sherifali et al., 2018).

The high penetration of mobile phones worldwide (8.3 billion subscribers) (Statistica, 2020) increases the reach of mobile health interventions. In recent years, there has been extensive growth in the use of mobile health technologies for diabetes management (Kitsiou Paré, Jaana, & Gerber, 2017). Mobile health (mHealth) is defined 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" (World Health Organization, 2011; p.6). Interventions that use mobile technology have the potential of facilitating self-management, education, and support (Jones, Lekhak, & Kaewluang, 2014; Spruijt-Metz et al., 2014; Bashi, Fatehi, Fallah, Walters, & Karunanithi, 2018).

## **1.2 The Usefulness of Mobile Text Messaging in Type 2 Diabetes Self-Management**

Mobile text messaging through short message services (SMS) is the most common application of mHealth, consisting of curation and exchange of alphanumeric messages up to 160 characters. Mobile text messaging has been used in a variety of types of health interventions for nearly 17 years (Naughton & Sutton, 2011). Previous research provided evidence for the positive impact of mobile text messaging interventions on the self-management abilities of patients with chronic diseases (Jones et al., 2014; Fjeldsoe, Marshall, & Miller, 2009; Hall, Cole-Lewis, & Bernhardt, 2015). Particularly in type 2 diabetes self-management, mobile text messaging can be used to fulfil patients' need for close monitoring, convenient and individualized care. With the high feasibility of design and capacity to deliver tailored messages based on patients' needs and expectations, it is possible to achieve better outcomes in mobile text messaging-based interventions targeting type 2 diabetes self-management (Spruijt-Metz et al., 2014; Peimani et al., 2015).

Existing reviews highlighted the significant effects of mobile text messaging interventions on type 2 diabetes self-management interventions. Mobile text messaging interventions/programs were effective in improving patients' glycemic control and medication adherence (Hall et al., 2015; Arambepola et al., 2016; Farmer et al., 2016; Faruque, Wiebe, & Ehteshami-Afsha, 2017).

## **1.3 Statement of the Problem**

Although there is considerable literature providing evidence for the effectiveness of text messaging interventions in type 2 diabetes self-management, there is a lack of knowledge about the optimal approach to designing and delivering mobile text messages. Unfortunately, there was considerable heterogeneity in the existing reviews in terms of targeted behaviours, such as

physical activity and diet (Arambepola et al., 2016), medication adherence (Farmer et al., 2016); glycated hemoglobin control (Dobson, Whittaker, Dale, & Maddison., 2018; Faruque et al., 2017), and the moderators of effectiveness (i.e., interactivity, study duration, frequency). The scopes of these reviews were also different. There was only one systematic review (Dobson et al., 2018) specifically focused on mobile text messaging studies. Other review studies, including umbrella reviews, partially included text messaging interventions (i.e., Arambepola et al., 2016; de Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, and Atun 2012; Fjeldsoe et al., 2009; Cole-Lewis & Kershaw, 2010; Free et al., 2013).

Patient-oriented research and the adoption of evidence-based practices are both needed to mitigate the widespread prevalence of type 2 diabetes in the world (Sherifali et al., 2018). Research that synthesizes the evidence about patients' perspectives on self-management interventions/programs implemented via mobile text messaging and their experiences with intervention components is needed. Although it is vital to apply more persuasive message strategies in these interventions, the research has so far provided limited information about message design considerations and effective message content and structures that would stimulate and sustain behaviour change in patients with type 2 diabetes.

Previous research has provided strong evidence for the effect of tailoring intervention messages and message delivery schedules on behaviour change (Krebs, Prochaska, & Rossi, 2010; Militello, Kelly, & Melnyk, 2012; Head, Noar, Iannarino, & Harrington, 2013; Orr & King, 2015; Armanasco, Miller, Fjeldsoe, & Marshall, 2017). However, the majority of the studies to date focused on the efficacy of tailoring or compared tailored messages with non-tailored or generic messages as if the tailoring was a "unitary construct" (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008; Noar & Harrington, 2016). There is a need to investigate how tailoring was used and which types of tailoring strategies were more effective in specific

contexts and for specific groups of people (Hawkins et al., 2008; Noar, Harrington, & Aldrich, 2009; Noar & Harrington, 2016).

#### **1.4 The Manuscripts and The Contributions of The Dissertation**

Within an integrated perspective and mixed methods approach, this dissertation presents three studies that were designed to address the identified gaps in the previous research. The first manuscript includes a systematic review and a meta-analysis of the tailored text messaging interventions targeting type 2 diabetes self-management. The systematic review identifies and analyzes message content, design and delivery characteristics of tailored mobile text messaging interventions and examines which type of tailoring strategies were used in the interventions and how message content was developed. The meta-analysis concentrates on assessing the moderators of the effectiveness of tailored text messaging interventions.

Complementary to the first study and the manuscript, the second study was designed as a systematic review of qualitative studies and a meta-synthesis on mobile text messaging studies targeting type 2 diabetes self-management. The second manuscript synthesizes the evidence for patients' perspectives about mobile text messaging, tailoring strategies, and message-specific elements and provides insights on their experiences with these interventions.

Together, these two manuscripts provide a full picture of the current state of mobile text messaging research in type 2 diabetes self-management and specifically contribute to the understanding of message tailoring strategies and their importance for patients. Both studies identified the lack of communication and persuasion theories or frameworks in the studies. However, these theories or frameworks may provide better guidance for researchers than behavioural theories in tailoring messages based on patients' specific needs and preferences. The

results of the first two studies also indicate a need for further investigation of patients' attitudes toward message delivery schedules.

As a result, a patient-oriented study (described in the third manuscript) was conducted to assess patients' preferences on selected well-known message design strategies, such as message framing, evidence, tone, tailoring, and structure. This qualitative study also provides more insights on patients' perspectives about using text messaging for type 2 diabetes self-management, and message delivery schedules, such as frequency, timing, automated or in-person message delivery.

Briefly, some significant contributions of these studies include

- synthesizing the quantitative evidence for tailored text messaging interventions on type 2 diabetes self-management and identifying the moderators of effectiveness;
- analyzing message design and delivery features and describing effective tailoring strategies for the studies on type 2 diabetes self-management;
- synthesizing the qualitative evidence for the design and implementation of text-messaging interventions/programs targeting type 2 diabetes self-management and synthesizing patients' experiences with these interventions;
- exploring appropriate text message design factors for patients with type 2 diabetes

The manuscripts fill a significant gap and inform research and practice for the development of more effective strategies that could lead to reducing the spread of type 2 diabetes worldwide. It will be important that future research investigates the relative effectiveness of different tailoring strategies and validate the conclusions drawn from this dissertation about message design and delivery features. There is also a strong need for understanding the possible effects of different

demographic and psychosocial factors on type 2 diabetes self-management via mobile text messaging to develop successful tailoring strategies and design more efficient interventions.

## References

- Arambepola, C., Ricci-Cabello, I., Manikavasagam, P., Roberts, N., French, D. P., & Farmer, A. (2016). The impact of automated brief messages promoting lifestyle changes delivered via mobile devices to people with type 2 diabetes: a systematic literature review and meta-analysis of controlled trials. *Journal of Medical Internet Research*, *18*(4), e86. <http://doi.org/10.2196/jmir.5425>.
- Armanasco, A. A., Miller, Y. D., Fjeldsoe, B. S., & Marshall, A. L. (2017). Preventive health behavior change text message interventions: a meta-analysis. *American Journal of Preventive Medicine*, *52*(3), 391–402. <http://doi.org/10.1016/j.amepre.2016.10.042>
- Bashi, N., Fatehi, F., Fallah, M., Walters, D., & Karunanithi, M. (2018). Self-management education through mHealth: review of strategies and structures. *JMIR Mhealth Uhealth*, *6*(10): e10771.
- Chen, L., Chuang, L. M., Chang, C. H., Wang, C. S., Wang, I. C., Chung, Y., ...& Lai, F. (2013). Evaluating self-management behaviors of diabetic patients in a telehealthcare program: Longitudinal study over 18 months. *Journal of Medical Internet Research*, *15*(12), 1–15. <http://doi.org/10.2196/jmir.2699>.
- Cole-Lewis, H., & Kershaw, T. (2010). Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic Reviews*, *32*(1), 56–69. <http://doi.org/10.1093/epirev/mxq004>.
- de Jongh, T., Gurol-Urganci, I., Vodopivec-Jamsek, V., Car, J., & Atun R. (2012). Mobile phone messaging for facilitating self-management of long-term illnesses. *Cochrane Database Systematic Review*, *12*:CD007459.
- Diabetes Canada (2020) Type 2 diabetes. Retrieved from <https://www.diabetes.ca/recently-diagnosed/type-2-toolkitpdf?ext=.pdf>.
- Diabetes.co.uk. (2019). Type 2 diabetes. Retrieved from <https://www.diabetes.co.uk/type2-diabetes.html>.
- Dobson, R., Whittaker, R., Pfaeffli, Dale, L., & Maddison, R. (2017). The effectiveness of text message-based self-management interventions for poorly-controlled diabetes: A systematic review. *Digital Health*, *3*. <http://doi.org/10.1177/2055207617740315>.
- Farmer, A. J., McSharry, J., Rowbotham, S., McGowan, L., Ricci-Cabello, I., & French, D. P. (2016). Effects of interventions promoting monitoring of medication use and brief messaging on medication adherence for people with Type 2 diabetes: a systematic review of randomized trials. *Diabetic Medicine*, *33*(5), 565–579. <http://doi.org/10.1111/dme.12987>.

- Faruque, L.I, Wiebe, N. & Ehteshami-Afsha, A. (2017). Effect of telemedicine on glycated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials. *Canadian Medical Association Journal*, 189(9): E341–E364.
- Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine*, 36(2), 165–173. <http://doi.org/10.1016/j.amepre.2008.09.040>.
- Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., ... & Haines, A. (2013). The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. *PLoS Medicine*, 10(1). <http://doi.org/10.1371/journal.pmed.1001362>.
- Hall, A. K, Cole-Lewis, H., & Bernhardt, J. M. (2015). Mobile text messaging for health: A systematic review of reviews. *Annual Review Public Health*, 36(20), 393–415. <http://doi.org/10.1146/annurev-publhealth-031914-122855>.
- Hawkins, R. P., Kreuter, M., Resnicow, K., Fishbein, M., & Dijkstra, A. (2008). Understanding tailoring in communicating about health. *Health Education Research*, 23(3), 454–466. <http://doi.org/10.1093/her/cyn004>.
- Head, K. J., Noar, S. M., Iannarino, N. T., & Harrington, N. G. (2013). Efficacy of text messaging-based interventions for health promotion: A meta-analysis. *Social Science and Medicine*, 97, 41–48. <http://doi.org/10.1016/j.socscimed.2013.08.003>.
- Holtz, B., & Lauckner, C. (2012). Diabetes management via mobile phones: a systematic review. *Telemedicine and E-Health*, 18(3), 175–84. <http://doi.org/10.1089/tmj.2011.0119>.
- Hood, M., Wilson, R., Corsica, J., Bradley, L., Chirinos, D., & Vivo, A. (2016). What do we know about mobile applications for diabetes self-management? A review of reviews. *Journal of Behavioral Medicine*, 39, 981–994. <http://doi.org/10.1007/s10865-016-9765-3>.
- International Diabetes Federation (IDF) (2019). IDF diabetes atlas. 9th edition. Retrieved from <http://www.diabetesatlas.org>.
- Jones, K. R., Lekhak, N., & Kaewluang, N. (2014). Using mobile phones and short message service to deliver self-management interventions for chronic conditions: a meta-review. *Worldviews on Evidence-Based Nursing / Sigma Theta Tau International, Honor Society of Nursing*, 11(2), 81–8. <http://doi.org/10.1111/wvn.12030>.
- Kitsiou, S, Paré, G, Jaana, M, & Gerber, B. (2017). Effectiveness of mHealth interventions for patients with diabetes: an overview of systematic reviews. *PLoS One*, 12(3): e0173160.
- Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). Defining what works in tailoring: a meta-analysis of computer-tailored interventions for health behavior change. *Preventive Medicine*, 51(3-4), 214–221. <http://doi.org/10.1016/j.ypmed.2010.06.004>

- Krošel, M., Svegl, L., Vidmar, L., & Dinevski, D. (2016). Empowering diabetes patients with mobile health technologies. In W. Bonney (Ed.), *Mobile health technologies – theories and applications*. InTech. Retrieved from <https://www.intechopen.com/books/mobile-health-technologies-theories-and-applications/empowering-diabetes-patient-with-mobile-health-technologies>
- Militello, L. K., Kelly, S. A., & Melnyk, B. M. (2012). Systematic review of text-messaging interventions to promote healthy behaviors in pediatric and adolescent populations: implications for clinical practice and research. *Worldviews on Evidence-Based Nursing*, 9(2), 66–77. <http://doi.org/10.1111/j.1741-6787.2011.00239.x>.
- Naughton, F. & Sutton, S. (2011). Going mobile: Delivering behavioural support via SMS text messages. *European Health Psychology*, 13, 27–29. <http://doi.org/10.1037/e544722013-004>
- Noar, S. M., Harrington, N. G., & Aldrich, R. S. (2009). The role of message tailoring in the development of persuasive health communication messages. *Communication Yearbook*, 33(1947), 73–133. <http://doi.org/10.1080/23808985.2009.11679085>.
- Or, C. K. L., & Tao, D. (2014). Does the use of consumer health information technology improve outcomes in the patient self-management of diabetes? A meta-analysis and narrative review of randomized controlled trials. *International Journal of Medical Informatics*, 83(5), 320–329. <http://doi.org/10.1016/j.ijmedinf.2014.01.009>
- Peimani, M., Rambod, C., Omidvar, M., Larijani, B., Ghodssi-Ghassemabadi, R., Tootee, A., & Esfahani, E. N. (2016). Effectiveness of short message service-based intervention (SMS) on self-care in type 2 diabetes: A feasibility study. *Primary Care Diabetes*, 10(4), 251–258. <http://doi.org/10.1016/j.pcd.2015.11.001>
- Sherifali, D., Berard, L.D., Gucciardi, E., MacDonald, B., & MacNeill, G. (2018). Self-management education and support. Diabetes Canada Clinical Practice Guidelines Expert Committee. *Canadian Journal of Diabetes*, 42, S36-S41.
- Song, D., Xu, T. Z., & Sun, Q.H. (2014). Effect of motivational interviewing on self-management in patients with type 2 diabetes mellitus: a meta-analysis. *International Journal of Nursing Science*, 1, 291–297.
- Spruijt-Metz, D., O'Reilly, G. A., Cook, L., Page, K. A., & Quinn, C. (2014). Behavioral contributions to the pathogenesis of type 2 diabetes. *Current Diabetes Reports*, 14(4), 475. <http://doi.org/10.1007/s11892-014-0475-3>
- Torjesen, I. (2012). More than half of diabetes patients are not getting standard health checks. *BMJ*, 344: e3393.
- World Health Organization (2011). New horizons for health through mobile technologies. *Global Observatory for eHealth Series*, 3, pp. 1-104. Retrieved from [https://www.who.int/goe/publications/goe\\_mhealth\\_web.pdf](https://www.who.int/goe/publications/goe_mhealth_web.pdf).

## **Chapter 2: Tailored Mobile Text Messaging Interventions Targeting Type 2 Diabetes Self-Management: A Systematic Review and a Meta-Analysis**

### **2.1 Abstract**

**Objectives:** This study aimed to identify, assess and summarize available scientific evidence on tailored text messaging interventions focused on type 2 diabetes self-management. The systematic review concentrated on message design and delivery features and tailoring strategies. The meta-analysis assessed the moderators of the effectiveness of tailored text messaging interventions.

**Methods:** A comprehensive search strategy included major electronic databases, key journal searches and reference list searching for related studies. PRISMA and Cochrane Collaboration's guidelines and recommended tools for data extraction, quality appraisal and data analysis were followed. Data were extracted on participant characteristics (age, gender, ethnicity), and interventional and methodological characteristics (study design, study setting, study length, choice of modality, comparison group, message type, format, content, use of interactivity, message frequency, message timing, message delivery, tailoring strategies and theory use). Outcome measures included diet, physical activity, medication adherence and glycated hemoglobin data (HbA1C). Where possible, a random-effects meta-analysis was performed to pool data on the effectiveness of the tailored text messaging interventions and moderator variables.

**Results:** The search returned 13 eligible trials for the systematic review and 11 eligible trials for the meta-analysis. The majority of the studies were randomized controlled trials, conducted in high-income settings, used multi-modalities, and mostly delivered informative, educational messages through an automated message delivery system. Tailored text messaging interventions

produced a substantial effect ( $g = 0.54$ , 95% CI = 0.08–0.99,  $p < 0.001$ ) on HbA1C values for a total of 949 patients. Subgroup analyses revealed the importance of some moderators such as message delivery (QB = 18.72, df = 1,  $p = 0.001$ ), message direction (QB = 5.26, df = 1,  $p = 0.022$ ), message frequency (QB = 18.72, df = 1,  $p = 0.000$ ) and using multi-modalities (QB = 6.18, df = 1,  $p = 0.013$ ).

**Conclusions:** Tailored mobile text messaging interventions can improve glycaemic control in type 2 diabetes patients. However, more rigorous interventions with larger samples and longer follow-ups are required to confirm these findings and explore the effects of tailored text messaging on other self-management outcomes.

**Keywords:** Text messaging, type 2 diabetes, systematic review, meta-analysis, tailoring, message design, health behaviour, self-management

## 2.2 Introduction

The rapid growth of type 2 diabetes in the world is a serious concern (International Diabetes Federation, IDF, 2017). Type 2 diabetes is a life-threatening condition, but it is possible to prevent the development of illness, delay or even reverse its complications through effective diabetes management (Diabetes Canada, 2019). Because a major part of diabetes management (nearly 95%) is executed by the patients (Diabetes UK, 2009), it is highly critical to increasing patients' self-management skills. More often, mobile health technologies (mHealth) are being used to provide support to these patients who often fail to follow traditional self-management practices (Spruitz-Metz, Nielsen, & Pavel, 2015; Hood et al., 2016). Particularly, mobile text messaging offers customized, cost-effective, and convenient support and can help patients to track their medical and behavioural outcomes continuously (de Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, & Atun 2012).

Despite expanding use of mobile text messaging, there is still a lack of knowledge on the optimal way to create and deliver mobile text messages that could stimulate behaviour change (Arambepola et al., 2016; Hall, Cole-Lewis, & Bernhardt, 2015; Suffoletto, 2016; Muench & Baumel, 2017). Previous research so far provided mixed evidence for the moderators of the effective text messaging interventions such as frequent messaging (Orr & King, 2015, Kitsiou, Pare, Jaanna, Gerber, 2017), infrequent messaging (Head, Noar, Iannarino, & Harrington, 2013) one-way messaging (Head et al., 2013; Orr & King, 2015), two-way messaging (Hall et al., 2015), and using multi-modalities (e.g., text messaging, WEB portal, assessment devices) (Kitsiou et al., 2017, Armanasco, Miller, Fjeldsoe, 2017; Farmer, McSherry, Rowbotham, 2016). There were also studies revealing no effects of some moderators, such as message direction

(whether one way or two-way messaging) (Arambepola et al., 2016) or choice of modality (whether text messaging only or text messaging plus) (Head et al., 2013).

The limited space and design opportunities provided by mobile text messaging may also make it difficult to craft effective messages for behaviour change. Using different message design elements such as message appeal (e.g., fear, guilt, humour), message tone (e.g., authoritarian vs. friendly, directive vs. passive), message format (e.g., textese), or use of evidence (e.g., statistical evidence, testimonial evidence) persuasively might create important differences in receivers' message involvement, message receptivity, and message retention (O'Keefe, 2002; Noar, Benac, & Harris, 2007; Muench, van Stolk-Cooke, & Morgenstern, 2014). Previous research (Rothman, Bartels, Wlaschin, & Salovey, 2006) also demonstrated that health messages could be framed to emphasize either the benefits of performing a specific behaviour (a gain-frame) or the costs of not performing a specific behaviour (a loss-frame). Gain-framed messages are more associated with prevention behaviours, while loss-framed messages are more appropriate for detection behaviours.

According to Elaboration Likelihood Model (Petty & Cacioppo, 1986), the messages, including personally relevant features, increase one's motivation and ability to elaborate on the message content, enhance his/her involvement with the message and thereby increase persuasion. Tailoring message delivery and content could be more effective than providing a standard self-management program for patients with type 2 diabetes. For example, intervention messages can be tailored based on patients' psycho-social needs (e.g., awareness, perceived risk, self-efficacy), their performance (e.g., providing individual feedback), preferences (e.g., time and frequency of messages) or demographics (e.g., Young Latino-American Women) (CDA, 2019; Arambepola et al., 2016; Kitsiou et al., 2017; Head et al., 2013). For example, text messaging interventions

targeted young people and children were more successful if they were using personalized messages (e.g., using the child's name), using informal short message services (SMS) content and text (e.g., "ur goal is 2 eat less sugary things 2 get ur blood down!") (Militello, Kelly, & Melnyk, 2012).

The Transtheoretical Model (TTM) has frequently been used in interventions to address the specific needs and expectations of patients in different stages of behaviour change (Glanz & Bishop, 2010). For example, in a text messaging intervention, message content can be tailored to eliminate the barriers at the initial pre-contemplation stage or reward the desired behaviour for patients in the latter action stage. The Health Belief Model (HBM) has also been used for tailoring messages and other components in behaviour change interventions. The HBM assumes that the perceptions of the threat coming from a health problem and the benefits of avoiding the risk influence one's readiness to act (Glanz & Bishop, 2010). If messages are specifically designed to target individual characteristics, perceived barriers, perceived benefits, perceived susceptibility, cues to action and self-efficacy, they can induce behaviour change. Using more theoretical constructs (4-5) could be more effective than using fewer theoretical constructs (0-3) in tailoring (Noar et al., 2007). Computer-tailored interventions were effective on health behaviour change (Lustria, Noar, Cortese, 2013; Krebs, Prochaska, & Rossi, 2010), but there is a lack of knowledge in tailoring message design and delivery mode and other intervention components in these interventions (Lustria et al., 2013).

Previously, tailoring was considered as a "unitary construct" as opposed to either personalized and/or standardized messages (Orr & King, 2015; Armanasco et al., 2017). However, different types of tailoring strategies with changing effects on behaviour are available, and personalization is also a form of tailoring (Noar & Harrington, 2016; Dijkstra,

2016; Hawkins, Kreuter, & Resnicow, Fishbein, & Dijkstra, 2008). **Personalization** frames the information to create a perception in the participants as if the message is specifically designed for them, and it is not specifically related to the content of the message. Using the name or other identifiers of participants such as age or ethnicity while delivering a generic message could increase the message persuasiveness. Another commonly applied tailoring strategy is **Feedback**. It includes providing descriptive, comparative, and evaluative messages to participants about their psychological and behavioural conditions during the intervention. **Content-matching** is an advanced level of tailoring where key theoretical constructs are used to match the personal needs, goals and interests of participants. It can be used to guide patients as they move through different stages of behaviour change (Noar & Harrington, 2016; Dijkstra, 2016). Especially in the age of computer-tailored interventions where employing different types and combinations of tailoring are possible, there is a strong need for understanding which type of tailoring strategies and message-specific elements are more important in a specific context and for a specific group of people.

Various demographic, medical, motivational, and behavioural factors can influence Type 2 diabetes self-management (Pal et al., 2018; Dobson, Whittaker, Pfaeffli, & Maddison, 2017; Sherifali, Berard, Gucciardi, MacDonald, & Mac Neill., 2018). Therefore, it is necessary to understand the underlying mechanism of tailoring for patients with type 2 diabetes. To our knowledge, no existing reviews of mobile text messaging in the area of Type 2 diabetes management have focused on tailored interventions and synthesizing the evidence for the optimal tailoring strategies, message design and delivery features in these interventions. Hence, the main purposes of this systematic review and meta-analysis were a) to identify, assess, and summarize available scientific evidence for tailored mobile text messaging interventions focused on Type 2

diabetes self-management, b) to examine the characteristics of tailored interventions by concentrating on their message design features, tailoring strategies and message delivery features, c) to explore a link between tailoring strategies and self-management outcomes which were specified as glycated hemoglobin monitoring (HbA1C), diet, physical activity, and medication adherence, d) to assess the effect of tailored mobile text messaging interventions on specified Type 2 diabetes self-management outcomes, and e) to identify the moderators of the effectiveness of the interventions to define the optimal tailored mobile messaging strategies and intervention characteristics for Type 2 diabetes self-management.

## **2.3 Method**

The systematic review and meta-analysis were planned, conducted, and reported according to the process described in the Methodological Expectations of Cochrane Intervention Reviews (MECIR) (Higgins and Green, 2011) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009).

### **2.3.1 Inclusion/exclusion criteria**

Eligible interventions were tailored randomized trials focused on Type 2 diabetes self-management via mobile-phone-based text messaging that involved the delivery of behaviour change content through short message services (SMS), multimedia message services (MMS), or instant messaging (i.e., WhatsApp). The interventions that used at least one type of tailoring variables such as personalized message or feedback on behaviour and included a non-tailored control/comparison group were considered. To be able to include all the relevant studies, no additional filter was applied to limit study participants regarding ethnicity, age, religion,

occupation, income or any other demographic variables. Table 2.1 presents the eligibility criteria developed for considering the studies in the systematic review.

**Table 2.1 Eligibility criteria for considering the studies in the review**

	<b>Inclusion Criteria</b>	<b>Exclusion Criteria</b>
<b>Types of Studies</b>	<ul style="list-style-type: none"> <li>• Randomized trials</li> <li>• Written in English</li> </ul>	<ul style="list-style-type: none"> <li>• Unpublished studies, conference abstracts /posters</li> </ul>
<b>Types of Participants</b>	<ul style="list-style-type: none"> <li>• People with Type 2 diabetes</li> <li>• The studies with a mixed population, such as individuals with Type 1 and Type 2 diabetes were only considered if separate data were provided for participants with Type 2 diabetes</li> </ul>	<ul style="list-style-type: none"> <li>• Interventions that focused on patients with Type 1 diabetes or gestational diabetes or diabetic retinopathy.</li> <li>• The studies whose participants included healthcare providers or other stakeholders rather than patients or consumers of health care services</li> </ul>
<b>Types of Interventions</b>	<ul style="list-style-type: none"> <li>• Mobile phone-based text messaging interventions that involved the delivery of behaviour change content through short message services (SMS), multimedia message services (MMS), or instant messaging using mobile messaging apps like WhatsApp.</li> <li>• Interventions that used at least one type of tailoring variables such as personalized message or feedback on behaviour</li> <li>• Interventions including a non-tailored control/comparison group</li> </ul>	<ul style="list-style-type: none"> <li>• Mobile app or web-based interventions without any mobile-phone-based text messaging component to deliver behaviour change messages</li> <li>• The studies delivered generic (standard) messages or only included the appointment and simple medication reminders (prompts) or instructions for medication use (i.e., insulin dose adjustment)</li> <li>• The studies used audio or voice message (including IVR) without using any mobile text messaging component</li> <li>• The interventions delivered generic (standard) messages</li> <li>• The studies whose messages included only the appointment and simple medication reminders (prompts) or instructions for medication use (i.e., insulin dose adjustment)</li> </ul>
<b>Types of Outcomes</b>	<ul style="list-style-type: none"> <li>• At least one of the measures of self-management behaviours described by Diabetes Canada (2019): diet (including nutrition, healthy eating, calorie intake), physical activity, medication adherence, or glycated hemoglobin monitoring (HbA1C).</li> </ul>	<p>Clinical measures other than HbA1C, and attitudinal and behavioural variables related to intervention development or process/implementation evaluations such as usability, feasibility, and cost-effectiveness</p>

### **2.3.2 Search strategy**

A comprehensive search was conducted between 18 and 29 January 2018. The search strategy included major electronic database searches, key journal searches and hand searches of reference lists from recent systematic reviews and meta-analyses (Appendix I). Combinations of key terms, MeSH terms, and CINAHL subject headings were searched across the selected electronic databases (Appendix II). PubMed search strategy, which was modified for other databases, was provided in Appendix III.

### **2.3.3 Selecting studies and collecting data**

Search results from different sources were exported to the Zotero 5.0 Citation Manager (Zotero.org, 2018), where duplicates were removed, and titles and abstracts of the remaining citations were examined against the eligibility criteria. In cases where the abstracts were not available or explanatory, full-text reviews were conducted to assess the eligibility of the studies. Further, full-texts of all the studies that passed the initial title-abstract screening were scrutinized.

Using a structured form adapted from the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2011), data were extracted on several variables, including participants' characteristics, interventional and methodological components (Table 2.2). Tailoring strategies were identified using the guideline developed based on Noar & Harrington (2016), Hawkins et al. (2008), and Dijkstra (2016). The guideline (Appendix IV) includes detailed descriptions and examples of each tailoring strategy. For the classification of trial setting (high income or low and middle-income country setting), the World Bank's country classification was used (The World Bank Group, 2018).

**Table 2.2 Variables examined in the reviewed studies**

<b>Participants' characteristics</b>	<ul style="list-style-type: none"> <li>• age</li> <li>• gender (female ratio)</li> <li>• number of participants in each group</li> </ul>
<b>Interventional and methodological components</b>	<ul style="list-style-type: none"> <li>• study design</li> <li>• study length</li> <li>• study setting (high vs. low and middle-income setting)</li> <li>• choice of modality</li> <li>• control condition</li> <li>• message type</li> <li>• message format</li> <li>• message design features</li> <li>• message direction (one-way messaging or two-way messaging)</li> <li>• message frequency</li> <li>• message timing</li> <li>• message delivery features</li> <li>• tailoring method and strategies</li> <li>• use of theory</li> </ul>
<b>Intervention outcomes</b>	<ul style="list-style-type: none"> <li>• self-management outcomes (<i>i.e., physical activity, diet, medication adherence, glycated hemoglobin control-HbA1C</i>)</li> <li>• relevant attitudinal and behavioural outcomes (<i>i.e., self-efficacy, health belief, self-determination, satisfaction</i>)</li> </ul>

The researcher and two reviewers with a doctorate and master's level qualifications and specific research interests in mobile communication and behaviour change worked independently during the screening, assessment, and data extraction processes. Any disagreement was discussed until consensus was reached, and the reasons for excluded studies were recorded.

#### **2.3.4 Assessing risk of bias**

The methodological validity and risk of bias in the selected studies were checked based on the Cochrane Handbook for Systematic Reviews of Interventions (Higgins & Green, 2011). If available, study protocols and trial registry sites were examined to improve the judgment on the bias. The researcher and the reviewer independently assessed the risk of bias in the studies and

discussed any discrepancies until consensus was reached. The risk was judged as high, low, and unclear, and the rationale for each judgment was recorded.

### **2.3.5 Data synthesis and analysis**

Quantitative data, where possible, were pooled in a statistical meta-analysis to estimate the size of the effects of tailored interventions on the outcomes of mobile text messaging interventions on Type 2 diabetes management.

For categorical data, odds ratio, and for continuous data, weighted mean differences and confidence intervals (95%) were selected to express the effect sizes. Random-effects meta-analytical procedures were followed. Effect sizes were weighted by their inverse variance weight in calculating mean effect sizes. As an estimate of the effect size for each study, Hedges *g* was used (Borenstein, Hedges, Higgins, & Rothstein, 2009). The effect sizes 0.20, 0.50, and 0.80 were used as a threshold for the effect sizes of small, medium, and large, respectively (Cohen, 1992). Based on the findings of the previous text messaging reviews (Head et al., 2013; Armanasco et al., 2017), a small to moderate effect of the tailored text messaging interventions on type 2 diabetes self-management outcomes was expected.

Following the Cochrane guideline (Higgins & Green, 2011), the mean, standard deviation (SD), and the number of participants in the intervention and control groups of the last follow-up measurement from each study and for each outcome were collected. The authors were contacted if related data were missing in the studies. Some data sets (Capozzo et al., 2015) were derived from another review (Arambepola et al., 2016) and necessary calculations were made by the formula provided in the Cochrane Handbook (Higgins & Green, 2011) using the same correlation coefficient (0.5) (please see the Supplementary Note). The data provided as median and range

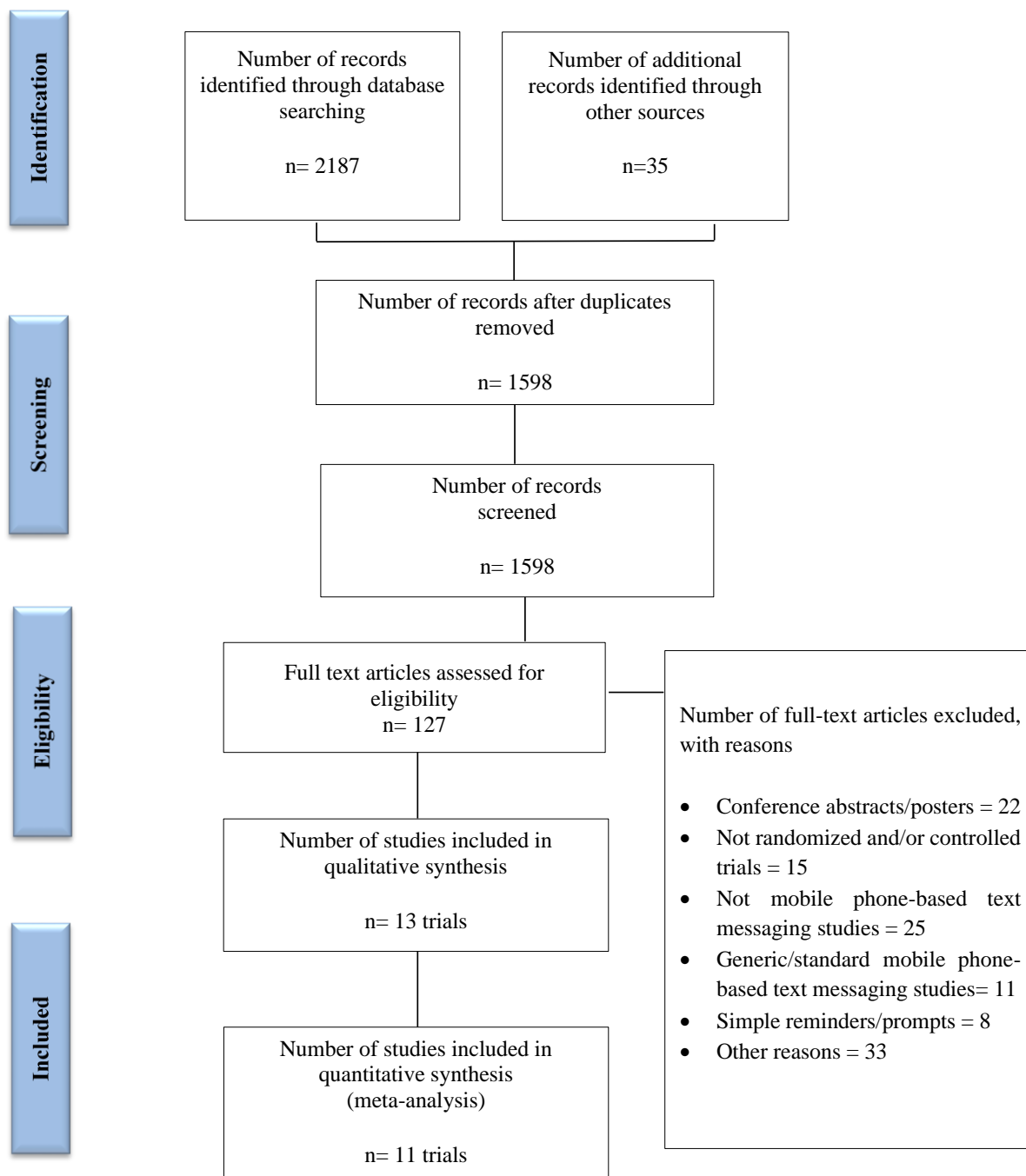
were converted into a mean and standard deviations based on the estimates provided by Hozo, Djulbegovic, & Hozo (2005).

Publication bias analysis was performed to assess the robustness of results by applying a funnel plot asymmetry test and using the “trim and fill” method. Egger Regression and Begg and Mazumdar Rank Correlation tests (Suurmond, van Rhee, & Hak, 2017) were also performed to detect any possible bias in the data. Heterogeneity was assessed statistically using the  $I^2$  statistic, where  $I^2 > 50\%$  was accepted as the indicator of substantial heterogeneity (Higgins & Green, 2011). For pre-specified eleven moderators (Appendix V), subgroup analyses were performed to examine potential sources of heterogeneity, and Cochran Q statistic was used to identify statistically significant differences between interventions.

A software program (Meta-Essentials 1.2) (Suurmond, van Rhee, & Hak, 2017) was used to carry out the meta-analysis. As a result of the impracticality of statistical pooling, the findings were presented in narrative form.

## **2.4 Results**

The combined database searches returned 2187 records, and with 35 records from other sources, a total of 2222 records were collected. After duplicates were removed, 1598 records were screened for eligibility using title and abstract. A total of 127 articles was shortlisted for eligibility, and full-text screening resulted in 13 eligible trials for systematic review and 11 trials for meta-analysis. Appendix VI lists the excluded studies with their reasons. The search results are summarized in the PRISMA flow diagram (Figure 2.1).



**Figure 2. 1 Study selection flow diagram based on the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) guideline**

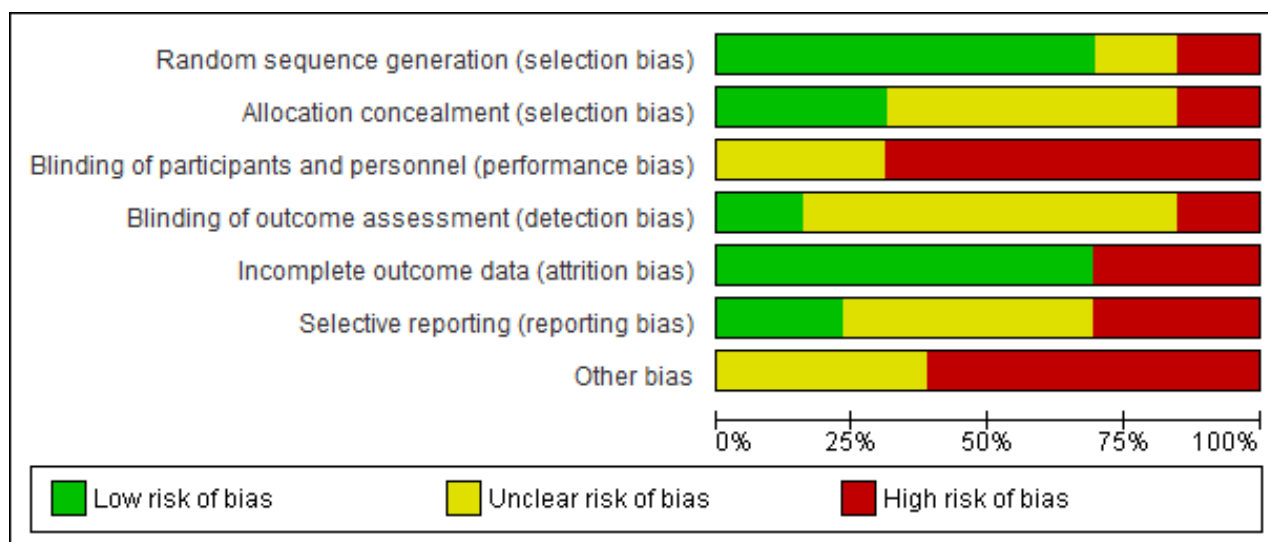
Some articles were evaluated together with their related studies (Arora et al. (2014) with Burner et al. (2013); Capozza et al. (2015) with Abebe et al. (2013), Fortmann et al. (2017) with Philis- Tsimikas et al. (2011); Gatwood et al. (2016) with Gatwood et al. (2014) to provide a more thorough assessment about their message content and tailoring strategies. Among the studies reported on the same trial, preliminary studies were excluded [(e.g. Kim and Song (2008), Agboola et al. (2013))] and final studies with the maximal treatment results were included [(e.g. Kim and Kim (2008), Agboola et al. (2016) respectively].

#### **2.4.1 Risk of bias**

The most commonly observed high-risk bias was related to performance bias, where blinding of participants and personnel to the intervention was often impossible due to the nature of the interventions. For example, when participants received pedometers, they were more likely to understand that the intervention related to physical activity. In the majority of the studies (62 %, n=8), there was a high risk of some other form of bias, mostly related to small sampling size and poor methodology. Figure 2.2 summarizes the risk of bias assessment for each included study and Figure 2.3 demonstrates the portion of each risk of bias, as low, unclear, and high. Also, Appendix VII presents the detailed risk of bias estimates for each study and the rationale given for each judgment.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Agboola et al., 2016	+	+	-	+	+	+	-
Arora et al., 2014	+	?	-	-	+	-	-
Capozza et al., 2015	+	+	?	?	+	-	-
Faridi et al., 2008	?	?	-	?	-	?	-
Fortmann et al., 2017	+	+	-	-	-	?	?
Gatwood et al., 2016	+	?	?	?	-	?	-
Kim & Kim 2008	-	-	-	?	+	+	-
Lim et al., 2016	+	?	?	?	+	-	?
Peimani et al., 2015	+	?	-	?	+	?	-
Shetty et al., 2011	+	?	?	?	-	-	?
Tamban et al., 2013	+	+	-	+	+	?	?
Yoo et al., 2009	?	?	-	?	+	?	?
Yoon & Kim, 2007	-	-	-	?	+	+	-

**Figure 2.2. Risk of bias summary: Reviewers' judgments about each risk of bias item for each included study**



**Figure 2.3. Risk of bias presented as percentages across all included studies**

#### 2.4.2 Characteristics of the included studies

All articles reported on only one trial. Eleven trials were randomized controlled trials (RCTs), whereas the remaining two used pre-test-post-test control group design (Kim & Kim, 2008; Yoon & Kim, 2007). On average, the length of the intervention was 6.5 months. Ten trials were conducted in high-income settings, whereas three interventions were carried out in low and middle-income settings. A total of 1328 participants enrolled in these trials (mean= 102; range= 30 to 215). Each included only adult participants with Type 2 diabetes (51.2% female), and with a mean age ranging from 47 to 65 years of age and with HbA1C values at baseline ranging from 6.5-8%.

SMS text messaging was the primary mode of communication to deliver the intervention messages in all studies. Seven trials used multi-modalities (text messaging plus), whereas six trials either only used text messaging or combined it with usual care. Twelve studies provided usual care to their comparison groups, while four studies also provided

usual care to their treatment groups. In four studies, usual care included regular clinic visits and consults with a healthcare provider (i.e. endocrinologist, physician).

In all trials, message content included educational, behavioural and/or motivational features to induce behaviour change. In general, messages were created based on the recommendations of reference institutions, such as the American Diabetes Association. The intervention messages were not customized using the framing effect or any other message-specific elements (e.g. humour, fear, directive, passive tone).

Varying frequencies were used for the delivery of the messages in the trials. They were broadly grouped into two categories, frequent messaging and infrequent messaging. Frequent messaging was conceptualized as sending at least one message per day, whereas infrequent messaging was described as sending three messages per week or less. Nine trials delivered messages frequently, and four trials delivered messages infrequently.

Five studies implemented two-way messaging, while the remaining eight studies used one-way messaging. The majority of the interventions (n=8) delivered automated messages, which mostly included immediate feedback and recommendations provided by a decision algorithm in response to patients' uploaded data. In contrast, in three studies, tailored messages were sent directly from a healthcare provider or an investigator.

The personalization strategy employed in the interventions (n=4) included an adaptation of timing (Tamban et al., 2013) and number and frequency of messages (Shetty et al., 2011; Arora et al., 2014) based on participants' preferences, identifying areas of specific interest in self-management of diabetes and providing options to select message categories (i.e., diet or exercise-related messages) (Arora et al., 2014; Fortmann et al., 2017; Shetty et al., 2011), and presenting options for message language (Arora et al., 2014, Fortmann et al., 2017).

Six studies employed psychosocial-behavioural tailoring. The messages included specific recommendations, reminders, and feedback that matched with participants' uploaded measurements or health records. Three studies (Agboola et al., 2016; Capozza et al., 2015; Gatwood et al., 2016) demonstrated the use of all tailoring types in their intervention.

The use of theory was reported in only four studies (Arora et al., 2014; Gatwood et al., 2016; Agboola et al., 2016; Peimani et al., 2015). The Transtheoretical Model, Health Belief Model, Self-determination Theory, Social Cognitive Theory and Information-Motivation-Behavioral Skills model were used to guide the tailoring of intervention components and message content in the interventions. Only one study (Gatwood et al., 2016) employed multiple behavioural theories and used the Technology Acceptance Model for measuring the acceptability of text messaging. Table 2.3 presents the characteristics of the included studies in this systematic review.

**Table 2.3 Characteristics of the interventions included in the review**

Study Author name, year,	Study Design /Duration	Sample Characteristics /Size (baseline); Female ratio/Age (baseline mean (SD)/ Country: Level of Income	Intervention Modality	Comparison	Message Type/Format/Design Features	Message Frequency/ Timing/Delivery	Tailoring Method & Strategies	Use of Theory
Agboola et al., 2016	RCT Parallel 2 arms 6 months	Adults with T2D (HbA1C>7%) n= 126; %32.5 female Age: 51.45 (11.6) USA: High income	Pedometer, mobile phone text messaging, telephone reminders, web portal, and usual care	Pedometer, telephone reminders, web portal and usual care (No text messaging)	Two-way messaging SMS text  TEXT to Move study: <ul style="list-style-type: none"> <li>• Morning messages provided feedback based on the previous day's activity.</li> <li>• Afternoon and evening messages included coaching themes, such as support, health education, motivation, and reminders to engage in healthy behaviours.</li> <li>• Some of the interactive messages focused on satisfaction with the program, health status, knowledge of the physical activity, food intake, and medication adherence.</li> </ul>	At least 2 messages per day <ul style="list-style-type: none"> <li>• Morning-messages at 9 am, EST on weekdays &amp; 11 am EST on weekends,</li> <li>• Evening messages at 6 pm EST</li> </ul> Messages were delivered automatically	A combination of personalization and Psychosocial -behavioral Tailoring  Based on language preferences (English or Spanish) and demographic and behavioural information obtained at baseline, web-portal content, training materials, and text messaging were personalized.  Behavioural feedback, and educational, motivational messages were sent to induce behaviour change  Example: "as of 8:27 am, you were active for 45 mins yesterday, which is 75% of your daily goal."	Transtheoretical Model  The theory was used to assess participants' stage of change and design the corresponding message content
Arora et al., 2014	RCT Parallel 2 arms	Adults with T2D (HbA1C>8%)	Mobile phone text messaging and usual care	Usual care	One-way messaging SMS text	2 messages per day at 9 am and 5 pm	<b>Personalization</b> Text messages were designed based on	Health Belief Model

	6 months	n= 128; 64 % female Age: 50.7 (10.2) USA: High Income			TEXT-MED intervention: <ul style="list-style-type: none"> <li>Educational/motivational messages, (1 per day)</li> <li>Medication reminders (3 per week)</li> <li>Challenge messages on healthy living (2 per week)</li> <li>Trivia (2 per week)</li> </ul>	Messages were delivered automatically	language preferences (English or Spanish). Optimal message frequency and content (knowledge gaps/topic preferences) for the target group were identified in the previous study  <b>Example:</b> “Having diabetes can lead to a heart attack and stroke! But it doesn’t have to.”	The theory was used in the development of TExT-MED program to develop message contents to address specific barriers and knowledge gaps of T2D patients
Capozza et al., 2015	RCT Parallel 2 arms 6 months	Adults with T2D (HbA1C>8%) n=93; 61.5% female Age: 53.25 (10.95) USA: High income	Mobile phone text messaging and usual care	Usual care	Two-way messaging SMS text Care4Life Intervention: <ul style="list-style-type: none"> <li>Unidirectional and generic messages on diabetes education and health improvement were sent each day.</li> <li>Patients were able to activate optional two-way messaging protocols (totally 6) including medication reminders, glucose testing reminders, BP monitoring reminders, and tracking and encouragement for exercise and diet</li> </ul>	1-7 text messages per day. One text messaging per day was mandatory, others depended on the use and preferences of patients  Messages were delivered automatically	Combination of Personalization and Psychosocial-Behavioral Tailoring Based on language preferences (English or Spanish), messages were personalized. Patients were able to control the type and frequency of the messages. Also based on their uploaded data, patients received some reminders and feedback messages  Example: “How are you? Feeling stressed about diabetes is normal. Getting support will help you feel better and control glucose. Ask for help when you need it.”	None reported
Faridi et al, 2008	RCT Parallel 2 arms 3 months	Adults with T2D (HbA1C <8%) n= 30; 63.4% female	Web-based system (NICHE technology), Mobile phone	Usual care and pedometer	Two-way messaging SMS text Automated feedback messages based on	At least one daily, the real-time feedback message	<b>Psychosocial -Behavioral Tailoring</b> Messages were tailored to provide feedback on	None reported

		Age: 56.45 (9.6) USA: High income	text messaging and biometric wireless assessment devices (glucose meter and pedometer)		patients' uploaded HbA1c and physical activity data The content aimed to enhance diabetes self-management and self-efficacy	(Participants are requested to upload their data each day)  Messages were delivered automatically	specific patient data. The content was arranged to enhance diabetes self-management skills and diabetes care self-efficacy. No example was provided	
Fortmann et al. 2017	RCT Parallel 2 arms 6 months	Hispanic adults with T2D (HbA1C > or = 7.5%) n= 126; 75 %female Age: 48.4 (9.8) USA: High income	Mobile phone text messaging, blood glucose meter, and usual care	Usual care and blood glucose meter	One-way messaging SMS text Educational, motivational, and call-to-action messages on diabetes self-care and medication reminders and blood glucose monitoring prompts	2-3 messages per day (at the beginning) Message timing was standardized for all patients  Messages were delivered automatically	<b>Personalization</b> Messages were culturally tailored to the needs of the specific population (Project Dulce curriculum was used which aimed to address cultural barriers and beliefs about diabetes) <b>Example:</b> "Use small plates! Portions will look larger, and you may feel more satisfied after eating" "It takes a team! Get the support you need, family, friends and support groups can help you to succeed."	None reported
Gatwood et al., 2016	RCT Parallel 2 arms 3 months	Adults with T2D (HbA1C >8%) n= 48, 50% female Age: 47.0 (11.7) USA: High income	Mobile phone text messaging	Usual care and a monthly "check-in" text message	One-way messages SMS text  Messages were designed to increase patients' knowledge and motivation for improvement in their medication adherence and diabetes-related health beliefs.  A total of 168 theory-based messages (84 Self-determination theory messages, 96	At least 1 message per day  Ordering and timing of the message were arranged based on the patient's daily medication schedule  Messages were delivered automatically	<b>Combination of Personalization and Psychosocial -Behavioral Tailoring</b>  The subject's name was used in every message and their age was used sporadically.  Some details about the patient's current diabetes medications, including the name of the medications, number of times taken each day, number of pills	Health Belief Model  Self-Determination Theory  Both theories were used to develop content for the mobile messaging intervention  Technology Acceptance

					Health belief model messages) and 128 tailored medication specific messages were used.		taken at each dose, and time of day the medication was taken for tailoring the text message delivery and arranging messages specifically to each subject's treatment (benefits, safety, and mechanism of action). The name of medication was also included in some theory-driven messages.  <b>Example:</b> "It may be tough to see but taking your diabetes medications is vital to your health. Taking them as directed may help you see their value".	Model was used to guide questionnaire items to assess the acceptance of text messaging
Kim & Kim 2008	Pre-test – Post-test Control Group Design 12 months	Adults with T2D and obesity (HbA1C>7%) n=34, 53% female Age: 47 (8.6) Korea: High income	Website platform, mobile phone text messaging, wired internet, and usual care including 4-5 visits to an endocrinologist	Usual care including 4-5 visits to an endocrinologist	One-way messaging SMS text  Messages on continuous education and reinforcement of diet, exercise, medication adjustment and frequent monitoring of blood glucose levels	Weekly messages  Messages were delivered by a healthcare professional	<b>Psychosocial -Behavioral Tailoring</b> Feedback messages and recommendations were sent based on patient-specific uploaded data <b>Example:</b> "Your glucose control seems to be good" or "Please add one tablet of sulfonylurea in the evening" or "lack of exercise may be the cause of the aggravated glucose level"	None reported
Lim et al., 2016	RCT Parallel 2 arms 6 months	Adults with T2D (HbA1C 7 -10.5%) n= 100, 25% female Age: 65.0 (4.9)	Website, physical activity monitor, glucometer, and	Usual care and glucometer	Two-way messaging SMS text  U-Healthcare intervention:	For each message type, a different schedule was applied.	<b>Psychosocial -Behavioral Tailoring</b>  Specific feedback messages, instructions, and	None reported

		Korea: High Income	mobile phone messaging		Feedback messages and instructions on medication adjustments, diet pattern, physical activity, and other lifestyle modifications	Weekly average glucose levels were sent on: Mondays at 10.00 am, monthly average glucose levels were sent on the last day of every month at 11.00 am, reminder messages were sent every Tuesday at 10.00 am. Messages were delivered automatically	recommendations based on patients' uploaded data were generated by the decision rule engine and sent back to the patient immediately. Also, reminder messages on glucose monitoring, diet, and physical activity were sent regularly. No example was provided	
Peimani et al., 2015	RCT Parallel 3 arms 3 months	Adults with T2D (HbA1C not specified), n= 150, 46% female Age: 52.5 (10.9) Iran: Upper middle income	2 intervention groups:  Tailored text messaging group vs. non-tailored messaging group	No treatment-no messaging	One-way messaging SMS text  Educational and motivational messages on diet, exercise, medication adjustment, and self-monitoring of blood glucose monitoring	On average 7 messages per week for both treatment groups  Automated messages were delivered	<b>Psychosocial -Behavioral Tailoring</b> Tailored messages were motivational and persuasive and focused on increasing awareness of each self-management behaviour. 75 % of the messages addressed patients' specific barriers to adhering prescribed diet, exercise or medication. No example was provided	Self-efficacy/Social Cognitive Theory  The theory was used to tailor the intervention message content
Shetty et al., 2011	RCT Parallel 2 arms 12 months	Adults with T2D (HbA1C 7-10%) n= 215, The gender ratio was not provided Age: 50.3 (9.1)	Mobile text messaging	Usual care including appropriate prescriptions of drugs based on the clinical and laboratory	One-way messaging SMS text  Educational and motivational messages on diet, physical activity, medication	Once every 3 days  Frequency of messages varied as per patients' preferences	<b>Personalization</b> Mobile text messages were personalized based on patients' preferred frequency of receiving messages and preferred content/topic including	None reported

		India: Low Middle Income		investigations and advice on diet modification and physical activity	adherence, and healthy living	Unclear information about how messages were delivered	instructions on medical nutrition, physical activity, reminders for medication adherence, and healthy living habits. No example was provided	
Tamban et al., 2013	RCT Parallel 2 arms 6 months	Adults with T2D (HbA1C >7) n= 104, 46% female Age: 49.5 (7.1) Philippines: Lower middle income	Mobile text messaging and usual care	Usual care including scheduled consults with an endocrinologist and visit to a DM educator	One-way messaging SMS text  Messages on diet, physical activity, and other self-management issues	3 messages per week <b>Mondays:</b> Messages about diet <b>Wednesdays:</b> Messages about exercise <b>Fridays:</b> Messages about the consequences of nonadherence to diabetes self-care  Messages delivered by a research assistant	<b>Personalization</b>  Messages were delivered based on patients' preferred timing.  SMS messages included 2 sentences. First one included facts about proper diet and exercise, the second sentence acted as a reminder for adhering diet and exercise given by diabetes educator.  <b>Example:</b> "Calorie counting is good for diabetics. Ask your dietitian how to do it and follow her advice"	None reported
Yoo, et al., 2009	RCT 2 parallel arms 3 months	Adults with T2D (HbA1C>6.5-10) n= 123; 41% female Age: 58.2 (8.7) Korea Rep: High income	The Ubiquitous Chronic Disease Care System includes mobile text messaging and using assessment devices (i.e. glucometer) and a web-based physician communication	Usual care including clinic visits and regular consults with physicians	Two-way messaging SMS text  Motivational messages on a healthy diet, exercise, and glucose monitoring along with general information about diabetes, hypertension, and obesity.	3 messages per day  Automated feedback messages were sent immediately after patients uploaded their measurements	<b>Psychosocial -Behavioral Tailoring</b>  Recommendations and reminders were sent immediately after patients uploaded their specific data, and motivational and educational messages were sent three times a day <b>Example:</b> "Your fasting blood glucose level is very high compared with the	None reported

						Messages were delivered automatically	appropriate target level for Type 2 diabetes (<7.2. mmol/l. Reduce your calorie intake and avoid foods high in fat. Also, plan for regular exercise after your meals.”	
Yoon & Kim, 2007	Pretest post-test control group design 12 months	Korean adults with T2D (HbA1C>7%) n=51, 57% female, Age 47.1 (8.9) Korea Republic: High income	The website, wired internet, and mobile messaging	Usual care including clinic visits and consults with an endocrinologist	One-way messaging SMS text  Informative and motivating messages on continuous education and reinforcement of diet, exercise, medication adjustment and frequent monitoring of blood glucose levels	Once a week, on average 52 times in a year  Messages were sent by healthcare professionals	Psychosocial -Behavioral Tailoring Feedback messages and recommendations based on patient-specific uploaded data on diet, exercise, medication, or glucose monitoring. Example: “Please check the amount that you eat”, Your glucose control seems to be good”	None reported

### **2.4.3 The effect of tailored text messaging interventions on self-management outcomes**

Only two interventions (Arora et al., 2014 and Shetty et al., 2011) assessed all the specified diabetes self-management outcomes while one study (Gatwood et al., 2016) measured only medication adherence. Six studies measured the effect of treatment on physical activity, and two studies (Tamban et al., 2013; Lim et al., 2016) reported statistically significant improvements. Five studies measured the effect of treatment on dietary habits of participants, and two studies found statistically significant increases in dietary adherence (Tamban et al., 2013; Lim et al., 2016). Medication adherence was assessed in three studies, and one study (Arora et al., 2014) reported a statistically significant effect of the treatment. According to the tailoring strategies, no meaningful difference was observed between the interventions on physical activity, diet, and medication adherence outcomes. The interventions also measured a limited number of attitudinal and behavioural outcomes related to diabetes self-management, such as acceptability, knowledge, health belief, self-determination, and self-efficacy. Satisfaction with the intervention was measured in four studies, which reported high satisfaction scores (more than 94%) with their interventions (Appendix VIII).

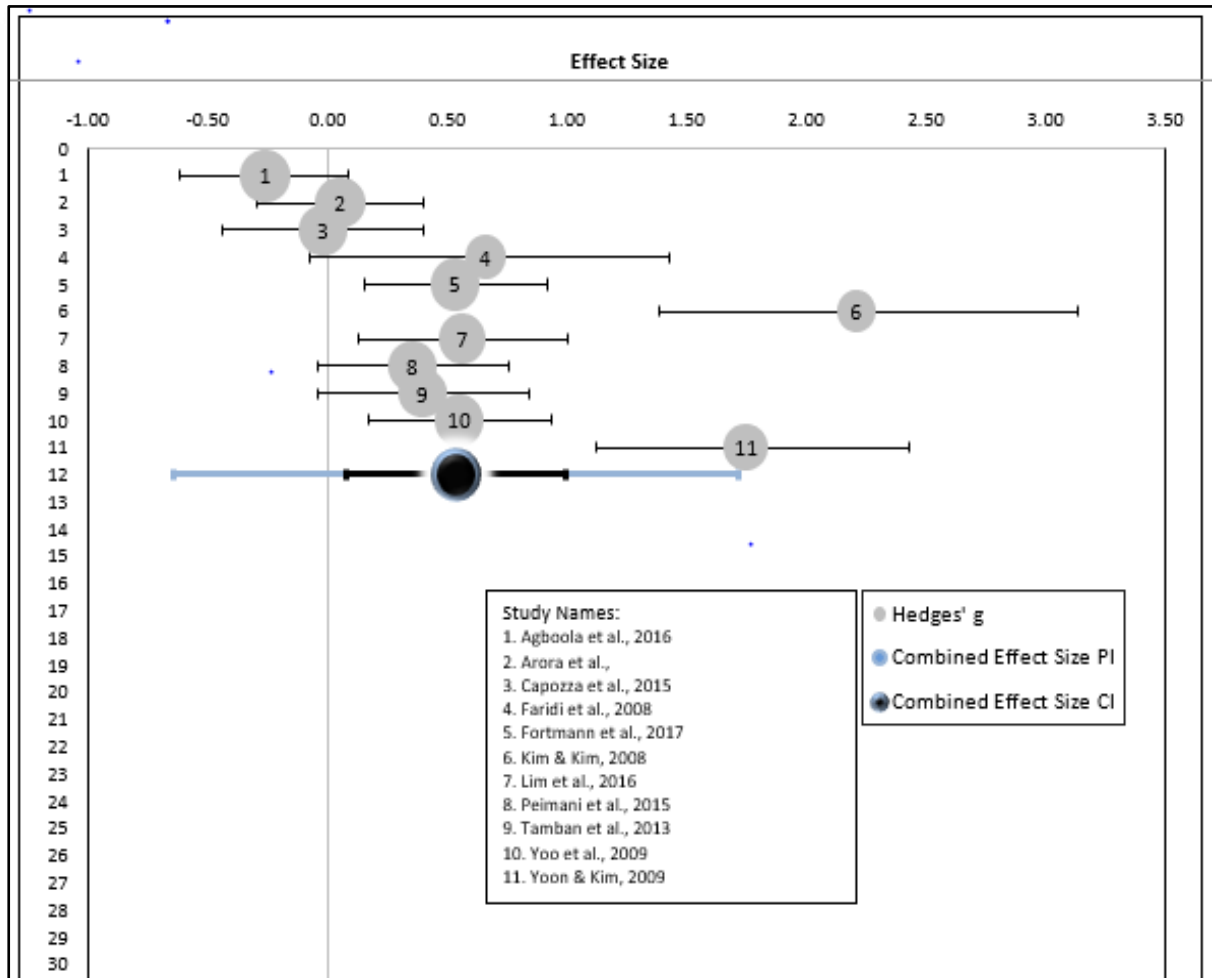
Due to the insufficient number of interventions reporting the effect of interventions on physical activity, diet, and medication adherence, and the inconsistent scale of measurements (i.e., rates, counts, means), the data on these self-management outcomes could not be pooled in a meta-analysis. However, data from 11 trials that provided the effect of treatment on glycated hemoglobin monitoring (HbA1C) were pooled in a meta-analysis. One study (Shetty et al., 2011) was excluded from the meta-analysis due to data inconsistency.

## 2.5 A Meta-Analysis: The Effect of Tailored Interventions on Glycated Hemoglobin Monitoring

The effect of 11 eligible tailored interventions on HbA1C values of a total 949 Type 2 diabetes patients showed a moderate and statistically significant weighted mean effect size,  $g = 0.54$  (95% CI= 0.08-0.99,  $p < 0,001$ ). Table 2.4 presents information on combined effect size, point estimates with confidence intervals, and weights calculated for each study, and Figure 2.4 illustrates the forest plot diagram of the results.

**Table 2.4 Effects of tailored text messaging interventions on glycemic control**

Study Name	Hedges' g	CI Lower limit	CI Upper limit	Weight
Agboola et al., 2016 "Text to Move" Intervention	-0.26	-0.61	0.09	10.09%
Arora et al., 2014 "TEXT-MED" Intervention	0.05	-0.30	0.40	10.12%
Capozza et al., 2015 "Care4Life" Intervention	-0.02	-0.44	0.40	9.61%
Faridi et al., 2008 "NICHE" pilot study	0.66	-0.07	1.43	7.32%
Fortmann et al., 2017 "Dulce Digital" intervention	0.53	0.15	0.92	9.87%
Kim & Kim, 2008 "Mobile and internet" intervention	2.21	1.39	3.14	6.44%
Lim et al., 2016 "Multifactorial intervention"	0.56	0.13	1.00	9.51%
Peimani et al., 2015 "SMS-based intervention"	0.35	-0.04	0.75	9.78%
Tamban et al., 2013 "The SMS intervention"	0.40	-0.04	0.84	9.46%
Yoo et al., 2009 "The UCDC intervention"	0.55	0.17	0.93	9.89%
Yoon & Kim, 2007 "The SMS intervention"	1.75	1.12	2.43	7.91%
<b>Combined Effect Size</b>				
<b>Hedges' g</b>		0.54		
<b>Standard error</b>		0.20		
<b>CI Lower limit</b>		0.08		
<b>CI Upper limit</b>		0.99		
<b>PI Lower limit</b>		-0.64		
<b>PI Upper limit</b>		1.72		
Note: CI: Confidence interval, PI: Prediction interval				



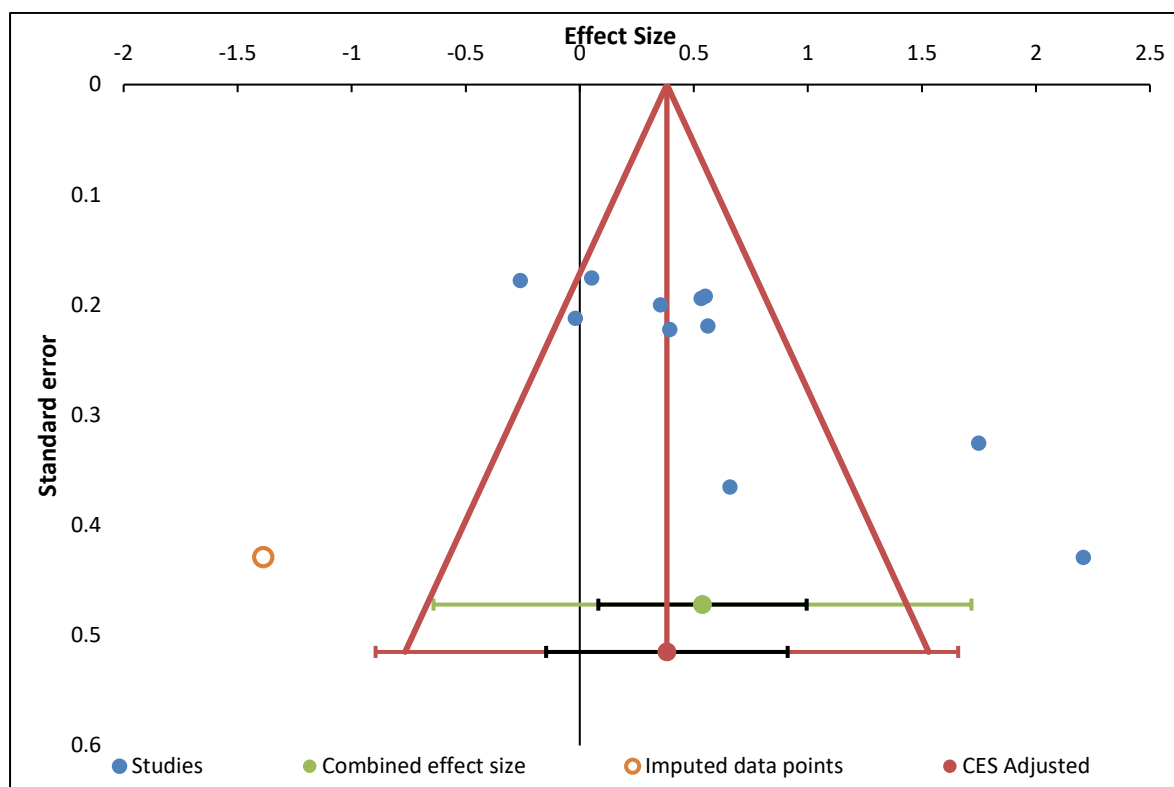
**Figure 2.4. Forest plot of tailored text messaging interventions' effect on glycemic control**

Publication bias analysis revealed a small degree of asymmetry of data ( $p=0.052$  in Begg and Mazumdar test, and  $p=0.002$  in Egger regression test) Trim-and-fill analysis imputed one study to the left of the mean resulting in a decrease to the effect size to  $g=0.38$  (95% CI=-0.15, 0.91). Figure 2.5 illustrates the funnel plot demonstrating combined and adjusted effect sizes and imputed data points.

Performing a leave-one-out sensitivity analysis by removing one study each time showed that the combined effect size was in minimum at  $g=0.41$  (Kim & Kim, 2008) and in

maximum at  $g = 0.62$  (Agboola et al., 2016). Removing two studies that were assessed as low quality due to their study design and sampling size (Kim & Kim, 2008; Yoon & Kim, 2007) did not have a significant effect on the data asymmetry. Funnel plot analysis still demonstrated a need for an imputed data point on the left side of the mean and a substantial degree of heterogeneity among studies ( $I^2 = 55.52$ ); therefore, these studies were not excluded from the analysis.

The sample of studies indicated a significant level of heterogeneity ( $Q_{11} = 58.4$ ,  $p < 0.00$ ,  $I^2 = 82.8\%$ ), and a priori subgroup analyses with the random-effects model were conducted to investigate the reasons for the heterogeneity and possible effects of interventional and methodological components on the combined effect size.



**Figure 2.5. Funnel plot assessment of asymmetry in data**

### 2.5.1 Subgroup analyses

Subgroup analyses were conducted for the interventional and methodological moderators. The pre-specified subgroups related to participant characteristics (age, gender, and ethnicity/race) and study design could not be analyzed quantitatively due to insufficient data.

The studies significantly differed in terms of their message frequencies ( $Q_B=18.72$ ,  $df=1$ ,  $p=0.000$ ), message direction ( $Q_B= 5.26$ ,  $df=1$ ,  $p=0.022$ ), message delivery ( $Q_B=18.72$ ,  $df=1$ ,  $p=0.000$ ), and choice of modality ( $Q_B= 6.18$ ,  $df=1$ ,  $p=0.013$ ). We had hypothesized that the studies using interactive (two-way) messages, mixed modalities (i.e. SMS and Web portal) and non-automated message delivery would produce larger effect sizes than their counterparts. The results confirmed our hypotheses on these variables. However, we had to reject our hypothesis on message direction because one-way messaging produced a larger effect size than two-way messaging. The interventions did not significantly differ according to their tailoring strategies, study lengths and study settings (Table 2.5).

**Table 2.5. Weighted mean effect size by moderating variables**

Subgroups	n	Hedges' g (95% CI)	p-value	$Q_B$
<b>Tailoring strategies</b>				
Advanced	8	0.66 (CI:0.09-1.22)	0.00	
Basic	3	0.31 (CI: 0.02-0.60)	0.17	
				0.55 (p=0.457)
<b>Message frequency</b>				
Frequent messaging	8	0.27 (CI: 0.04-0.51)	0.01*	
Infrequent messaging	3	1.41 (CI: 0.33-2.50)	0.00*	
				18.72 (p=0.000*)
<b>Message direction</b>				
One-way messaging	6	0.79 (0.13-1.46)	0.00*	
Two-way messaging	5	0.27 (-0.10-0.63)	0.00*	
				5.26 (p=0.022*)

<b>Message delivery</b>				
Automated	8	0.27 (CI:0.04-0.51)	0.01*	
Non-automated	3	1.41 (CI:0.33-2.50)	0.00*	
				18.72 (p=0.000*)
<b>Intervention modality</b>				
Text messaging	4	0.18 (CI:-0.02-0.38)	0.38	
Multi-modality	7	0.79 (CI:0.19-1.39)	0.00*	
				6.18 (p=0.013*)
<b>Study length</b>				
Short-term (3 months)	3	0.48 (CI: 0.32-0.64)	0.68	
Long-term (6 months or more)	8	0.57 (CI:0.00-1.14)	0.00	
				1.04 (p=0.309)
<b>Study setting</b>				
High income	9	0.59 (CI: 0.09-1.10)	0.00	
Low and middle income	2	0.37 (0.33-0.41)	0.89	
				0.04 (p=0.975)

**Notes.** n= number of studies in each group, g= weighted mean effect size,

CI: confidence interval, P<.05: statistical significance

\*: statistically significant, Q<sub>B</sub>: the difference between groups based on combined effect size

## 2.6 Discussion

This study presented a comprehensive review and a meta-analysis of tailored mobile text messaging interventions on type 2 diabetes self-management. The main characteristics of tailored interventions and their moderators of effectiveness were analyzed. This study acknowledged that different tailoring strategies are available, and by proposing a guideline for classifying tailoring strategies, it attempted to increase the comparability of the findings across reviews. Therefore, this study not only contributes to the growing field of type 2 diabetes self-management but also offers a useful framework for other text messaging interventions. The majority of the trials were RCTs, conducted in high-income settings, and used multi-modalities for the delivery of interventions. All interventions targeted people with type 2 diabetes and used SMS as the form of text messaging.

Text messaging content in the reviewed studies generally included cognitive and rational attributes aiming to increase awareness and knowledge about diabetes self-management. For example, *“Having diabetes can lead to a heart attack and stroke! But it doesn’t have to”* (Arora et al., 2014), *“Calorie counting is good for diabetics. Ask your dietitian how to do it and follow her advice”* (Agboola et al., 2013) and *“How are you? Feeling stressed about diabetes is normal. Getting support will help you feel better and control glucose. Ask for help when you need it”* (Capozza et al., 2015). However, behaviour change also has affective and conative aspects (Fishbein & Ajzen, 1975), and integrating cognitive and affective interventions can increase self-management skills of patients and lower their HbA1C (Sherifali et al., 2018).

Further, a randomized controlled trial revealed that type 2 diabetes patients should receive more specific messages about what to do about medications, tests or treatment goals instead of receiving simple educational messages (Adams et al., 2009). Also, the educational and informative messages used in the interventions mostly relied on standard guidelines. The effectiveness of educational and informative components of diabetes self-management increases when they are customized (Sherifali et al., 2018).

Another important result was the lack of message- specific elements or the framing effect in the message design considerations of the interventions. Considering the rapid growth of type 2 diabetes and the ineffectiveness of traditional self-management practices and insufficient evidence provided by previous research (Arambepola et al., 2016; Dobson et al., 2017), there is a strong need for employing more persuasive message strategies in the interventions that will be guided by communication and persuasion theories. The previously identified lack of a theoretical grounding in mHealth-based studies (Arambepola et al., 2016; Dobson et al., 2017; Free et al., 2013) was confirmed by this systematic review. Although these behavioural theories have

been the most frequently used theories in behaviour change interventions (Glanz, Rimer, & Lewis, 2002) they may be limited in addressing the adaptive, customized and contextual nature of mHealth-based studies (Spruijt-Metz, Nilsen, & Pavel, 2015; Saranummi et al., 2013; Davis, Campbell, Hildon, Hobbs, & Michie, 2015). As expected, tailored text messaging interventions had a moderate, positive, significant effect on HbA1C values. This result is consistent with the findings of the previous meta-analyses (Arambepola et al., 2016; Orr & King, 2015; Head et al., 2013), which indicated small to moderate effects of text messaging interventions.

The subgroup analysis revealed that one-way, non-automated messages that are supported by additional modalities and sent infrequently are likely to be more effective for glycemic control in type 2 diabetes patients than other text messaging strategies. It was expected that patients would prefer less frequent messaging, but contrary to our hypothesis, they may not prefer interactive communication either.

Previous reviews have provided mixed results on the effectiveness of multi-modalities (e.g., text messaging, WEB portal, assessment devices) (Kitsiou et al., 2017; Head et al., 2013; Armanasco et al., 2017). The findings of this study support our hypothesis and are also consistent with the mass media and communication studies that the seamless integration of multiple channels to reach a specific audience leads to more effective outcomes (Kotler, 2003).

The effectiveness of non-automated messages on HbA1C control could be an indication of how patients value tailoring and personalized communication. Non-automated message delivery may create a personalization tailoring effect and increase the engagement with the intervention. Although too much interactivity and message frequency appear less impactful, messages designed specifically for participants and

coming from real people (i.e. healthcare provider, nurse and dietitian) are likely to be more effective.

There were some limitations to the study that should be noted. First, a meta-analysis could not be implemented on physical activity, diet and medication adherence because of the insufficient data provided for these outcomes. Due to the same reason, the relative effectiveness of different tailoring strategies used in the interventions could not be assessed. Because our focus was to examine the message design features, we included only the English articles. Further, the data provided about the tailoring strategies and the message content in this review were limited by the short explanations or examples provided in the articles.

The majority of the interventions included some risks of bias mainly due to the small sample sizes and insufficient blinding, and therefore it might have increased the possibility of publication bias in the meta-analysis. The Trim-and-fill method revealed an imputed study that would be placed at the lower left side of the funnel to correct the asymmetry of data. It probably relates to the poor methodological designs in trials with small sample sizes, which can cause an absence of studies on the left-hand side at the base of the funnel (Sedgwick, 2013; Higgins & Greene, 2011). However, by the correction of asymmetry, the tailored interventions still produced a substantial combined effect ( $g$  0.38) on glycemic control. Although a significant heterogeneity among the studies was observed, the random-effects model was used, and subgroup analyses with a priori moderators were performed to understand how and to what degree the interventions differed from each other.

## 2.7 Comparisons with Previous Reviews

Previous related studies on type 2 diabetes management either particularly focused on lifestyle behaviours (diet and physical activity) (Arambepola et al., 2016) or medication adherence (Farmer et al., 2016) or glycated hemoglobin control (Dobson et al., 2017; Faruque, Wiebe, & Ehteshami-Afsha, 2017). This study examined all these self-management outcomes and therefore provided a more comprehensive approach to understanding the effects of text messaging interventions on type 2 diabetes self-management. However, the main goal of this study was to identify the characteristics of tailored text messaging interventions and to examine their tailoring strategies and message design and delivery features. Therefore, this study differs from the other reviews as it only included tailored interventions. Although Dobson et al.'s (2017) systematic review provided information on tailoring where available, our study provided an in-depth analysis of tailoring strategies used in the interventions and further elaborated on message design strategies. Contrary to their results, our meta-analysis found support for the previous research (Arambepola et al., 2016) and reported a significant effect of tailored mobile text messages on glycemic control of patients with type 2 diabetes.

Another important difference in this study is that it included both automated and non-automated text messaging interventions. By comparing the message delivery types, it was revealed that non-automated message delivery could be more effective than automated message delivery.

The meta-analysis examined the effects of a large number of moderators and found significant effects of message frequency, message direction and intervention modality on glycated hemoglobin control. In their meta-analysis, Arambepola et al.

(2016) found no significant difference between the effect on unidirectional and bidirectional messages on glycated hemoglobin control. Our study found that in tailored interventions, one-way (unidirectional) messaging could be more effective than two-way (bidirectional) messages and provided support for the previous text messaging reviews (Orr & King, 2015; Head et al., 2013). Unlike Farmer et al.'s findings (2016), this study revealed that using multi-modalities (i.e. web portal and text messaging) could be more effective than using only text messaging and provided support for previous research (Armanasco et al., 2017; Noar et al., 2007).

## **2.8 Conclusions**

Tailored mobile text messaging interventions were mostly RCTs, focused on adult patients, conducted in high-income settings, and used SMS to deliver intervention messages, which mainly aimed to increase awareness and knowledge about type 2 diabetes management. The review highlighted the use of different tailoring strategies that addressed the participants' preferences and needs. However, there is still a need for using more persuasive message design elements and comprehensive and dynamic theoretical approaches in these interventions.

The meta-analysis concluded that tailored mobile text messaging interventions could improve glycemic control in type 2 diabetes patients. Patients seem to prefer direct and personalized communication, but do not necessarily favour frequent contact and interactivity. Also, when combined with other modes of interaction (e.g., web page, assessment devices), the effects of tailored text messaging interventions on glycemic control can increase. However, more rigorous interventions with larger and carefully selected samples and longer follow-ups are required to confirm these findings and to explore the effects of tailored text messaging on other self-management behaviours.

## **Chapter 3: Patients' Experiences With Mobile Text Messaging Studies for Type 2 Diabetes Management and Their Perspectives for Text Message Design and Delivery: A Systematic Review and a Meta-Synthesis**

### **3.1 Abstract**

**Objectives:** A systematic review and a thematic synthesis were performed to identify, assess, and summarize available scientific evidence on text messaging studies focused on patients' experiences and perspectives about text messaging interventions, text message content and delivery features.

**Methods:** A comprehensive search strategy included major electronic databases, key journal searches, and hand searches of the reference lists of related systematic reviews and meta-analyses. The Cochrane Qualitative and Implementation Methods Group and PRISMA guidelines were followed for data extraction, quality appraisal, data analysis and report. A thematic synthesis was performed to integrate the findings of the included studies. The Grade CERQual tool was utilized to assess the confidence in the findings.

**Findings:** The search returned 14 eligible studies for the systematic review and 13 studies for the thematic synthesis. Thematic synthesis identified 19 categories with a moderate and high level of confidence, which clustered into three domains: perspectives on interventions/programs, perceptions about text messaging, and experiences with diabetes management. In addition to increased self-awareness, knowledge and control on diabetes, text messaging created a sense of "feeling supported" in patients, improved their communication with family/friends and care providers, and positively changed their habits towards medication adherence and diabetes regimen. Preferred message timing and frequency varied among patients indicating the need for customized message delivery.

**Conclusions:** Text messaging was perceived as a suitable technology for type 2 diabetes self-management. Patients with Type 2 diabetes highly valued the tailored content in text

messages. Future research needs to explore which tailoring strategies and message design elements could be particularly effective in reaching patients with type 2 diabetes. The findings of this meta-synthesis provide significant implications to healthcare professionals, organizations, and researchers to effectively design and deliver text messages based on patients' preferences and expectations.

**Keywords:** Text messaging, Type 2 diabetes, health promotion, behaviour change, systematic review, thematic synthesis

### 3.2 Background

Type 2 diabetes is a complex, progressive life-long condition, and one of the most rapidly developing diseases globally (International Diabetes Foundation, IDF, 2017). The causes and consequences of this disease are highly divergent that there could be different types of type 2 diabetes requiring different treatment plans (Ahlqvist et al., 2018). The majority of type 2 diabetes management includes patients' self-care activities, such as self-monitoring of blood glucose levels regularly and adopting appropriate lifestyle changes (e.g., diet, physical activity, medication adherence, stress management) (Diabetes Canada, 2019). However, patients often fail to adhere to these self-management activities (Capozza et al., 2015; Spruijt-Metz et al., 2015). Patients should be knowledgeable about diabetes and should have adequate cognitive and psychomotor skills that will lead to performing the necessary behaviours for the improvement of their health (Sousa, Zauszniewski, Musil, McDonald, & Milligan, 2004). Further, the severe complications of diabetes and comorbidities, such as blindness, heart disease, kidney problems, nerve damage make its management more challenging over time (Diabetes Canada, 2019). Therefore, it is crucial to provide customized and continuous support to improve patients' self-management skills as each patient has specific challenges and experiences with diabetes (Sherifali et al., 2018).

Mobile text messaging has been widely used in health interventions to address various types of health conditions, including diabetes self-management (Naughton and Sutton, 2011; Hall et al., 2015). Because it is possible to provide continuous, customized, convenient, and cost-effective care by mobile text messaging, it can be particularly useful to support patients with type 2 diabetes (Spruijt-Metz et al., 2015, Peimani et al., 2015).

Existing systematic reviews and meta-analyses (Hall et al., 2015; Arambepola et al., 2016; Farmer et al., 2016; Kitsiou et al., 2017; Sahin et al., 2019) indicated the significant

effect of mobile text messaging interventions on Type 2 diabetes management. However, there was considerable heterogeneity in the moderators of effectiveness in these studies. Therefore, there is still a lack of knowledge about patient experiences in these programs to support the optimization of interventions. A qualitative synthesis may provide richer detail and insights from participants in these interventions and can counter the shortcomings of quantitative moderator analyses.

### **3.3 Objectives**

This paper is a systematic review and a meta-synthesis of qualitative studies conducted to design, implement, and/or evaluate mobile messaging interventions for Type 2 diabetes self-management. Specifically, the research sought to answer the following questions: 1) What are the main characteristics of mobile messaging-based qualitative studies conducted to improve Type 2 diabetes self-management? 2) What are the barriers and facilitators to the design and implementation of text-messaging programs for Type 2 diabetes self-management? 3) What are patients' perceptions and experiences toward message content and message delivery features (i.e., timing, frequency, interactivity)? 4) What are patients' perceptions and experiences toward tailored mobile messaging content for the self-management of diabetes?

### **3.4 Research Methodology**

We followed the recent guidelines of the Cochrane Qualitative and Implementation Methods Group (Noyes et al., 2017; Harris et al., 2017; Noyes, Booth, Flemming et al., 2017; Cargo et al., 2017; Harden et al., 2018; Flemming et al., 2018), the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009), and

the Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) criteria (Tong et al., 2012) to synthesize the qualitative studies and report the findings.

### **3.4.1 Inclusion criteria**

We included all the studies that were returned from our search and met our eligibility criteria (Appendix IX). The review included original research papers where data collection and analyses have been made using qualitative methods (e.g., focus group, in-depth interviews). Because of the message-specific focus of our study, we did not consider the studies written in another language other than English.

### **3.4.2 Search strategy**

A comprehensive search strategy was implemented between 2 and 5 October 2018. The search strategy included major electronic database searches, key journal searches, and hand searches of reference lists from recent systematic reviews and meta-analyses (Appendix X). Combinations of key terms, MeSH terms, and CINAHL subject headings were searched across the selected electronic databases (Appendix XI). PubMed search strategy, which was modified for other databases, were provided in Appendix XII.

### **3.4.3 Selecting studies and collecting data**

The search results obtained from different sources were combined and screened using Zotero 5.0 Citation Manager (Zotero.org, 2018). After the duplicates were removed, the titles and abstracts of the remaining citations were examined against the eligibility criteria. When the abstracts were not available or clear, the full texts of the studies were reviewed. Further, full-texts of all the studies that passed the initial title-abstract screening were scrutinized to assess the eligibility of the studies.

For data extraction, we developed a structured form adapted from the National Institute for Health and Care Excellence (NICE) ([nice.org.uk](http://nice.org.uk), 2018). We extracted data for study designs, theoretical approach, sample characteristics and setting; data collection technique; a method of data analysis; intervention/program features; text message content, and key findings. When studies contained other participants (e.g., physicians, doctors, family members), we only extracted patient participants' data and findings.

The first author and a reviewer with doctorate level qualifications independently screened the articles against inclusion criteria and extracted the data. Any disagreement was discussed until consensus was reached, and the reasons for excluded studies were recorded (Appendix XIII).

#### **3.4.4 Critical appraisal**

For quality assessment, we used the checklist of Critical Appraisal Skills Programme (CASP) (Noyes, Booth, Flemming, et al., 2017; Critical Appraisal Skills Programme (CASP), 2018). CASP includes ten questions. The screening questions assess the appropriateness of study rationale while the following questions evaluate whether the methods applied for sampling, data collection, and analysis were appropriate, ethically conducted, and reported. The first author and a reviewer independently assessed how the studies reported on their methodological processes and evaluated the limitations of the studies and discussed any discrepancies until consensus was reached. The studies were classified as high quality, medium quality or low quality, and the rationale for each judgment was provided (Appendix XIV).

### 3.4.5 Data synthesis and analysis

We applied a thematic synthesis approach (Thomas and Harden, 2008) to examine data and combine the findings. Atlas.ti 8.3 qualitative data analysis software (Atlas.ti, 2018) was used to classify and analyze the codes and perform the thematic synthesis.

The three-step coding and the theming process began with line-by-line coding to characterize the content of each line or sentence in the findings of each study. Then, the codes were analyzed and grouped according to their similarities and differences to develop categories and thematic categories in a hierarchical tree structure.

The coding process was initially carried out independently and then collaboratively by the first author and the reviewer. Prior to analysis, reviewers agreed on definitions of key concepts such as tailoring, diabetes self-management, feedback, automation, and interactivity in order to increase the consistency of interpretation. By performing line-by-line coding, every sentence and/or quote had at least one code applied; in most cases, multiple codes were utilized. In articles where different participants were involved (e.g., patients, caregivers, doctors), only the patient data were extracted. We examined the qualitative findings of the studies and checked other article sections to ensure that no relevant findings had been missed.

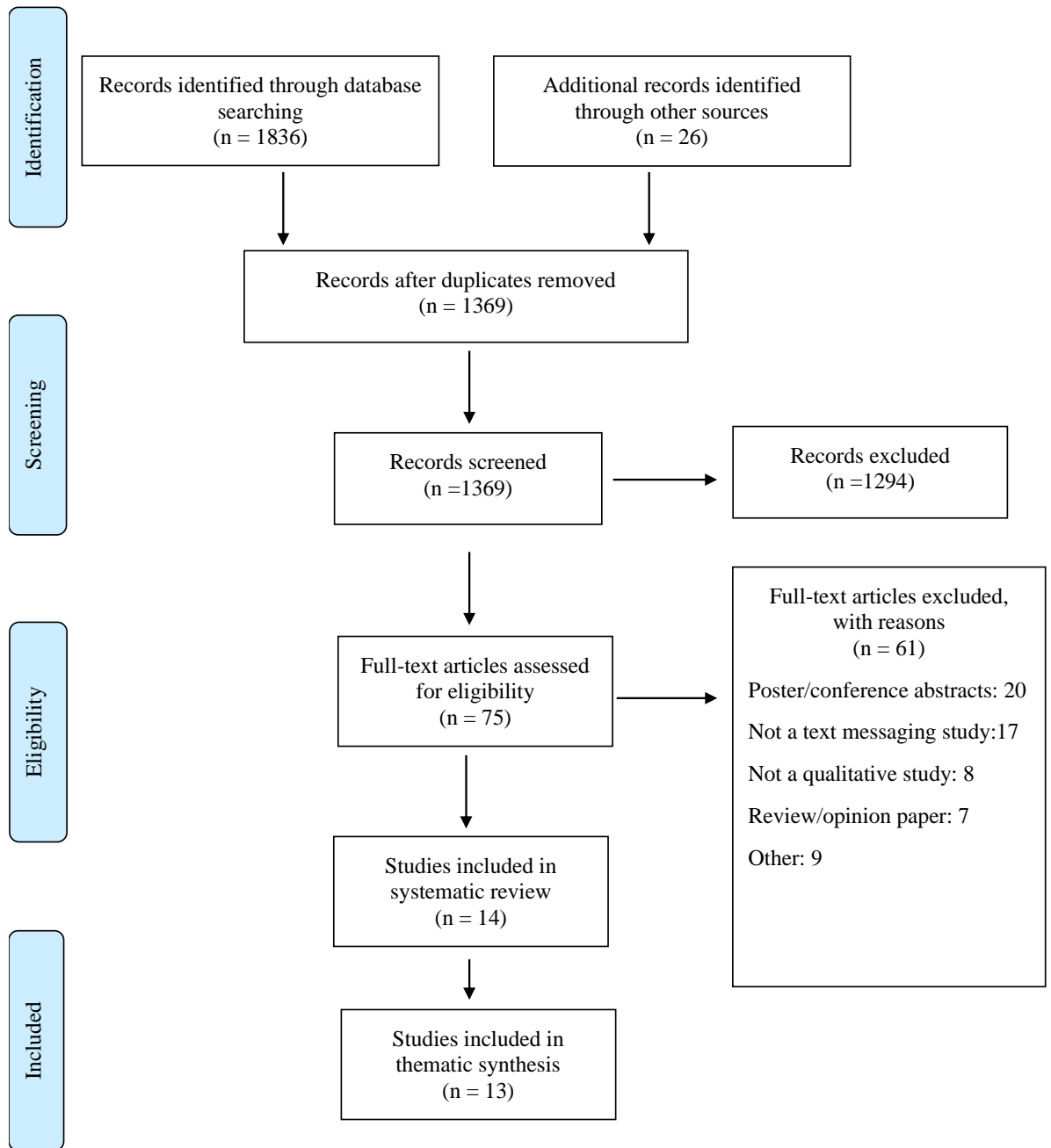
We assessed the confidence in the findings of the thematic synthesis using The Confidence in the Evidence from Reviews of Qualitative Research (CERQual) approach (Lewin et al., 2015). Because we applied a critical appraisal of the methodological limitations of the studies separately (Appendix XIV), the confidence assessment included three other components (relevance, coherence, and adequacy of data). We provided our judgments in detail in Appendix XV and included only medium and high-quality studies in our analysis.

### 3.5 Results

The combined database searches returned 1812 records, and with 26 records from other sources, a total of 1838 records were collected. After duplicates were removed, 1369 records were screened for eligibility using title and abstract. A total of 75 articles were shortlisted for eligibility, and full-text screening resulted in 14 eligible studies for a systematic review. The search results are summarized in the PRISMA flow diagram (Figure 3.1).

Among the studies reported on the same intervention/program, preliminary studies (e.g., Dick et al., 2011; Osborn and Mulvaney, 2013) were used as support studies, and the advanced studies including the patients' evaluations of interventions were included (e.g., Nundy, Dick, Solomon, & Peek, 2013; Nelson, Mulvaney, Johnson, & Osborn 2017, respectively).

We reported the result of our assessment of methodological limitations for each study in the Characteristics of Included Studies Table (Table 3.1). All but one study (Fortmann et al., 2017) had sufficient detail about methodology and findings and methodological quality to provide reliable evidence on patients' experiences and perspectives about designing and implementing text messaging interventions.



**Figure 3.1. Study selection flow diagram based on the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) guideline**

### 3.5.1 Study characteristics and quality

The dataset featured seven mixed methods studies in which qualitative phases followed the quantitative measurements. There were three qualitative studies conducted and reported separately from their related randomized trials and one qualitative evaluation from an ongoing trial. There was an exploratory qualitative study aimed to assess patients' perspectives in order to develop an optimal text messaging. Also, a mixed-methods usability-feasibility testing study was included in the sample. In summary, there were 11 studies focused on post-intervention evaluation, one study concentrated on intervention implementation, and two studies engaged in the design and development process of text messaging interventions.

Twelve studies reported the use of at least one theoretical framework, and the Health Belief Model was the most frequently used (n=6). In five studies, multiple theories were employed (Horner, Agboola, Jethwani, Tan-McGrory, & Lop, 2017; Gatwood et al., 2015; Nundy et al., 2013; Mayberry, Berg, Harper, & Osborn, 2016; Chen, Yu, Li, Zhan, & Yan 2018). Theoretical frameworks were generally used to develop intervention messages and to guide the intervention process.

Almost all studies (one was from China) were conducted in the USA. In six studies, the majority of participants were 50 years old or more. Some studies primarily targeted Latino/Hispanic patients (n= 5) and low-income patients (n=7).

Focus groups (n=4) and interviews (n=8) were the primary data collection methods used, and two studies incorporated both focus groups and interviews. The majority of the studies (n=12) reported the use of structured or semi-structured interview guides and recorded the interview sessions (n=10). Telephone interviews were conducted in five studies, and interview times ranged from 15 minutes to 120 minutes.

Eight studies addressed overall diabetes self-care, whereas other studies primarily focused on one diabetes-care behaviour such as medication adherence or problem-solving.

All interventions/programs presented various types of message content that were tailored based on language preferences (e.g., Burner, Menchine, Kubicck, Robles, & Arora, 2014; Burner et al., 2018); cultural and economic status (e.g., Watterson, Rodriguez, Shortell, & Aguilera, 2018); or psychosocial and behavioural needs and expectations of patients (e.g., Bergner, Nelson, Rothman, & Mayberry 2017; Horner et al., 2017).

Six studies used frequent messaging, defined as sending two or more messages daily. In the other six studies, one message per day or less was delivered. In one study, patient preference determined message frequency (Bergner et al., 2017). The use of message direction in the interventions/programs was heterogeneous; there were one -way messaging (n=6), two-way messaging (n= 4), and the use of both types (n=3). The majority of studies were text messaging only studies (n= 11). Some studies included phone coaching and support persons (Mayberry et al., 2016), web-portal (Mamykina et al., 2016), and IVR calls (Nelson et al., 2017). All interventions were delivered via automated messages.

Text messaging content included educational-informative and motivational messages. Tips, reminders, short questions, and challenges were used to enhance content variability in some of the studies. One study (Mayberry et al., 2016) reported the use of simplified sentence structure, active voice, credible sources, and removal of uncommon words and medical jargon from the message content. Chen et al. (2018) also stated the importance of using authoritative sources and breaking the monotony of messages to prevent the gradual loss of interest to the messages.

Table 3.1. Characteristics of included studies

Study Author's Name, Year	Study Design Aims and Objectives	Theoretical Approach	Sample Characteristics and Setting (only the qualitative phase and patient participants)	Data Collection Technique and Method of Analysis	Intervention /program features	Text message content	Findings by Key Themes	Study Quality
Bergner et al., 2017	<p><b>Design:</b> A 2-weeks mixed methods study including a qualitative study at the follow-up</p> <p><b>Aims:</b> To explore how patients engaged with and experienced the REACH program</p>	<p>“REACH” text messaging intervention, was designed based on Information-Motivation-Behavioral Skills (IMB) Model</p>	<p><b>No Participants:</b> 31</p> <p><b>Diabetes characteristics:</b> Type 2 patients that were prescribed at least one daily diabetes medication</p> <p><b>Language:</b> English</p> <p><b>Other:</b> Adult patients with adequate health literacy (n= 18) and limited health literacy (n= 13)</p> <p><b>Setting:</b> 2 federally qualified health centres in Nashville, TN, USA.</p>	<p>Semi-Structured telephone interviews were conducted by trained research assistants</p> <p>Interviews were audio-recorded and transcribed verbatim</p> <p>A thematic analytic approach was used for data analysis</p>	<p>REACH is an interactive and automated text-messaging intervention designed to address user-specific medication adherence barriers and support other self-management behaviors</p> <p>Daily and weekly messages were sent:</p> <ul style="list-style-type: none"> <li>• Daily messages for medication adherence and promotional messages for other self-care behaviors.</li> <li>• Weekly messages for feedback and support</li> </ul>	<p>REACH intervention delivered informative tailored messages to address users’ barriers to medication adherence (how to handle missed doses, manage side-effects, administer, store, and discard medication)</p> <p>Non-tailored messages were inspirational messages promoted diet, exercise, and self-monitoring of blood glucose</p> <p><b>Example:</b>  <i>“Remember that you have the power every day to make progress</i></p>	<p>Common themes indicating the benefits of the program regardless of the health literacy status:</p> <ul style="list-style-type: none"> <li>• <b>Reminders and accountability</b></li> <li>• <b>Information and motivation</b></li> </ul> <p>For patients with limited health literacy:</p> <ul style="list-style-type: none"> <li>• <b>Social support</b></li> </ul> <p>For patients with adequate health literacy:</p> <ul style="list-style-type: none"> <li>• <b>Augmented existing knowledge</b></li> <li>• <b>Convenience and Accessibility</b></li> </ul>	High Quality

					Message frequency and timing were determined based upon patient preferences	<i>toward improving your health!"</i>		
Burner et al., 2013	<p><b>Design:</b> A mixed methods analysis of a previously conducted pilot feasibility study - including a qualitative study in the second phase</p> <p><b>Aim:</b> To understand the effect of the intervention on diabetes self-management</p>	TEXT-MED intervention messages had been developed previously using the Health Belief Model to address specific barriers and knowledge gaps of T2D patients	<p><b>No. Participants:</b> 8</p> <p><b>Diabetes characteristics:</b> Diabetes patients (HbA1C <math>\geq</math>8%)</p> <p><b>Language:</b> 5 English speakers and 3 Spanish speakers</p> <p><b>Other:</b> Predominantly Latino adults (%75), equal male-female ratios (50%), have low income</p> <p><b>Setting:</b> Emergency Department of Los Angeles County Hospital at USC, CA, USA.</p>	<p>2 focus group studies were conducted, either in English or Spanish</p> <p>The sessions lasted 90 minutes</p> <p>A bilingual moderator led the sessions using a structured guideline</p> <p>Interviews were audio-recorded and transcribed verbatim</p> <p>Using an iterative process, codes were generated and categorized based on the gender of the participants</p>	<p>TEXT-MED is a one-way, fully automated text messaging intervention focused on increasing knowledge, self-efficacy, glycemic control, and diabetes self-management</p> <p>Patients received 3 messages per day, either in English or Spanish based on their preference</p>	<p>Messages include:</p> <ul style="list-style-type: none"> <li>• educational or motivational content (67%)</li> <li>• medication reminders (5%)</li> <li>• challenge messages on healthy living (14%)</li> <li>• trivia questions (12 %)</li> </ul>	<p>Themes that are differed by gender:</p> <ul style="list-style-type: none"> <li>• <b>dietary self-efficacy</b></li> <li>• <b>health information sources</b></li> <li>• <b>desired content of educational materials</b></li> </ul>	High Quality
Burner et al., 2014	<p><b>Design:</b> A qualitative study conducted after a</p>	Health Belief Model was used to develop the	<p><b>No. Participants:</b> 24</p>	5 focus groups were conducted; 2 in English and 3 in	TEXT-MED is a one-way, fully automated text messaging	The twice-daily messages included	<b>Useful medical reminder</b>	High quality

	<p>6-month randomized controlled trial</p> <p><b>Aims:</b> to examine the findings of the TExT-MED intervention further and to explore the perceptions and experiences of participants about the intervention</p>	<p>TExT-MED intervention messages and to guide the intervention process</p>	<p><b>Diabetes characteristics:</b> Diabetes patients (HbA1C <math>\geq</math>8%)  <b>Language:</b> Mainly Spanish speakers (58%)  <b>Other:</b> Predominantly Latino adults (75%), and female patients (67%) have low income  <b>Setting:</b> Emergency Department of Los Angeles County Hospital at USC, CA, USA.</p>	<p>Spanish, and 2 for men and 3 for women</p> <p>A semi-structured interview guideline was used, and the sessions lasted from 90 minutes to 2 hours</p> <p>Experienced bilingual researchers moderated the sessions which were audio-recorded and transcribed verbatim</p> <p>Using a modified grounded theory approach and applying line by line coding, 2 independent reviewers coded qualitative findings and generated 27 codes and 24 sub-codes</p>	<p>intervention focused on increasing knowledge, self-efficacy, glycemic control, and diabetes self-management</p> <p>Patients received 2 messages per day</p>	<ul style="list-style-type: none"> <li>educational or motivational messages</li> <li>medication reminders</li> <li>challenge messages on healthy living</li> <li>trivia questions</li> </ul> <p>Text messages were designed based on language preferences (English or Spanish).</p> <p><b>Example:</b> “Having diabetes can lead to a heart attack and stroke! But it doesn’t have to”</p>	<p><b>Impactful healthy living challenge</b></p> <p><b>Need to increase the personalization of message delivery</b></p> <p><b>Need to increase personalization of message content</b></p>	
<p>Burner et al., 2018</p>	<p><b>Design:</b> A 3-month mixed methods feasibility trial including a</p>	<p>TExT-MED intervention messages had been developed</p>	<p><b>No. Participants:</b> 14 patients (and 8 family members)</p>	<p>Individual interviews and 6 focus groups were conducted with</p>	<p>TExT-MED is a one-way, fully automated text messaging intervention focused</p>	<p>Patient messages included:</p> <ul style="list-style-type: none"> <li>educational or motivational</li> </ul>	<p><b>Positive regard for the TExT- MED+ FANS intervention</b></p>	<p>High Quality</p>

	<p>qualitative phase at the follow-up</p> <p><b>Aims:</b> to determine the acceptability, feasibility, and efficacy of a text messaging program including a social support feature (FANS)<sup>2</sup> Qualitative questions aimed to identify the effects of the intervention on patients' motivation and perception about diabetes</p>	<p>previously using the Health Belief Model to address specific barriers and knowledge gaps of T2D patients</p>	<p><b>Diabetes characteristics:</b> Diabetes patients (HbA1C <math>\geq</math> 9.6%)  <b>Language:</b> Speaking predominantly Spanish (%32).  <b>Other:</b> Predominantly Latino adults (%77), equal male-female ratios (50%), have low income  <b>Setting:</b> Emergency Department of Los Angeles County Hospital at USC, CA, USA.</p>	<p>patients and family members separately</p> <p>Both English and Spanish sessions were executed</p> <p>Verbatim transcripts were analyzed using a software program and following an iterative process for coding.</p> <p>Line-by-line coding was performed, a total of 32 codes and sub-codes were generated, and theme categories were identified</p>	<p>on increasing knowledge, self-efficacy, glycemic control, and diabetes self-management</p> <p>2 messages were sent per day at 9 am and 5 pm</p> <p>FANS messages were sent to supporters once or twice daily</p>	<p>messages (1 per day)</p> <ul style="list-style-type: none"> <li>• medication reminders (3 per week)</li> <li>• challenge messages on healthy living (2 per week)</li> <li>• trivia questions (2 per week)</li> </ul> <p>Patient messages were derived from the National Diabetes Education Program</p> <p>Text messages were designed based on language preferences (English or Spanish)</p> <p>Optimal message frequency and content (knowledge gaps/topic preferences) for the target group were identified in the previous study****</p> <p><b>Example:</b> “30 minutes of exercise a day (even walking) will give you MORE energy not less.</p>	<p><b>Desire to be healthy and honour responsibilities</b></p> <p><b>Desire for more personalization</b></p> <p><b>Change in supporters' health behaviors</b></p>	
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						<i>Make it part of your routine!"</i>		
Chen et al., 2018	<p><b>Design:</b> A qualitative study</p> <p><b>Aim:</b> To explore the perspectives of rural Type 2 diabetes patients and health workers on a text message-based intervention (TMI) for increasing patients' medication adherence in rural China.</p>	<p>The Health Belief Model (HBM) and the Communication -Persuasion Model (CPM) were used in explaining the rationale and discussing the effects of the text messaging intervention</p>	<p><b>No. Participants:</b> 26 patients</p> <p><b>Diabetes characteristics:</b> Adult Type 2 diabetes patients that had a history of taking antidiabetic medications for at least 2 years. Nearly half of them (n=11) was newly diagnosed (&lt;5 years) or have type 2 diabetes for 5-10 years (n=12)</p> <p><b>Language:</b> not specified, probably Chinese.</p> <p><b>Other:</b> Mostly female (n=18), 50+ patients living in rural areas of China whose education level mostly up to junior high level (n=16)</p> <p><b>Setting:</b> Three counties of Xianning City with different economic levels were chosen. Then, a random number generator was used to select two towns</p>	<p>6 Focus group interviews including 4-6 patients were conducted</p> <p>A semi-structured interview guide was used, and interviews lasted up to 90 minutes</p> <p>Interviews were audio-recorded, transcribed verbatim, and analyzed using software.</p> <p>Researchers also took field notes</p> <p>Using the method of grounded theory and constant comparative method, transcripts were coded</p> <p>Two independent coders worked in the process of open coding, axial coding, and</p>	<p>This is an initial study to assess patients and health workers' attitudes toward a text messaging intervention to be developed to increase medication adherence</p>		<p><b>Knowledge about diabetes</b></p> <ul style="list-style-type: none"> <li>Lack of knowledge of diabetes symptoms and consequences</li> </ul> <p><b>Treatment adherence</b></p> <ul style="list-style-type: none"> <li>Young people have poor med. adherence</li> <li>Forgetfulness and worrying about the side effects are important barriers</li> </ul> <p><b>Attitudes toward TMI</b></p> <ul style="list-style-type: none"> <li><b>High acceptability</b> <ul style="list-style-type: none"> <li>Convenient and accessible</li> <li>Ability to review and store information</li> </ul> </li> <li><b>Barriers</b> <ul style="list-style-type: none"> <li>Low education level/low health literacy</li> </ul> </li> </ul>	High Quality

			from each county to select the participants	selective coding, and based on their agreed coding framework, the analysis was performed			<ul style="list-style-type: none"> <li>○ Poor eyesight</li> <li>○ Gradual loss of interest (Use of medical jargon, too much frequency, monotonous content)</li> <li>● <b>Suggestions</b> <ul style="list-style-type: none"> <li>○ Getting family/friend support</li> <li>○ Tailoring message content</li> <li>○ Interactivity</li> <li>○ Using authoritative sources</li> <li>○ Delivering messages 2-3 times a week</li> <li>○ Combining with other formats (e.g., voice messages, videos)</li> </ul> </li> </ul>	
Fortmann et al., 2017	<b>Design:</b> A 6-month mixed methods study including a qualitative study at the follow-up	None reported	<b>No. Participants:</b> 12 <b>Diabetes characteristics:</b> Type 2 diabetes patients (HbA1C $\geq$ 7.5%)	2 Focus groups that lasted 90 minutes were conducted	Dulce digital is a mobile phone text messaging program sending one-way messages on diabetes self-care and	Educational, motivational, and call-to-action messages were culturally tailored to	<b>High degree of acceptability</b>  <b>Sufficient level of frequency</b>	Low Quality

	<p><b>Aims:</b> To investigate the glycemic benefit and acceptability of a culturally tailored, SMS-based diabetes self-management education and support intervention</p>		<p><b>Language:</b> Spanish and English  <b>Other:</b> Hispanic adults who have low income  <b>Setting:</b> Clinics within the Neighbourhood Healthcare in San Diego and Riverside counties, USA.</p>	<p>Participants were randomly selected from the trial cohort</p>	<p>medication reminders and blood glucose monitoring prompts</p> <p>Message timing was standardized for all patients and 2-3 messages were sent per day (in the beginning)</p> <p>Messages were delivered automatically</p>	<p>the needs of the specific population</p> <p>Project Dulce curriculum*** was used to develop message content which aimed to address cultural barriers and beliefs about diabetes</p> <p><b>Example:</b> <i>“Use small plates! Portions will look larger and you may feel more satisfied after eating”</i>  <i>“It takes a team! Get the support you need -family, friends and support groups can help you to succeed”</i></p>	<p><b>Easy to understand</b></p>	
<p>Gatwood et al., 2015</p>	<p><b>Design:</b> A 90-day mixed methods pilot RCT including a qualitative phase at the follow-up  <b>Aims:</b> to examine the acceptability and the use of mobile phones and gather the perspectives on tailored text</p>	<p>The Technology Acceptance Model, the Health Belief Model, and the Self-Determination Theory were used to develop survey items in the quantitative phase</p>	<p><b>No. Participants:</b> 12  <b>Diabetes characteristics:</b> Diabetes patients (HbA1C <math>\geq</math>8%) who take at least one anti-diabetic medication  <b>Language:</b> English  <b>Other:</b> Mostly male (67%) and Caucasian adult patients</p>	<p>One-to-one telephone interviews were conducted</p> <p>Participants were randomly selected from the intervention cohort</p> <p>A semi-structured interview guide was used and</p>	<p>The intervention included one-way text messages on medication adherence and healthy living</p> <p>Messages were delivered automatically and at least 1 message was sent per day</p>	<p>Messages were designed to increase patients’ knowledge and motivation for improvement in their medication adherence and diabetes-related health beliefs</p> <p>A total of 168 theory-based messages (84 Self-</p>	<p><b>General impressions</b></p> <ul style="list-style-type: none"> <li>• Enjoyable</li> <li>• Useful reminders</li> <li>• Provided encouragement</li> <li>• Helpful tips and information <ul style="list-style-type: none"> <li>○ Educational</li> <li>○ Confidence booster</li> </ul> </li> <li>• Adequate tailoring</li> </ul> <p><b>Impact of messages</b></p>	<p>Medium Quality</p>

	messages for medication adherence	Messages were crafted using the concepts from the Health Belief Model, and the Self-Determination Theory*****	<b>Setting:</b> Community Care Network, Michigan, USA	interviews lasted 10-15 minutes  Interview notes were recorded electronically	Ordering and timing of the message were arranged based on the patient’s daily medication schedule	determination theory messages, 96 Health belief model messages) and 128 tailored medication specific messages were delivered  Messages were personalized using the subject’s name in every message and their age and diabetes medication information sporadically.  <b>Example:</b> <i>“It may be tough to see but taking your diabetes medications is vital to your health. Taking them as directed may help you see their value”</i>	<ul style="list-style-type: none"> <li>• Provided confidence to manage their diabetes</li> <li>• Increased medication adherence</li> <li>• Motivational content was the most helpful</li> </ul> <b>Recommendations</b> <ul style="list-style-type: none"> <li>• Individualized messaging dose</li> <li>• Increased specificity</li> <li>• The inclusion of the feedback mechanism</li> </ul>	
Georgsson and Stagers, 2017	<b>Design:</b> An exploratory qualitative study conducted after a 6-month randomized trial  <b>Aims:</b> to assess patients’	Technology Acceptance Model (TAM) guided the data collection process in “Care4Life” text messaging study	<b>No Participants</b> 10 (randomly selected) <b>Diabetes-characteristics:</b> Type 2 diabetes patients, 90 % had diabetes for 3 or more years	A short demographic questionnaire was used to collect information on sex, ethnicity, age, education, profession, the amount of time	Care4Life is an SMS based program targeting diabetes self-management  Unidirectional and generic messages on diabetes education and health	Educational and motivational messages targeting various aspects of diabetes such as diet, exercise, blood pressure, blood glucose, medication adherence.	The acceptability of Care4Life was very high (% 100 either agreed or strongly agreed)  <b>Key themes:</b> <b>Overall System Perception</b>	High quality

	<p>experiences and perceptions about the “Care4Life” text messaging program</p>		<p><b>Language:</b> English or Spanish  <b>Other:</b> Equal gender ratio, predominantly white-Caucasians (80%), mostly mature adults (50% were between 60-69 years of age), highly educated (80% had college/university education)  <b>Setting:</b> A health research centre in Salt Lake City, Utah, USA.</p>	<p>with diabetes, education about diabetes.</p> <p>Semi-structured in-depth interviews were conducted to assess perceptions and experiences about the program</p> <p>The TAM guided the development of questions in both methods</p> <p>Interviews lasted up to 20 minutes, were recorded and transcribed verbatim</p> <p>Descriptive statistics for quantitative data and content analysis for qualitative data were performed. Inductive and deductive content analysis involving thematic coding were performed</p>	<p>improvement were sent each day.</p> <p>Patients were able to activate optional two-way messaging protocols (totally 6) including medication reminders, glucose testing reminders, BP monitoring reminders and tracking and encouragement for exercise and diet</p> <p>1-7 text messages per day depending upon patient uploaded data</p> <p>Messages were delivered automatically</p>	<p>Reminders, tips, opportunity to track measurements and trends visually were the main content features of the programme.</p> <p>Based on language preferences (English or Spanish) messages were personalized. Patients were able to control the type and frequency of the messages. Also based on their uploaded data, patients received some reminders and feedback messages</p> <p><b>Example:</b> <i>“How are you? Feeling stressed about diabetes is normal. Getting support will help you feel better and control glucose. Ask for help when you need it.”</i></p>	<ul style="list-style-type: none"> <li>Fairly complete systems</li> <li>Should accommodate elderly users</li> </ul> <p><b>General impression</b></p> <ul style="list-style-type: none"> <li>tracking measurements</li> <li>consolidated measurements</li> <li>trending and visualization</li> <li>educational messages and tips</li> </ul> <p><b>Reminder</b></p> <ul style="list-style-type: none"> <li>help remember blood glucose measurements and medication</li> </ul> <p><b>Control</b></p> <ul style="list-style-type: none"> <li>feel more in control of disease</li> </ul> <p><b>Independence</b></p> <ul style="list-style-type: none"> <li>feel more independent</li> </ul> <p><b>Disease-related suggestions/expectations</b></p> <ul style="list-style-type: none"> <li>new features are needed for insulin titration and upload capability</li> </ul> <p><b>Information related suggestions</b></p> <ul style="list-style-type: none"> <li>need for personal logs and social media forum</li> </ul>	
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							<b>Suggestions for food and Lifestyle -related support</b> <ul style="list-style-type: none"> <li>Carbohydrate counters, snack reminders, tips for weight and lifestyle management</li> </ul>	
Horner et al., 2017	<p><b>Design:</b> A qualitative study conducted after a 6-month trial</p> <p><b>Aims:</b> to assess participants' attitudes regarding their experience with Text to Move text messaging program focusing on perceived barriers and facilitators.</p>	<p>Transtheoretical Model (TTM) was used to develop the message content and intervention process in "Text to Move" Intervention</p> <p>UTAUT<sup>1</sup> framework was used to elaborate on the identified themes</p>	<p><b>No participants:</b> 31</p> <p><b>Diabetes characteristics:</b> Type 2 diabetes patients</p> <p><b>Language:</b> English (n=27) and Spanish (n=4)</p> <p><b>Other:</b> Adult (51.4 years of age on average), primarily male (n=19), married and white (74%), have a full-time job (50%), and at least 12<sup>th</sup>-grade level education</p> <p><b>Setting:</b> Health research centres of Massach. General Hospital Boston, MA</p>	<p>In-depth telephone interviews (n= 19) and 2 focus groups (n= 12; 7+5) were conducted.</p> <p>Semi-structured telephone interviews were conducted either in English or Spanish and lasted up to 45 min.</p> <p>Focus groups were conducted in English, lasted 90 min. and a semi-structured questionnaire was used.</p> <p>All interviews and focus groups were audio-recorded, transcribed, and reviewed.</p>	<p>"Text to Move" is a tailored, automated, interactive text messaging intervention focused on increasing physical activity of T2D patients</p> <p>2 messages were sent per day based on patients' stage of change</p>	<p>Messages focused on providing feedback, health education, motivation, and reminders to promote healthy behaviors (med.adherence, diet, etc.)</p> <p>Messages were tailored based on baseline stage of change (TTM) assessment and updated each month</p> <p>More than 1000 messages were created by a team of researchers and health researchers</p> <p>Messages were designed at 3<sup>rd</sup>-grade reading level and presented in English or Spanish based on participants' preferences</p>	<p><b>Domain 1: Effect of participation</b></p> <ul style="list-style-type: none"> <li>Increase in daily disease awareness</li> <li>Program integrated into daily life</li> <li>Connections arising from participation</li> </ul> <p><b>Domain2: Effect of wearing the pedometer</b></p> <ul style="list-style-type: none"> <li>Motivational thru viewing step count and text</li> <li>Sentinel effect from usage</li> <li>Evangelizing new technology to others</li> </ul> <p><b>Domain3: Effect of text messages</b></p> <ul style="list-style-type: none"> <li>Helpful daily reminders</li> <li>Informational or useful for idea generation for Phys. activity</li> </ul> <p><b>Domain4: Barriers to Text to Move intervention efficacy</b></p>	High Quality

				A ground theory approach was used in data analysis, codes were created by 2 independent researchers and themes were explored		Messages were prepared in a question form to enable interaction  <b>Example:</b> ”as of 8:27 am, you were active for 45 mins. yesterday which is 75% of your daily goal”	<ul style="list-style-type: none"> <li>• Technical issues</li> <li>• Personal reasons</li> <li>• Dislike of automation of text messages</li> <li>• Limited knowledge of recommended physical activity</li> </ul>	
Mamykina et al., 2016	<p><b>Design:</b> A qualitative study conducted at the 4-week of the ongoing randomized controlled trial</p> <p><b>Aim:</b> to assess participants experiences and level of engagement with the Mobile Diabetes Detective, MoDD intervention</p>	Sense-making perspective was used in intervention development and analysis	<p><b>No. Participants:</b> 18</p> <p><b>Diabetes characteristics:</b> Diabetes patients (HbA1C <math>\geq</math>8%)</p> <p><b>Language:</b> English</p> <p><b>Other:</b> Predominantly African-American (66%) and female (80%) adults (on average 50 years of age)</p> <p><b>Setting:</b> Clinical Directors Network, NY, USA</p>	<p>In-person and telephone interviews were conducted using open-ended questions</p> <p>Interviews were audio-recorded and transcribed verbatim</p> <p>Inductive thematic analysis with an open coding approach was performed to explore and categorize themes</p>	MoDD intervention is a web-based intervention using SMS text messaging as a primary mode of two-way communication between users	<p>MoDD encourages users to engage with the problem-solving process by:</p> <ol style="list-style-type: none"> <li>1. Selecting a BG pattern to improve on (e.g., <i>High BG after breakfast</i>)</li> <li>2. Choosing a potential behavioral trigger (eg., <i>Lack of protein for breakfast</i>)</li> <li>3. Select an alternative healthier behavior from a list and set an action-oriented goal for it</li> </ol> <p>Automated messages are sent once a day</p>	<p><b>Help identifying problematic (glycemic control) patterns</b></p> <p><b>Opportunity to recognize behavioral triggers</b></p> <p><b>Choosing action-oriented goals</b></p> <p><b>Implementing changes was easy</b></p> <p><b>Lasting impact on perceptions about diabetes and engagement with diabetes management</b></p>	High Quality

					<p>Feedback messages and new goals were set based on patients' uploaded data</p> <p>Reminder messages were sent based on patients' preferred scheduling</p> <p>The MoDD web interface is optimized for periodic use, to review captured data and set new goals (once per week)</p>	4. Implement the behavior, monitor the changes, and make a progress		
Mayberry et al., 2016	<p><b>Design:</b> A 2-week mixed methods usability/feasibility testing</p> <p><b>Aim:</b> To assess the acceptability and usability of the FAMS<sup>4</sup> diabetes self-care program and to obtain feedback and data to improve the intervention</p>	<p>Social Control Theory and Family System Theory were mentioned explaining the rationale for a family-focused mHealth intervention</p> <p>FAMS' phone coaching component was developed using goal-setting theory and cognitive-</p>	<p><b>No. Participants:</b> 19</p> <p><b>Diabetes characteristics:</b> Type 2 diabetes patients with a 7.4% HbA1C value on average</p> <p><b>Language:</b> English</p> <p><b>Other:</b> Predominantly African-American (44%) and female (53%) adults (on average 52 years of age) from low-income levels (83% had incomes under 35K annually)</p>	<p>3 iterative rounds of testing were conducted, each with a new sample of users</p> <p>Semi-structured interviews were conducted by phone</p> <p>Interviews were audio-recorded, transcribed verbatim, and analyzed using a software</p>	<p>FAMS is a family-focused mobile diabetes self-care program focused on increasing adherence to diet and exercise by increasing self-efficacy and family support and decreasing receipt of harmful actions</p> <p>FAMS intervention components include phone coaching, text messaging, and support persons.</p>	<p>Goal-support messages were one-way texts with tips and motivational content tailored to patients' selected goals and preferred time of day</p> <p>Text messages were designed to suit all health literacy levels and prepared to be &lt;6<sup>th</sup>-grade reading level</p> <p>Each sentence expressed one thought, used</p>	<p><b>Need for assigning a weekly goal instead of a daily one</b></p> <ul style="list-style-type: none"> <li>Example: A goal for <math>\geq</math> 4 days in a week</li> </ul> <p><b>Need for a more flexible assessment of "success"</b></p> <ul style="list-style-type: none"> <li>Meeting the goal for 4-6 days, instead of 7 days</li> </ul> <p><b>Providing a longer time to respond to the a goal assessment test</b></p> <ul style="list-style-type: none"> <li>Giving 4 hours instead of 2</li> </ul>	High Quality

		behavioral therapy	<b>Setting:</b> 3 Federally Qualified Health Centers, Nashville, TN, USA		FAMS delivers one-way and two-way/interactive, fully automated, and tailored text messages  2 non-tailored and one-tailored goal-support message were sent each week based on patients' preferred time of day  On Saturdays, a tailored, interactive goal-assessment message was sent	simplified sentence structure and active voice.  Uncommon words, multisyllabic words, and medical jargon were removed Messages avoid references to potentially unavailable resources  <b>Example:</b> <i>"Your goal was to walk 15 minutes 4 days. How many days did you meet this goal last week (Sun-Sat)? Reply with the number of days, 0-7"</i>	<b>Sending feedback texts when only 2 weeks responses were provided and if not, sending generic feedback texts</b> (i.e., Keep trying...)	
Nelson et al., 2017	<b>Design:</b> A mixed methods analysis of a 3-month pilot study <b>Aim:</b> to assess patients' experiences with and opinions of MED <sup>3</sup> intervention that focuses primarily on medication adherence	None reported	<b>No. Participants:</b> 60 <b>Diabetes characteristics:</b> Type 2 diabetes patients (HbA1C value =8%) <b>Language:</b> English <b>Other:</b> Adult patients (on average 50 years of age), mostly female (67%), low income (70 % has an annual income of 20K or	Semi-structured interviews and open-ended questions in the quantitative survey were used to collect data for qualitative analysis  Interviews conducted by trained research assistants and lasted 30-45 minutes	MED intervention delivered tailored messages and IVR calls to promote adherence to medication  One tailored message was sent at a random time per day	Informative and motivational messages and recommendations were delivered  Messages were tailored according to the 1 of 3 important barriers ranked by patients <b>Example:</b> <i>"Knowledge is power. Diabetes</i>	Daily tailored text messages were useful: <ul style="list-style-type: none"> <li>• Inform about the cost of medication</li> <li>• Suggest talking with a doctor or pharmacist</li> <li>• Offer strategies to make medication taking easier</li> <li>• Increase confidence about diabetes and its management</li> <li>• Reinforce taking meds</li> </ul>	

			less), and mostly non-white (62%) <b>Setting:</b> A federally qualified health center, Nashville, USA	All responses were transcribed and analyzed using an inductive content analysis approach  2 independent reviewers performed coding and categorized the data		<i>medications work best when used with meal planning and exercise"</i>	<ul style="list-style-type: none"> <li>• Provide emotional support</li> </ul> <b>Recommendations</b> <ul style="list-style-type: none"> <li>• Focus on other self-care behaviors</li> <li>• More motivational, inspirational messages</li> <li>• New and updated information</li> <li>• Suggest websites for more information</li> </ul>	
Nundy et al., 2013	<p><b>Design:</b> A qualitative study conducted after a 4-week pilot study</p> <p><b>Aim:</b> to explore the effects of the text messaging program, SMS-DMCare, on diabetes self-management</p>	Explored themes were examined using the constructs of the Health Belief Model, the Self-Efficacy Model, and the Social Support Model	<p><b>No. Participants:</b> 18</p> <p><b>Diabetes characteristics:</b> Type 2 diabetes patients on oral hypoglycemic agents and/or insulin.</p> <p><b>Language:</b> English</p> <p><b>Other:</b> Adult African-American patients, mostly female (67%), and most have higher education (61%)</p> <p><b>Setting:</b> University of Chicago Primary Care Group, IL, USA</p>	<p>In-depth, individual, semi-structured interviews were conducted and lasted about 60 minutes</p> <p>Interviews were audio-taped, transcribed verbatim, and analyzed using a software program</p> <p>Using the constant comparative method, transcripts were coded by a team of 6 researchers</p>	SMS-DMCare is a tailored, automated Interactive text messaging program focused on medication adherence, foot care, and blood sugar monitoring	<p>Messages were developed based on ADA recommendations for self-care</p> <p>Mainly informative messages and short questions requiring simple responses were sent</p> <p><b>Example:</b> "Did you take your diabetes medications today"</p>	<p><b>Increased self-awareness and control</b></p> <p><b>Reinforcing and providing feedback</b></p> <p><b>Increased awareness of diabetes risks and acceptance</b></p> <p><b>Feel supported</b></p>	High Quality

				Some explored themes were examined using the theoretical constructs to formulate a new behavioral model	care, and appointment reminders			
Watterson et al., 2018	<p><b>Design:</b> A 3-month pilot mixed methods study with a qualitative phase at the follow-up</p> <p><b>Aims:</b> To examine the effects of the CareMessage text messaging platform and evaluate the intervention implementation process</p>	Health Belief Model informed the intervention messages and process and was used in the data analysis	<p><b>No Participants:</b> 11</p> <p><b>Diabetes-characteristics:</b> Type 2 diabetes patients (<math>\geq 8.5\%</math> HbA1C)</p> <p><b>Language:</b> Spanish (n=6) or English (n=5)</p> <p><b>Other:</b> Primarily low-income adult Latino patients</p> <p><b>Setting:</b> From 2 federally qualified healthcare centres at Los Angeles, USA.</p>	<p>Structured telephone interviews were conducted in the preferred language and lasted approx. 45 minutes</p> <p>Interviews were recorded and professionally transcribed by a bilingual researcher</p> <p>A preliminary codebook was created based on literature and the Health Belief Model</p> <p>Additional coding was performed by 2 researchers iteratively and using a software program, and</p>	CareMessage is an automated text messaging platform delivering mostly interactive (55%) text messages focused on diabetes self-management	<p>Educational messages on self-management of diabetes included health tips, reminders, multiple-choice (31%), yes-no or true-false questions (24%)</p> <p>Messages were tailored to address cultural characteristics (traditional foods) and economic status of patients, especially for the Spanish-speaking patients</p> <p>Messages were generated based on ADA guidelines and included ten themes such as nutrition, exercise, medication adherence, foot care, mental health, foot</p>	<p><b>Positive messages</b></p> <p><b>Feel Supported</b></p> <p><b>Need for Message Retention</b></p> <p><b>Message Usefulness</b></p> <ul style="list-style-type: none"> <li>• Helpful reminders</li> <li>• New information</li> <li>• Help setting new goals and to keep in progress</li> </ul>	High Quality

				common themes were identified		care, annual exams, managing blood sugar levels and ABCs (A1C, Blood pressure, cholesterol)  <b>Example:</b> <i>“Do you know what can make you have low blood sugar? Text YES or NO”</i>		
<p>1. UTAUT: The unified theory of acceptance and use of technology</p> <p>2. FANS: Family and friends network supporters</p> <p>3. MED: Messaging for Diabetes</p> <p>4. FAMS: Family-focused add-on for motivating self-care</p>								

### 3.6 Thematic Synthesis of Included Studies

The coding process resulted in a total of 221 (107+114) codes. The codes were initially classified into 37 categories. After applying the GRADE-CERQual assessment (Appendix XV), 19 categories with a high and moderate level of confidence were identified and described in detail (Table 3.2) with illustrative quotes from participants in those studies. These categories clustered into three domains: (1) patients' perspectives on interventions/program; (2) patients' perceptions about text messaging; and (3) patients' experiences with diabetes management. The categories in the first domain were grouped across three higher-order categories: message content, message delivery, and message usefulness.

#### 3.6.1 Domain 1: Perspectives on interventions/programs

##### 3.6.1.1 Thematic category 1: Message content

**Tailoring and personalization:** Tailoring message content based on participants' needs and preferences was one of the most strongly argued themes across the studies (n=9). Not only using participants' names (personalization) but also providing related content and personalized responses enhanced patients' engagement with the text messaging program.

The studies also provided insights into how message content should be tailored. Some patients had comorbidities and specific challenges to adhere to diabetes regimen and self-care activities. Therefore, they required message content that focuses on their specific areas of difficulty and knowledge levels. Patients with a long history of diabetes asked for more specific

messages addressing their conditions and level of knowledge about diabetes and did not favour generic messages.

**Message variability:** Several studies (n=6) provided rich data on patients' preference for enhanced message variability in text messaging interventions/programs. Increasing the number and type of messages and addressing the different areas of diabetes self-care could increase patients' interest in the message content. Also, some patients seem to prefer receiving information about some problematic issues related to mental health and sexual/genital health through text messaging.

**Informative/educational content:** Seven studies reported patients' views on the informative or educational content of messages. Patients generally enjoyed the information provided through text messages. Some patients enjoyed receiving new information about medications and their costs. Patients also suggested to include more technical information about medications.

**Simple and easy to read:** Four studies provided rich data about the importance of messages to be easy to read and simple for patients, particularly for older patients. On the other hand, researchers (Chen et al., 2018; Watterson et al., 2018) added that these simple and easy to read messages should be designed without sacrificing the attractiveness of the content that would serve for knowledge retention.

**Motivational content and feedback:** Across the studies (n=11), feedbacks, and message content that included useful tips and strategies were motivating patients to improve their diabetes self-care.

**Goal-oriented messages with attainable goals:** Six studies provided rich data about the goal-oriented content in messages. Text messages included achievable goals and an encouraging tone were highly favoured by patients and created a sense of accomplishment.

### 3.6.1.2 Thematic category 2: Message delivery

**Tailoring message timing and frequency:** Across the studies (n=8), patients' preferences and needs were quite heterogeneous on message delivery timing and frequency. Some patients suggested specific delivery time, such as "dinner time" (Chen et al., 2018, p. 51), and some felt that the timing of the message delivery could be tailored based on their specific needs (Burner et al., 2014, p. 5). For some patients, "daily messaging" is needed (Nelson et al., 2017, p. 14), and for some, "2-3 times messaging per week" would be sufficient (Chen et al., 2018, p.51).

**Interactivity:** Four studies provided rich data on patients' preference for a feedback mechanism and interactivity in messages. However, Mayberry and colleagues (2016) also found that a small number of patients enjoyed having no obligation to reply during their participation in the program.

**Human contact:** The delivery format of text messages was covered in two studies that provided limited data. Some patients felt that having human contact would increase their motivation for participating in the text messaging program. An important point about message format arguments was that physicians or doctors are not necessarily expected to deliver the messages. Patients' preferences for message delivery, whether automated or not, seem to be more influenced by tailored message content. If impersonal message content is being delivered, patients may not particularly seek personal interaction.

### 3.6.1.3 Thematic category 3: Message usefulness

**Emotionally supported:** There were rich data about the emotional benefits of text messaging interventions across the studies (n=8). The studies indicated that patients felt as if they were supported in-person and had people around who did care about them. Nundy and colleagues (2013) found that patients described text messages as a “ friend,” and text messaging was replacing the role of caregivers and “reducing the burden” on caregivers. Text messaging helped patients to be more comfortable talking with others about their conditions.

**Increased self-awareness and control:** Seven studies reported increased patients’ awareness of diabetes management through text messaging interventions/programs. The studies concluded that text messages increased patients’ control over their condition and helped them stay on track.

**Improved overall diabetes management:** To a greater extent, patients found the interventions/programs very useful and appropriate to their life. Seven studies provided rich data on the improvement of diabetes self-management and related tasks. In only one study (Horner et al., 2017), some patients had technical difficulties arising from the program itself.

**Effective reminder:** Across the studies (n=10), one of the most important aspects of the interventions/programs was reminder messages. Patients found reminders very encouraging and useful for medication adherence.

**Improved communication with family/doctors:** Five studies reported increased communication of patients with their family members or doctors through text messaging. Georgsson and Staggers (2017) also found that patients felt more comfortable talking with their doctors as they were able to show their data and measurements accurately via text messaging.

### 3.6.2 Domain 2: Perceptions of text messaging

**Convenient and accessible:** In three studies, text messaging was perceived mainly as a convenient and accessible tool. Patients found text messaging highly compatible with their lifestyles.

**Ability to store and review information:** Five studies reported that patients, to a greater extent, welcomed the opportunity presented by text messages to store and review messages and medical information.

**Informational/educational tool and a reminder:** In two studies, text messaging was evaluated as an informational and/or educational tool, which can also be used to remind medications.

### 3.6.3 Domain 3: Experiences with diabetes management

**Forgetfulness in taking/refiling medications:** Four studies with rich data reported patients' forgetfulness to adhere to diabetes medication.

**Lack of knowledge of diabetes symptoms & complications:** Two studies with moderate data concluded that patients had a lack of knowledge of diabetes symptoms and complications. Chen and colleagues (2018) reported that "*The vast majority of patients ...knew only a few clinical symptoms of T2DM, such as frequent urination and increased thirst and hunger, and they usually misunderstood some common complications, such as diabetic foot and vision disorders, to be the side effects of taking hypoglycemic medications.*" (p. 49). Some patients realized how serious is the disease of diabetes after participated in the text messaging program/intervention.

**Table 3.2. The findings of the synthesis with the high and moderate level of confidence**

<b>Domains and Categories</b>	<b>Descriptions and Illustrative Quotes</b>	<b>Overall CERQual Assessment of Confidence</b>
<b>1. Perspectives on interventions/programs</b>	Having positive or negative views about text messaging interventions/programs	
<b>Message Content</b>	Having positive/negative interpretations about the subject and design of text messages	
Tailoring & personalization	Enjoying messages that are personally relevant and addressing the specific needs and expectations <i>“I could tell they were tailored for me because they mentioned the medications I am on. Made me more likely to take them”</i> [(Gatwood <i>et al.</i> , 2015), p.7]	High confidence
Message variability	Enjoying more variation in messages <i>“I wanted more variation in messages and sometimes get messages not only [intended] for barriers.”</i> ..... <i>“Tips on nutrition and other ways to manage diabetes would be helpful”</i> [(Nelson <i>et al.</i> , 2017), p.13]	High confidence
Informative/educational content	Enjoying the information and knowledge provided by the messages <i>“There are tips that come up... always nice...any form of education on diabetes and management of that is helpful”</i> [(Georgsson and Staggers, 2017), p.126]	High confidence
Simple and easy to read	Enjoying the simplicity and easiness of the messages <i>“I liked reading them. They were short, so it was not like I spent a lot of time reading them”</i> [(Mayberry <i>et al.</i> , 2016), p. 6]	High confidence
Goal-oriented messages with attainable goals	Enjoying messages that call for an achievable action <i>“I don’t want to start feeling bad about anything I’m doing .... So, I want to set another goal and try to achieve it and then want to feel good about what I’m doing”</i> [(Mamykina <i>et al.</i> , 2016), p.132]	High confidence
Motivational content and feedback	Enjoying messages that are encouraging and providing feedback on progress <i>“When I’m having one of those days when you don’t want to when you get that message, .... It helps you get motivated. It makes you want to do it”</i> [(Bergner <i>et al.</i> , 2017), e.198]	High confidence
<b>Message Delivery</b>	<b>Having positive/negative interpretations about the delivery type, schedule, and format of text messages</b>	
Tailoring message timing and frequency	Experiencing difficulties with standard message schedules and feeling comfortable with messages that are sent at specific time and frequencies based on personal needs and preferences	High confidence

	<i>"I think that as technology improves, we can also see on the Internet, putting the hours at which we have to take our pills so that it can tell us exactly at what hours we need to do that"</i> [(Burner et al., 2014), p. 5]	
Interactivity	Enjoying interactive messages and feeling bad about not responding <i>"You should be able to voice your opinion, which you can't answer them back when they send you a message. That they should let you do."</i> [(Horner et al., 2017), p. 5]	High confidence
Human contact	Enjoying messages that are delivered in-person compared to autonomous messages <i>"I would not like [a system without a text administrator]. If nobody is going to check the program, especially if you make it a more responsive program, then why am I responding?"</i> [(Nundy et al., 2013), p. 129]	Moderate confidence
<b>Message Usefulness</b>	<b>Having positive/negative interpretations of the effectiveness of text messaging interventions/programs</b>	
Emotionally supported	Experiencing that messages provide emotional support, like a "friend" or a "caregiver." <i>"It felt good...because I knew that someone was worrying about my health"</i> [(Watterson et al., 2018), p. 11]	High confidence
Increased self-awareness and control	Experiencing that messages enhance awareness about diabetes condition and improve its control <i>"I learned a little bit more about me. Because prior to the study, I did not take my blood sugar often, therefore, I didn't know when my sugar was high or low, but now I do."</i> [(Nundy et al., 2013), p.127]	High confidence
Improved overall diabetes management	Ability to manage diabetes-specific tasks more successfully <i>"I am living well with this program. It has helped me enormously, enormously... I come because it's worked for me."</i> [(Burner et al., 2014), p. 3]	High confidence
Useful reminder	Experiencing that reminder messages help to keep on track <i>"The medicine reminders are great. I sometimes forget to take my meds. I also learned when to check my blood"</i> [(Georgsson and Stagers, 2017), p.127]	High confidence
Improved communication with family members/friends and doctors	Experiencing that messages help increase the sharing with family members, friends, and doctors <i>"I thank you very much for this, the messages, because that's how my husband would communicate with me. Let me tell you, he and I did not have a good relationship. But now, he is my support"</i> [(Burner et al., 2018), p. 45]	High confidence
<b>2. Perceptions of text messaging</b>	<b>Being aware of the benefits and challenges of text messaging for diabetes</b>	
Convenient and accessible	Finding text messaging compatible with lifestyle and easy to reach	High confidence

	<i>"People use their phones every day, and they're used to texts...I think it's become part of regular life and routine now, so I think ....a good way to use technology to help people out"</i> [(Bergner et al., 2017), p. e199]	
Ability to store and review information	Being able to save and reexamine personal and medical data <i>"Everything's saved for you; it is wonderful...you just print and go or even export to some drive or whatever...or even email it to your doctor"</i> [(Georgsson and Staggers, 2017), p.127]	High confidence
Informational/educational tool and a reminder	Ability to learn and recall through informational/educational and reminder messages <i>"this novel strategy could be a useful, informative, educational, and a mindful tool. We are certainly willing to accept this way because it will provide us with lots of knowledge about this disease and be of great benefit to our adherence."</i> [(Chen et al., 2018), p. 50].	Moderate confidence
<b>3. Experiences with diabetes management</b>	<b>Having some insight into the self-management of diabetes</b>	
Forgetfulness in taking/refiling medications	Being forgetful about adhering to medication <i>"I was very forgetful about taking my medication; I wasn't taking it in a timely manner"</i> [(Nundy et al., 2013), p. 128]	High confidence
Lack of knowledge of diabetes symptoms & complications	Being unaware of the seriousness of diabetes, its symptoms, and consequences <i>"I really don't know it is a chronic disease. The reason why I am suffering from this disease is that I reached the age of sickness"</i> [(Chen et al., 2018), p. 49]	Moderate confidence

### 3.7 Discussion

This study provided an in-depth analysis of the qualitative studies focused on Type 2 diabetes management via mobile text messaging and summarized key concepts that were identified across studies. Although a significant number of reviews and meta-analyses (i.e., Hall et al., 2015; Arambepola et al., 2016; Dobson et al., 2017; Farmer et al., 2015; Sahin et al., 2019) have been conducted in this area, there was limited knowledge about the experiences of patients with these interventions/programs. To our knowledge, this is the first qualitative systematic review and meta-synthesis in this area providing qualitative evidence on the optimal interventional and methodological characteristics that should encourage patients' acceptance and behaviour change.

The sample of the included studies (n=14) was heterogeneous enough to provide a broad perspective on different phases of text messaging programs/interventions, such as design, implementation, and post-intervention. To a large extent, the included studies used mixed methods designs and have had high methodological quality.

Contrary to the previous systematic reviews of *quantitative* studies (i.e., Hall et al., 2015, Arambepola et al., 2016; Dobson et al., 2017; Sahin et al., 2019), this review identified extensive use of theoretical frameworks. All the studies except one relied on at least one theoretical framework, and some studies used triangulation of multiple theories. Although there has been increasing recognition for using new and dynamic approaches in mHealth-based interventions (Spruijt-Metz et al., 2015; Davis et al., 2015), the studies mainly relied on traditional behavioural theories (e.g., Social Cognition Theory, Health Belief Model, Transtheoretical Model).

The interventions demonstrated various forms of tailoring in their message content and delivery. The majority of the interventions applied *personalization* by using patients' names,

ages, their cultural/ethnic status, and by delivering messages based on their preferred time and frequency. The interventions often sent feedback messages to participants about their physical or psychological states and behaviours. *Feedback* is an important type of tailoring which may increase self-monitoring abilities of patients and satisfy some emotional needs such as “feeling acknowledged” or “feeling understood” (Noar & Harrington, 2016). The included studies also demonstrated the advanced use of tailoring, which is called “*content matching*,” referring to the use of theoretical constructs to match personal needs, goals, and interests of receivers (Dijkstra, 2016). The majority of the studies tailored their messages based on patients’ knowledge gaps or stated barriers (e.g., medication education), areas of difficulty (i.e., diet), their stage of behaviour change (e.g., increasing intention to change the behaviour) or their health beliefs (e.g., perceived susceptibility).

Tailoring message content and delivery was the central argument of the thematic synthesis and seemed to influence the other categories. Our findings provided support to the previous research (Militello et al., 2012; Head et al., 2013; Lustria et al., 2013; Krebs et al., 2011) that using patients’ name in messages and preparing and sending the messages based on their specific characteristics (e.g., years of experience with diabetes, age, education level, stage of behaviour change), and their preferred timing and frequency can enhance patients’ engagement with the interventions and induce behaviour change.

Patients request more customized content and message delivery as they are aware of that technology enables intervention/program developers to send individualized messages. The findings underlined that informative/educational messages are equally preferred with the goal-oriented, motivational messages as long as both types of messages are personally relevant. For example, long term patients did not want to receive basic informative messages about diabetes. In their qualitative study; Pal and colleagues (2018) identified a wide range of educational

expectations of patients. Therefore, educational content needs to be tailored to patients' knowledge levels, areas of difficulty, and interests. These are important implications for diabetes educators, and research should focus more on providing text messaging support for different educational needs and expectations of patients.

Determining an optimal level of frequency is a hard task because too many messages may create boredom (Gatwood et al., 2015), and fewer messages may not be enough to create knowledge retention (Chen et al., 2018). Therefore, individualizing message doses and providing patients with more control over texting frequency and timing can increase their involvement in text messaging interventions.

The findings also indicated that patients' preference for message delivery is conditional. Patients may not seek personal contact if there is standard, generic information to be delivered automatically to everyone. In the case of individualized messages, they look for a human-contact to deliver the information. This personal contact may not necessarily be a physician or doctor; patients seem to be open to receive messages from any experts as long as they provide accurate information. These are essential insights for the effective delivery of text messages in which there is limited information available about the patients' perspectives (Farmer et al., 2015). The findings also support the previous research on tailored text messaging interventions (Sahin et al., 2019), which revealed that nonautomated messages could be more effective than automated messages for glycemic control.

Increasing message variability was another important point identified in the synthesis. Even in the interventions focused on a single diabetes self-management behaviour (e.g., medication adherence), patients preferred to receive messages on other aspects of diabetes self-management such as diet, physical activity, and stress management. For each type of behaviour, patients also wanted to have a variety of messages to avoid boredom. The findings support the

previous research (Nundy et al., 2014) that comprehensive text messaging programs/interventions providing rich information on overall diabetes management could be more useful for behaviour change.

Patients had significant improvements in the management of diabetes after the text messaging interventions/programs. One of the remarkable benefits of the text messaging interventions/programs was their ability to increase the attention of patients to their “self.” Reminders, the ability to store and review medical information and personal data, informative/educational and motivational messages and feedback enhanced patients’ involvement in their condition, helped them to stay on track while also increased their risk perception about diabetes complications. In general, patients perceived text messaging as a convenient and accessible intervention tool for diabetes self-management. Text messaging was perceived to be easily integrated into patients’ everyday routines with diabetes. These results provided support to previous research addressing the benefits of text messaging for health promotion and chronic disease management (Shaw & Bosworth, 2014; de Jongh et al., 2012; Fjeldsoe et al., 2009; Hall et al., 2015).

Another significant effect of the interventions/programs was their emotional support to patients. Text messaging played the role of a “caregiver” and was positioned as a “caring friend” by some patients. Because patients felt “supported” during the interventions/programs, their control over diabetes, and confidence in its management increased. Compared to traditional self-management programs, which often include standardized content and inadequate social support (Kim and Seo, 2014; Spruijt-Metz et al., 2015), text messaging interventions seem to be capable of addressing patients’ need for emotional and social support.

Mobile text messages also helped patients to strengthen their relationship and communication with their family and friends and reduced the burden on their caregivers. Patients

improved their communication with physicians or doctors because they have had increased awareness and knowledge about diabetes, and they were better prepared for discussing their conditions during their appointments.

There were some limitations to the study that should be noted. We included only the English written research articles because our main focus was to analyze the message content of the studies. We included all the studies returned from the comprehensive search, but almost all of them were from the United States. Although some of these studies focused on low-income patients and minority groups (e.g., Latin-Americans), they were conducted in a high-income setting. They may not represent the patients living in other regions or other income settings.

### **3.8 Implications for Future Research**

The findings of this meta-synthesis provide important implications to develop more effective self-management interventions or programs. Future interventions should consider patients' preferences for tailoring message content and delivery and their expectations for social support. Particularly, there is a strong need for customization of diabetes self-management education to the needs and expectations of patients.

Designing effective text messages is a delicate task because of the limited space and creative opportunities in text messaging platforms. Behavioural theories can present a general frame for message design (what will be the message about?). Still, there is a need for communication or persuasion theories to guide message design and structure (how the message will be arranged?) that will be relevant and persuasive to a specific target group (Cappella, 2006). In general, patients with Type 2 diabetes prefer messages to be simple and easy to read, yet attractive enough to avoid boredom. The fatigue factor in text messages is an important concern and relates to both message content and delivery. O'Keefe (2015) suggests using evidence-based

message strategies to increase the persuasiveness of health interventions. Adopting appropriate message-specific elements for a target audience such as message framing (gain or loss framing), message appeal (e.g., fear, guilt, humour), message evidence (e.g., statistical evidence, testimonial evidence) or message tone (e.g., empathetic) can help increase the effectiveness of text messages and facilitate behaviour change (Pollard et al., 2016; Shen & Bigsby, 2013; Edgar & Volkman, 2012).

It would also be useful if future studies address the effects of different patient characteristics on their attitudes toward text messaging interventions. For example, age, gender, educational level, and time since diagnosed with diabetes could be important variables influencing the self-management of diabetes and text messaging-related attitudes.

The included studies lasted a maximum of six months so that there is a need for longitudinal studies to provide more insights about changing needs and preferences of patients in the long run. This review also highlighted the need for assessing the challenges for patients to adopt and maintain the use of text messaging for Type 2 diabetes management. Although there were a few barriers mentioned about the use of text messaging for Type 2 diabetes management, such as poor eyesight, poor educational level, use of medical jargon (Chen et al., 2018), these findings should be confirmed by more studies.

### **3.9 Conclusions**

Mobile text messaging interventions/programs were able to increase patients' self-awareness, knowledge and control of diabetes. Mobile text messaging created a sense of "feeling supported" in patients, strengthened their communication with family/friends and care providers, and positively changed their habits towards medication adherence and diabetes regimen. Patients highly valued the tailored message content and message delivery that explicitly addressed to their

needs and preferences. To a greater extent, patients had highly positive experiences with text messaging interventions/programs and perceived them as an integral element of their life with diabetes.

## Chapter 4: A Qualitative Study on Text Messaging Preferences of Patients With Type 2 Diabetes: A Social Marketing Perspective

### 4.1 Abstract

**Background:** The increasing prevalence of Type 2 diabetes worldwide requires taking more effective actions to improve the self-management knowledge and skills of patients. Text messaging studies on type 2 diabetes management have largely focused on behavioural theories when designing their message content. However, some well-known message design approaches can provide a useful guide to transforming the abstract knowledge gained about attitudes, beliefs, and behaviours into solid communication messages that will stimulate behaviour change.

**Objectives:** This study aimed to explore insights about the perspectives of patients with type 2 diabetes using text messaging and their preferences for message design and delivery features.

**Methodology:** Using a social marketing framework, a qualitative methodology was implemented. Semi-structured interviews were conducted either in-person or online with adult patients. Participants' preferences on several message design approaches such as message framing, tone, tailoring strategies, evidence, and format were asked by showing them different message dyads. Preferred message time, frequency and format (autonomous or in-person) were also assessed. Thematic analysis was performed for coding, categorizing, and interpreting the qualitative data.

**Findings:** Data saturation was achieved at the 12<sup>th</sup> interview [range 40-71 years old; male (58%), have type 2 diabetes for nearly 3.9 years on average]. Participants provided insights into a possible marketing mix (4Ps) for effective text messaging interventions on type 2 diabetes self-management. As a *Product*, using text messaging for type 2 diabetes self-management was

perceived positively and compatible with patients' lifestyles. Text messaging-based programs seemed to have some relative advantages for patients, such as being a convenient source of information and emotional support, and their exchange value, the *Price* seemed to rely on their timely nature. The most appropriate *Place* could be providing an individualized schedule of message delivery based on patients' specific needs and expectations. Automated and nonautomated messages were both favourable if they contained only personally relevant and accurate information. *Promotion* could be more effective if gain-framed messages were used, and the messages included an authoritarian tone, a standard format, and provided statistical evidence. Psychosocial and behavioural tailoring were preferred more than a personalization strategy; however, patients tended to like both types of tailoring strategies in text messages.

**Conclusions:** Text messaging appears to be a convenient and acceptable method for sending health behaviour change messages for individuals with Type 2 diabetes, especially when the message content is tailored based on their preferred message design elements. Future research needs to test the effectiveness of patients' message preferences on their self-management behaviours and explore what other text message design elements can influence type 2 diabetes management.

**Keywords:** Text messaging, diabetes mellitus-Type 2, social marketing, qualitative methodology.

## 4.2 Introduction

Increasing prevalence of type 2 diabetes in the world (International Diabetes Federation, 2017), combined with the insufficient traditional diabetes self-management programs (Sherifali et al., 2018; Spruijt-Metz et al., 2014) highlights a need for more effective behaviour change and communication strategies to facilitate change in patients. Mobile text messaging has increasingly been identified as an effective intervention method when used in type 2 diabetes self-management (Head et al., 2013; Arambepola et al., 2016; Sahin et al., 2013). Recent reviews revealed that text messaging interventions to date had used behaviour change theories to design intervention messages for type 2 diabetes management. Unfortunately, understanding the psychological process of behaviour change does not necessarily lead to effective health communication messages. Furthermore, message design communication frameworks and concepts that affect message design considerations, such as message framing, tone, evidence, have not been used (Sahin et al., 2019; Sahin et al., 2020). A theory of message design can provide a useful guide to transforming the abstract knowledge gained about attitudes, beliefs, and behaviours into solid communication messages that will stimulate behaviour change (Cappella, 2006; Cho, 2012). Using the message design elements such as message frame, tone, evidence, and format can stimulate behaviour change by increasing receivers' message involvement, message receptivity, and message retention (O'Keefe, 2002; Noar et al., 2007; Shen, 2013; Muench et al., 2014).

Although crafting effective message content and structure becomes more critical in mobile text messaging due to limited character space and design options, little is known about designing persuasive text messages. Suffoletto (2016) reported that goal-oriented messages that are fully or partially capitalized and/or used multiple punctuation marks were highly preferable in

SMS-driven interventions. Also, less educated users favoured emoticons more compared to educated users. A survey of SMS user preferences (Muench et al., 2014) revealed that accurate spelling and grammar, and polite, positive messages were more favoured.

The effectiveness of tailoring on intervention effectiveness have been reported in different health contexts (i.e., Kreuter, Strecher, & Glassman, 1999; Kreuter & Wray, 2003; Krebs, Prochaska, & Rossi, 2010; Noar, Harrington, & Aldrich, 2009; Hall., et al., 2015; Hood et al., 2016, Sahin et al., 2019). Specifically, tailored and personalized content was the most effective component of text messaging interventions for health promotion (Head et al., 2013; Militello et al., 2012; Armanasco et al., 2017). The text messaging interventions targeted young people and children were more successful if they were using personalized messages (i.e., using the child's name), using informal SMS content and textese (i.e., ur goal is 2 eat less sugary things 2 get ur blood down!) (Militello et al., 2012). Text messaging interventions for Type 2 diabetes management have used various tailoring strategies for message delivery and design (Sahin et al., 2019). Rather than providing a broad and standard self-management program, tailoring messaging and message delivery for specific sub-groups and specific contexts could be more useful for individual behaviour change and behaviour maintenance. However, we still need more explanations on how patients respond to different types of tailoring strategies, especially in a text messaging context (Morrison, 2015; Noar & Harrington, 2016; Sahin et al., 2019). Pelletier and Sharp (2008) suggested that tailored messages addressing personal preferences might not be sufficient to induce behaviour change; addressing “the way” the message communicates with the target group could be more effective.

Moreover, patients with type 2 diabetes seem to be highly sensitive about the words contained in messages, such as “diabetic,” “fat,” “obese,” and “poorly controlled” (Dickinson & Maryniuk, 2017); therefore, they might have particular message preferences in text messaging.

Previous research has also provided little information about patients' perspectives on automated messages (Farmer et al., 2015; Sahin et al., 2019; Sahin et al., 2020), and there was ambiguity on effective text message delivery schedules (Farmer et al., 2015, Arambepola et al., 2017; Sahin et al., 2019). Therefore, this study aimed to increase the understanding of how to design more effective self-management interventions via text messaging by investigating patients' perspectives on using text messaging and their preferences for message design and delivery features. Specifically, the primary objective of the study was to explore which type of message framing, message tailoring, message evidence, message tone, and message format were preferred by patients. A secondary objective was to identify preferred message timing, frequency and format (automated vs. nonautomated) for patients with type 2 diabetes.

#### **4.3 Social Marketing Framework and Research Questions**

The social marketing framework brings a “consumer-oriented” approach, where the primary focus is identifying and satisfying consumer wants, needs, and preferences (Mattson & Basu, 2010). Successful social marketing interventions focus on behaviour change, segment the target audience and tailor messages, and use all four traditional marketing mix elements together: product, price, place, and promotion (Andreasen, 2002; Serrat, 2017).

*Product* refers to consumers' expected behaviour after social marketing activities (French & Gordon, 2015). In our study, the “*product*” was the use of mobile text messaging for self-management of Type 2 diabetes. According to the social marketing approach, consumers are more likely to adopt the expected behaviours if the behaviours are relevant, possible, and achievable for them (LeFebvre, 2011). Patients' experiences about using mobile phones and mobile text messaging could ease their adoption of text messaging programs for Type 2 diabetes management. The accessibility of SMS technology can also increase the favourability of self-

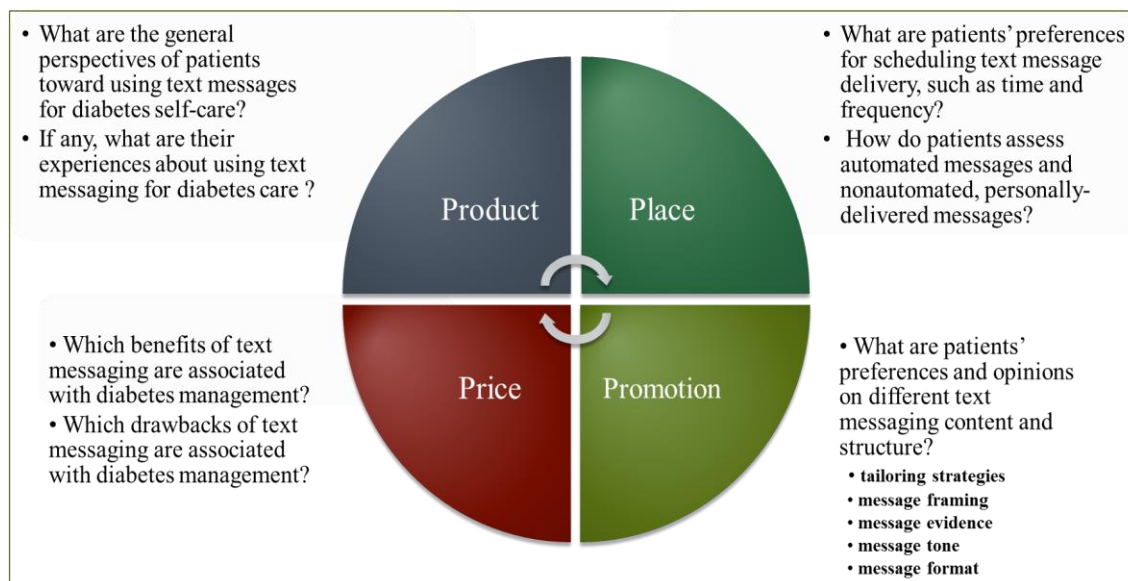
management programs implemented through text messaging.

**Price** refers to the exchange value associated with the product. Social marketing requires making cost and benefits analysis and comparisons with the product or service it supersedes (Mattson & Basu, 2010). Text messaging programs can provide important advantages compared to traditional and other self-management programs (e.g., online) in terms of reduced time and effort and increased convenience. There may also some drawbacks such as its cost, sending and receiving messages too frequently or message boredom.

**Place** involves decisions about increasing the availability of the product and the quality of service delivery to reach consumers more efficiently (French & Gordon, 2015; Mattson & Basu, 2010). The use of text messaging for type 2 diabetes management requires taking a series of decisions about message delivery schedules, such as message frequency, timing, and format (autonomous or in-person).

**Promotion** is defined as “*communication-persuasion strategy and tactics that will make the product familiar, acceptable, and even desirable to the audience*” (Kotler & Zaltman, 1971, p.7). Because promotion includes decisions about communicating what is being offered in the other marketing mix elements, it is the final stage and should follow the arrangements made for the others (Cheng, Kotler, & Lee., 2011). Andreasen (2002) suggested customizing activities and messages based on specific needs and wants of distinct groups in the target audience. Using relevant tailoring strategies and persuasive message design elements in text message content may create positive effects on patients’ self-management behaviour.

We derived our research questions to identify the possible marketing mix for effective text messaging strategies for patients with type 2 diabetes (Figure 4.1). For each marketing mix element, we decided to deepen our investigation to see if there are any differences in patients’ responses in terms of their age, gender, and time since diagnosed with type 2 diabetes.



**Figure 4.1. Identifying marketing mix for effective text messaging strategies for patients with type 2 diabetes**

## 4.4 Methodology

### 4.4.1 Text message development

Text message examples were developed based on the well-known communication - persuasion frameworks and concepts such as message framing (Rothmann et al., 2006), tailoring (Noar & Harrington, 2016; Dijkstra, 2016), and message design features (Shen, 2013) (Table 4.1). The medical information was obtained from the Diabetes Canada website (<https://www.diabetes.ca>) and the study of Brunetti & Kalabalik (2012). Text messages focused on blood sugar monitoring content, which is the only self-management behaviour appropriate for all patients regardless of their lifestyle, weight, diet or physical activity. An internal medicine physician (content expert) checked the content applicability, and an English language expert reviewed the messages based on their purposes (i.e. empathetic tone). A maximum of 160

characters was used to maintain short messaging characteristics. Text messages were tested to match the 6<sup>th</sup>-7<sup>th</sup> grade reading level based on the Automated Readability Index (Smith & Senter, 1967).

**Table 4.1. Definitions of message categories and text message examples**

Theoretical Frameworks /Message Design Elements	Type	Definition	Example
Message Framing (Rothmann et al., 2006)	Gain-Framed Messages	Messages that emphasize the benefits of performing a specific behaviour	By lowering your blood sugar level, you will reduce your risk of heart disease, stroke, kidney disease, eye problems, nerve damage, and foot problems.
	Loss-Framed Messages	Messages that emphasize the costs and consequences of not performing a specific behaviour	If you don't lower your blood sugar level, you will increase your risk of heart disease, stroke, kidney disease, eye problems, nerve damage, and foot problems.
Message Tone (Pollard et al., 2016)	Authoritarian Tone	Messages that include directives about what and what not to do with educational reasoning	Check your blood sugar regularly and share the results with your healthcare team to keep on track.
	Empathetic Tone	Messages that contain friendly suggestions about what and what not to do with a sympathetic approach	We understand it may be hard sometimes but checking your blood sugar regularly and sharing the results with your healthcare team can keep you on track.
Message Tailoring (Noar & Harrington, 2016; Dijkstra, 2016; Health Belief Model-Jan & Becker, 1984)	Personalization	A basic level of tailoring that aims to increase attention to the message by using the name or other identifiers of the receiver. It is not explicitly related to the content of the message, instead aims to frame the information to create a sense of meaning in the audience as if the message is specially designed for them	Hello ..., regular monitoring of blood sugar helps you to track the foods and drinks that may not be good for you.
	Psychosocial & Behavioural Tailoring	An advanced level of tailoring that includes providing descriptive,	Hello ..., your blood sugar seems to fluctuate this week. Please check your

		comparative, and evaluative feedback messages to participants about their psychological and behavioural states and using key theoretical constructs to match personal needs, goals, and interests of the participants	blood sugar about 2 hours after your meals and keep track of your responses.
Message Evidence (Shen, 2013; Shen & Bigsby, 2013)	Statistical Evidence	Messages that present statistics (e.g., percentages, figures, rates) to support the claim	For every 1% reduction in blood sugar level, the risk of nerve damage (i.e. foot ulcer) in your body is reduced by 33% to 37%.
	Testimonial Evidence	Messages that use one's personal experience or opinion to support the claim (e.g., expert opinion).	Doctors/ Diabetes Canada suggests that by reducing your blood sugar level, you can also reduce the risk of nerve damage (i.e. foot ulcer) in your body.
Message Format <a href="https://www.opentextingonline.com/textspeak.aspx">https://www.opentextingonline.com/textspeak.aspx</a>	Standard Format	Usual text messages that do not use any spelling abbreviations	Please don't forget, you need to check your blood sugar before breakfast. Take care!
	Textese	Messages that use SMS language and the widely known spelling abbreviations	Pls dnt 4get, u need 2 chek ur blood sugar be4 breakfast, tc!

#### 4.4.2 Study design and sampling

A qualitative research design with purposive sampling was used in the study. Participants were English-speaking adults (19 years old or older) with Type 2 diabetes who were using mobile phones and SMS text messages. Multiple recruitment strategies were employed. Posters and flyers were placed in public places in Victoria, BC, Canada, where patients were most likely to visit, such as the Diabetes Education Centre, recreation and community centres, wellness and healthcare centres, and university buildings. Health clinics (i.e. Revive, UVIC Health Services) were also contacted to refer their patients to the study. Type 2 diabetes-related Facebook groups and online platforms, and the Facebook pages of diabetes associations of English-speaking

countries (i.e. UK, Ireland, Scotland, Australia, Singapore, Malta, India) were contacted to reach potential participants for the study.

#### **4.4.3 Data collection**

The study received the Human Research Ethics Board approval (REB number: H19-00598) from the University of Victoria and Island Health Authority (Appendix XVI). Written informed consent was obtained from the participants. We conducted one-on-one interviews either in-person in a convenient public place for participants (i.e. public library) or online through Facebook Messenger and Skype video calling platforms. The interviews were conducted from June to November 2019, and the interview sessions lasted approximately 25-45 minutes. All interviews were audio-recorded using a handheld recording device and transcribed verbatim. The researcher also took notes during the interviews. At the end of the interview, participants received compensation (\$10 CAD) for their participation.

A semi-structured interview guide (Table 4.2) was developed based on the social marketing framework and used to address the research questions. In the first part of the interview, participants' demographic information (age, gender identity, and time since diagnosed) was collected, and their opinions and experiences about using mobile text messages were explored. In the second part of the interview, participants were asked to evaluate the message dyads and indicate their preferences. Participants viewed a picture of a mobile phone with a sample message and were asked to share their opinions on message content, style, wording, and language. In the last portion of the interview, participants were asked about their preferred delivery methods of text messaging in terms of frequency, timing, and message delivery format (automated vs non-automated).

**Table 4.2. Semi-structured interview guide**

I am conducting this interview to learn your opinions about text messages to be used for Type 2 diabetes management. I would like to remind you that there are no right or wrong answers in this interview, so please feel free and share your opinions about text messaging and message examples.
1. How long have you been using SMS texting?
2. How often do you use SMS texting? Daily, weekly?
3. How old are you?
4. How long ago have you been diagnosed with Type 2 diabetes?
5. How do you identify your gender?
6. What do you think about delivering diabetes-related messages through text messaging?
7. Do you think text messaging may offer benefits for diabetes management? Please tell me more.
8. Do you think there are drawbacks to using text messaging for diabetes management? Please tell me more.
9. Have you ever participated in a text messaging-based diabetes care program?
10. What do you think about this message (e.g., gain-framed messages)?
11. Could you tell me what this message is about?
12. What do you think about the information is being delivered?
13. What do you think about the expression, use of language and the words provided here?
14. Would you change any of them? Would you like to add /remove any word? Why?
15. What would be your suggestions?
16. (after showing the other message of the dyad) Which message do you prefer most?
17. Which one do you think works for you? Why is it so?
18. Was there anything you especially liked/disliked about the messages? Why?
19. What would be your preferred time in a day for receiving diabetes care messages if you were to participate in a text program? Why?
20. How often would you like to receive text messages? Multiple times a day, once in every day, 4-5 days in a week, once in a week, bi-weekly or once in a month? Why?
21. Now, I would like to learn your opinions on automated text messages. Automated text messages, also known as scheduled text messages, are SMS messages that you write in advance and schedule to send automatically to your contacts. What do you think about receiving automated messages?
22. Do you make a difference between automated and non-automated, personally-delivered messages- like the ones come from a researcher, a dietitian or a physician?
23. Do you think some diabetes care messages can be autonomous? Which ones could they be?
24. What would be your suggestions to improve automated messages?
25. What would be your final remarks to create more effective diabetes care messages?

#### **4.4.4 Data analysis**

A thematic analysis was implemented to explore themes and interpret findings based on the guideline provided by Braun and Clarke (2006). Consistent with the a priori theoretical framework and research objectives, we used a list of concepts and themes for coding (e.g., text messaging use, message frequency, message framing). Using Atlas.ti 8.3 qualitative data analysis software ([www.atlasti.com](http://www.atlasti.com)), transcripts were coded by line-by-line coding to characterize the content of each line or sentence. Then, the codes were examined and grouped according to their similarities and differences, and recurrent themes were identified. In addition to a priori themes, the transcripts were reviewed for any emergent themes. The number of participants providing a quote within a theme was counted to demonstrate the common themes across the participants' responses. Relevant themes were further categorized under a priori thematic category derived from the theoretical approach (e.g., product, price, promotion). At last, for each hierarchical tree structure, a domain name was created.

#### **4.5 Findings**

The study achieved data saturation at the 12<sup>th</sup> interview such that no new themes emerged, and preferences for message dyads became distinctive. The sample included five female and seven male participants aged between 40 to 71 years (mean age 55 years). Half of the participants were newly diagnosed with Type 2 diabetes (for less than two years) (Table 4.3). The participants have been using text messaging for more than five years and not participated in a text messaging program related to diabetes before. For the majority of participants, text messaging was an essential way of daily communication.

**Table 4.3 Participant characteristics**

	<u>N= 12 N (%)</u>
Male	7 (58.3)
Female	5 (41.7)
Age (years)	
< 55 (40-51)	6 (50)
55 and older (55-71)	6 (50)
Time since diagnose (years)	
< 2	6 (50)
2 +	6 (50)

Thematic analysis generated three broad domains where the related thematic categories were grouped into 1. Perspectives on Using Text Messaging for Diabetes Care, 2. Preferred Schedule for Text Message Delivery, 3. Preferred Text Message Design (Table 4.4). The findings were further examined based on participants' demographic characteristics (gender, age, and time since diagnosis). Those that generated notable differences were explained in the following sections.

#### **4.5.1 Domain 1. Perspectives on using text messaging for type 2 diabetes self-management**

Patients' perspectives on using text messaging for diabetes care were grouped under the "Product" and "Price" thematic categories.

##### **4.5.1.1 "Product" thematic category: Using text messaging for type 2 diabetes self-management**

All participants affirmed that the idea of using text messaging for diabetes self-care was exciting, and they were highly positive about receiving diabetes-related text messages.

Participants emphasized the importance of accessibility of mobile text messaging. For example,

one participant expressed, *“It would be great because I always have my phone with me. It’s the fastest way to communicate, you know, you can check messages anytime”* (Participant #2).

#### **4.5.1.2 “Price” thematic category: Perceived benefits and drawbacks of using text messaging for type 2 diabetes management**

##### **Perceived benefits**

Almost all participants emphasized that text messaging is convenient and can serve as a useful reminder to take medications and follow treatment plans such as diet plans or daily physical activity tasks. They also stated that mobile text messaging could be an efficient way to reach information and gain knowledge about diabetes, as one participant expressed, *“I think those reminders are really beneficial. Information could be another benefit, I guess, you know like new research, ways of coping. I think it’s a good reminder to people how not to say that a little exercise but how what a little exercise will do to help your numbers”* (Participant #6). Mainly, the participants who have been newly diagnosed with diabetes suggested that text messaging programs could be particularly beneficial to educate new patients. Two participants highlighted that using SMS text messaging could be more convenient and comfortable than email messaging to reach the information. Half of the participants indicated that text messaging programs could be encouraging and supportive in controlling diabetes.

##### **Perceived drawbacks**

Several participants highlighted that a high frequency of delivering messages (multiple times a day) and delivering the same messages repetitively could result in a loss of interest and message fatigue. For example, one participant expressed, *“If I keep reading the same message every day, then I’m going to disregard it... I like to have a mix of messages”* (Participant# 3).

Some participants emphasized the limited capacity of SMS texting (160 characters) as a disadvantage to deliver adequate information, which can lead to misunderstandings in patients.

Text message readability was also mentioned by some participants as a barrier to patients who have older model phones and could not navigate easily. Several participants expressed their discomfort with the text messages that are sent randomly (inappropriate times). Also, the cost of text messages was seen by some participants as a disadvantage if messages exceed the limits of mobile phone text plans.

#### **4.5.2 Domain 2. Preferred schedule for message delivery**

##### **4.5.2.1 “Place” thematic category: Preferred delivery schedule of text messages for type 2 diabetes management**

The participants stated quite different hours and frequencies to receive text messages. Morning hours were the most often mentioned preferred hours, which were reported by five participants. Most participants were interested in receiving text messages infrequently; 1-2 messages a day, and 2-3 times in a week were the most often stated frequencies. Some participants suggested that text message scheduling should be customized to fit their complex treatment plans.

Almost all participants stated that receiving automated messages would be something they would expect in a text messaging program and would not create any adverse effects for them. Some participants emphasized that they understand the necessity of using automated text messages. For example, one participant explained, *“Well, sure everyone prefers personal messages, but it's not realistic, you know if they're coming from my doctor or my dietician and you know they have hundreds of clients and they're not going to sit there and write a personal message to me”* (Participant #4).

Most participants stated that it would not make a big difference for them whether the message is sent in-person or automatically as long as the message is accurate and relevant to their personal needs. They also did not indicate any preference for the sender of the messages, whether a doctor, nurse or dietician. For example, one participant emphasized, “*No, (the sender of the messages) doesn't matter, you know, the nurses at the diabetes education centre can be more knowledgeable than GPs*” (Participant #12).

### **4.5.3 Domain 3. Preferred text message design**

#### **4.5.3.1 “Promotion” thematic category: Preferred text message design for type 2 diabetes self-management**

Thematic analysis revealed an emergent theme “message content” in addition to our a priori message themes. The message content theme included participants’ suggestions for possible text message content for Type 2 diabetes management.

#### **Message framing**

**Almost all participants preferred the gain-framed message over the loss-framed one.** Participants explained that the gain-framed message was positive, encouraging, and direct, and these types of text messages would work better for them in the management of diabetes. On the other hand, they found the loss-framed message as threatening, scary, complicated, and like scolding and preferred not to have these types of messages. For example, one participant noted, “*I don't prefer this type of messages, you know “If you don't do that, you're going to be in big trouble,” that's threatening*” (Participant #4)

#### **Message tone**

Most participants preferred the message with an authoritarian tone. Participants perceived the message as simple, direct, and more suitable to text messaging rather than finding the tone

patronizing or commanding, *“It's fine. Nothing offensive, and it could very well be a great reminder for someone who hasn't checked their blood sugar in a few days”* (Participant #2). The participants who did not prefer the empathetic tone stated that the message was too long, insincere, and confusing. For example, one participant expressed, *“Well, they're trying to be a little more compassionate. This one is giving me an option. I mean, either have to check my blood sugar. Don't tell me well. ... Well, yeah. It's not just worthy... I don't want you to explain messages like that. Especially as this is a text message because you know, there's no room for nuance in a text message”* (Participant #4). Those participants who preferred the empathetic tone stated that the message is more friendly, understanding, and encouraging, whereas the message with an authoritarian tone was too general and distant. For example, one participant highlighted, *“It (authoritarian) is very generic. I like this one better (empathetic) It is a pain, it is really uncomfortable, it is a hassle to have it, and this one is understanding that and the importance of doing it”* (Participant #6).

### **Message evidence**

Almost all participants preferred the message providing statistical evidence over the message providing testimonial evidence. Participants explained that the information with statistics was much more convincing and trustworthy. For example, one participant (Participant #5) wanted to take a picture of the message because he thought that it was beneficial information and something to be remembered and studied.

The participants stated that the testimonial message was wordy, generic, and looked like a commentary. When asked their thoughts if the message would come from a well-known organization such as Diabetes Canada, the majority of the participants answered that they would prefer these messages rather than “doctors or research suggest” type of messages. However, they still indicated that their number one choice would be the one providing statistical information.

### **Message format**

All participants preferred the standard message format over textese. They commented that textese messages could be more suitable for young people and informal communication.

Participants expressed that the message in textese form was informal, unclear, and confusing.

They suggested using a universally-accepted format and keep a certain level of professionalism in text messaging programs, as one participant noted, *“I expect professional, formal messages from my doctor or nurse. If I get this (textese) type of message, it would be a waste of my time”*

(Participant #3).

### **Message tailoring**

The participants indicated that the message included psychosocial and behaviour tailoring was personally relevant, informative, goal-oriented, and helpful. Most of them affirmed that the primary goal of participating in a text messaging program would be to receive this type of message. For example, one participant commented, *“This is personally relevant, beneficial, this is I expect from a text messaging program that I would participate in”* (Participant #9).

On the other hand, participants noted that the message with personalization was generic and too simplistic. Some participants, mainly the female participants, emphasized that they like the use of greetings and names in text messages. Still, the majority of the participants stated that such personalization could create no effect on them, as one participant expressed, *“I don’t want my name to be used, and I don’t need “hello,” “take care,” “thank you’s.” I don’t have time for that. These are not sincere enough for me, just be direct”* (Participant #8). Participants also added that the message with personalization seemed like a typical message coming from a database so that it was not personal at all, even if it was using their names. Several participants preferred receiving both types of messages and suggested that informational or educational messages which might be generic in-nature could be conveyed in the form of personalization.

## Message content

Most participants recommended including smart tips, reminders, actionable messages, along with encouraging and informative information on diabetes management. They emphasized their preference for the new information, such as new research results or quick facts about diet and exercise. Some participants suggested that a text messaging program should have a wide scope to address different aspects of diabetes management such as healthy eating, exercise, stress management, even information about using herbals. Two participants also suggested adding links in text messages to websites or community groups to receive more information. For the improvement of text messages, some participants recommended using such creative hooks as “remember,” “did you know,” “research says,” “take care,” “you can do it,” when starting and ending text messages.

**Table 4.4. Summary of the findings**

<b>Domain 1. Perspectives on Using Text Messaging for Type 2 Diabetes</b>			
<b>“Product” Thematic Category: Using Text Messaging for Type 2 Diabetes Self-Management</b>			
<b>Themes</b>	<b>Definition</b>	<b>Quote</b>	<b>No. of Participants Mentioned the Theme</b>
Positive	Being open to receiving diabetes-related information via text messages	<i>“I think it’s great; it is a brilliant idea to use text messaging for diabetes support”</i> Participant #6	12
Accessibility	Consider that mobile text messages make it easy to reach information	<i>“It tights to your phone; you can check your message anytime”</i> Participant #3	10
<b>“Price” Thematic Category: Perceived Benefits and Drawbacks of Using Text Messaging for Type 2 Diabetes Self-Management</b>			
<b>Thematic Sub-Category: Perceived Benefits</b>			

Themes	Definition	Quote	No. of Participants Mentioned the Theme
Useful reminder	Text messages help patients to follow their treatment plans	<i>"The best use is as a reminder to medication, to blood sugar monitoring"</i> Participant #4	11
Educational	Gain knowledge of diabetes and its management	<i>"I believe it would be useful. I like to learn some information about diabetes, you know, medical point of view, new research, exercise, diet-related information. That sort of information. How to manage the disease, like that"</i> Participant #8	8
Motivational	Text messaging can be supportive in diabetes management	<i>"Text messages can be encouraging. You know, "you can do it!" type of messages, positive messages. I certainly like to have this type of message,"</i> Participant #2	6
Convenient	Perceiving text messaging fits well with diabetes management	<i>"It is timely. You can get the information very fast; you can ask some questions, response back. It is a very convenient way to reach patients"</i> Participant #1	11
<b>Thematic Sub-Category: Perceived Drawbacks</b>			
Themes	Definition	Quote	No. of Participants Mentioned the Theme
Message Wear-out	Receiving the same messages frequently	<i>"(It would be ) Receiving the exact same message day and night. If I am getting a particular message over and over again, it wouldn't resonate anymore, right?"</i> Participant# 2	7
Limited Information	Addresses the limited character/word capacity in SMS texting	<i>"Text messages are brief in-nature. So, the limited information provided here can be misunderstood or may not be very useful"</i> Participant #4	3
Challenges in reading text	Finding text messages difficult to read in especially older model phones due to small screens and layout	<i>"I have this phone (showing an older model phone), see it has a small screen, it is hard to read and follow the messages in these phones, you need smartphones for this type of program"</i> Participant #5	3
Inappropriate timing of message delivery	Receiving messages in an inconvenient time	<i>"It is disturbing to have notifications in an unwanted situation or in time, like in a meeting or early in the morning when trying to get up and go"</i> Participant #1	4

<b>Domain 2. Text Message Design</b>			
<b>“Promotion” Thematic Category: Preferred Text Message Design for Type 2 Diabetes Self-Management</b>			
<b>Themes</b>	<b>Definition</b>	<b>Quote</b>	<b>No. of Participants Mentioned the Theme</b>
Gain-Framed	Perceiving the message positive, encouraging, and direct	<i>“This is a good reminder. It is straightforward, not judgmental, like the other one (loss-framed). I definitely prefer this one, the other one (loss-framed) is little too alarming, almost as a scolding”</i> Participant #9	11
Authoritarian Tone	Perceiving the message direct and easy to read	<i>“This is a direct message, easy to follow, plain language. The other one (empathetic tone) is too complicated. You just want to be fast on the phone, this (empathetic) is too wordy, too much”</i> Participant #8	8
Statistical Evidence	Finding numerical information more persuasive, trustworthy and credible	<i>“I’m a numbers guy; this one works better for me. It is more convincing, gives you a fact, more motivational”</i> Participant # 1	11
Standard Format	Finding standard written text messages clear, understandable, and formal	<i>“It (textese format) is very unprofessional, informal. I don’t want to get this type of message, (this is) not clear for me. Maybe, I’m old-fashioned, but I want to see standard messages, usual messages. This (textese format) is too chatty”</i> Participant #10	12
Psychosocial & Behavioural Tailoring	Finding the message personally relevant, accountable, and supportive	<i>“Aha! This actually says something about my situation, monitoring my information, sending feedback. This supposed to be the use of text messaging”</i> Participant #4	12
Personalization	Finding the message generic and informative. Some perceived the use of greeting and name as a human-touch.	<i>“I love it when they use my name (in messages). It feels more personalized, like direct talks to me”</i> Participant #7	5
Preferred Content	A comprehensive, tailored text messaging content, including a variety of topics, smart tips, new research information.	<i>“This (diabetes) is a very personal thing. It is not only related to diet; stress is there, too. It would be good to have some practical tips on meal planning. I just need small tips on preparing healthier snacks, meals. I don’t want judgments, don’t eat this! kind of messages. I want to know how to cook potatoes in a healthy way, and how to handle stress, information about small exercises would be good.”</i> Participant #6	10
	Providing links to websites and community/peer groups,	<i>“It would be more useful if messages include links to some websites or videos</i>	2

		<i>that can provide more detailed information”</i> Participant #4	
	Using creative hooks	<i>It would be catchy if the message starts with “did you know” or “research suggests”</i> Participant #9	3
<b>Domain 3. Text Message Delivery</b>			
<b>“Place” Thematic Category: Preferred Text Message Delivery Schedule of in Type 2 Diabetes Self-Management</b>			
<b>Themes</b>	<b>Definition</b>	<b>Quote</b>	<b>No. of Participants Mentioned the Theme</b>
Preferred Time	Ranged from morning hours to before sleep	<i>“In the morning, before taking medicine, it would be useful as a reminder”</i> Participant # 12	-
Preferred Frequency	Ranged from multiple times a day to once a week	<i>“Twice in a week, one reminder, one informational maybe. I don’t have time for more than that”</i> Participant #8	-
Preferred Delivery Format	Favoured both automated and nonautomated messages if only they provide accurate and personally relevant information	<i>“I know there are too many people, so some messages have to be automatic. As long as they include something relevant to me, I don’t mind if they are automatic or not”</i> Participant #11	11

#### 4.6 Discussion

This qualitative study provided an analysis of specific characteristics of text messages that might influence behaviour change with a small purposive sample of patients with type 2 diabetes. Using message design approaches and communication frameworks has been one of the neglected issues in text messaging research, and the body of literature is scant in this area. Similarly, there were conflicting ideas in the preferred text message delivery schedules of patients. Therefore, the insights provided by this study may help to design more effective behaviour change interventions for patients with Type 2 diabetes.

The use of a patient-oriented approach helped us to identify a possible marketing mix to reach patients more effectively. As a “product,” using text messages for Type 2 diabetes self-management has positive associations in the minds of patients. The accessibility of SMS and

mobile technology was the most commonly mentioned product feature and interpreted as “effortless” and “continuous” support. These findings were consistent with the previous research, which suggested that mobile text messaging can increase the reach of digital interventions (Shaw & Bosworth, 2014; Michie, Yardley, West, Patrick, & Greaves, 2017). There are approximately 7.1 billion mobile phone users around the world (The International Telecommunication Union, 2017), and nearly 74% of them use SMS texting daily and check their messages frequently (Deloitte, 2017). Therefore, mobile text messaging seems to continue to be a significant medium for diabetes self-management and other health interventions.

For patients, the most important relative advantage of using text messaging for type 2 diabetes care seemed to rely on its timely nature. Considering the effort and time spent on participating in traditional self-management programs and the accessibility of online applications, text messaging programs can offer more convenience to patients. A significant barrier to text messaging programs was message wear-out. It was linked with both message content and message delivery. Text messaging could be more appealing for these patients if message variability increases. Consistent with the previous research (Nundy et al., 2012; Chen et al., 2018), our study revealed that patients were more likely to participate in a comprehensive text messaging program that would provide information on various subjects, from diet to exercise, stress management, and new research findings.

Our findings highlighted that text messages should also be delivered at selected times, not randomly. Patients’ preferences for text messaging delivery schedules were highly divergent, which indicated that patients should be able to set the delivery times. However, there was some consensus on receiving text messages infrequently. These findings were consistent with our previous study of meta-analysis (Sahin et al., 2019), which concluded that infrequent messaging could be more effective than frequent messaging for patients with Type 2 diabetes. In our meta-

analysis (Sahin et al., 2019), we also found that non-automated message delivery could be more effective than automated delivery. This study showed that patients might not necessarily require in-person message delivery. They seemed to be open to receiving automated messages as long as the content is accurate and relevant to their needs. These findings suggested designing more complex interventions for type 2 diabetes self-management in which tailoring message delivery and message content and structure would be a central consideration.

Patients were appeared to prefer gain-framed messages and found them direct and encouraging. The effect of message framing has widely been investigated in health interventions (Jang & Feng, 2017); however, a few studies examined its use in text messaging (Muench et al., 2014; Kuerbis, Mulliken, Muench, Moore, &, Gardner, 2017). As suggested by previous research (Rothman & Salovey, 1997; Jang & Feng, 2017), gain-framed messages could be more useful for prevention (low-risk) behaviours. Diabetes self-management involves taking a series of actions to decrease the threat of the disease; therefore, gain-framed text messages could be more useful to reach patients with type 2 diabetes.

Patients were appeared to prefer text messages that were written as simple, direct, easy to read, to-the-point as possible, and seemed not to mind whether it has a condescending tone or not. In their nutrition text messages, Pollard et al. (2016) found that some rational reasons exist behind the favourability of authoritative messages, such as being more direct and informative. Kuerbis et al. (2017) also suggested that older people tend to like directive text messages and consistently, in our study, the majority of the participants who preferred the authoritarian tone were older (> 55 years old). Text messaging seems to have its own voice and reshapes the message perceptions of users.

Our findings indicated that using statistical evidence in text messages can enhance message trustworthiness and credibility. Although the message did not include any source of

information such as the name of a university or a diabetes association, providing information using percentages and numbers was enough to create the desired effect in the target audience. Because some participants questioned the sources used in the messages, using expert testimonials in text messages might not be an effective strategy to reach patients with Type 2 diabetes. These findings provided valuable insights into the research, which has so far produced mixed evidence on whether testimonial or statistical evidence was more persuasive (Shen, 2013).

Previous research (Muench et al., 2014; Suffoletto, 2016) revealed that text message users tend to prefer accurately written messages over the messages with textese or grammatical errors. Patients with type 2 diabetes seemed to be no different in their preferences. Moreover, they were more likely to have specific requirements in message formats, such as keeping professionalism in language and word use.

The findings demonstrated that text messaging programs for type 2 diabetes self-management should include psychosocial and behavioural tailoring strategies, such as providing timely feedback and goal-oriented messages to maintain patients' participation. The personalization strategy in this study, which included greetings and using the name with generic messages, was mostly associated with informative and educational content. Therefore, it could particularly be useful for newly diagnosed patients. Therefore, text messaging programs that successfully blend both types of tailoring strategies could be more effective. This finding supported the previous research, which suggested the use of different tailoring variables and strategies in combination with each other (Noar & Harrington, 2016; Dijkstra, 2008; Morrison, Yardley, Powell, & Michie, 2012).

In their review of e-health interventions, Morrison and colleagues (2012) concluded that using additional contacts could be more effective for behaviour change. Parallel to this, our findings demonstrated that providing multiple sources of interaction (i.e., video links, peer-

support groups) in text messages could increase patients' engagement with a text messaging program.

#### **4.7 Limitations and Implications for Future Research and Practice**

Some limitations to this qualitative study should be mentioned. Although we were able to gain a wide age range in the sample group (40-71 years old), we could not reach younger patients (< 40 years old).

A methodological bias caused by the self-reporting of participants should also be mentioned. Our approach depends on the assumption that participants are rational and capable of choosing which message type works better for them. However, behaviour change is a multifaceted concept and also has affective and impulsive dimensions. Therefore, what participants believed and stated what was correct for them might not be necessarily effective for their behaviour change. Experimental research is needed to confirm the message preferences of patients on their self-management behaviour.

However, we have made several considerations and followed the recommendations made by Yardley (2017) to address the study's validity. Our previous studies that reviewed the type 2 diabetes interventions and patients' experiences increased our awareness regarding type 2 diabetes management and patients (Sahin et al., 2019; Sahin et al., 2020). It helped us to define our study objectives clearly and to formulate more operational research questions. The social marketing framework also broadened our patient-oriented perspective. We carefully considered using lay and non-stigmatizing language, such as using "patients with type 2 diabetes" instead of "type 2 diabetics." We put emphasis on transparency in each step of the study, from message development to data collection and presentation.

Because diabetes is a highly personal disease, patients' message preferences can be influenced by different demographic and psychosocial variables, such as education, income, marital status, and social support. Ethnic and genetic factors might also play a significant role. For example, Asian people are more likely to develop this disease (Rhee, 2015). Lifestyle choices and environmental context are also highly related to diabetes management (Spruijt-Metz et al., 2014). Acculturation may influence patients' coping skills with diabetes (O'Brien, Shuman, Barrios, Alos, & Whitaker, 2014). For example, Latin Americans tend to be more influenced by acculturation and consume more unhealthy foods and beverages and have a sedentary lifestyle, which increases the risk of developing the disease and challenges its effective management (O'Brien et al., 2014). Future research needs to examine how all these critical factors affect text message design and delivery preferences of patients and identify some other message design features to be used for effective Type 2 diabetes self-management. In clinical practice, the insights provided from this study can help improve the communication between patients and healthcare providers, reduce time and effort to engage with patients, and allocate resources effectively to conduct more successful interventions.

#### **4.8 Conclusions**

This study illustrated that text messaging was a convenient strategy for educational and behaviour change outreach to patients with type 2 diabetes. In line with the tenets of social marketing, this study illustrated that customization was integral to text messaging approaches and that message design elements should be included in health behaviour change messages. These findings provided significant implications for Type 2 diabetes research and practice as well as for text messaging studies where there has been limited knowledge about the use of communication and persuasion frameworks. Future research needs to test the effectiveness of patients' message

preferences on their self-management behaviours and explore what other message design elements and patient characteristics could be important for type 2 diabetes management via mobile text messaging.

## References

- Abebe, N. A., Capozza, K. L., Des Jardins, T. R., Kulick, D. A., Rein, A. L., Schachter, A. A., & Turske, S. A. (2013). Considerations for community-based mHealth initiatives: insights from three Beacon Communities. *Journal of Medical Internet Research*, *15*(10), e221. <https://doi.org/10.2196/jmir.2803>
- Adams, S. Y., Crawford, A. G., Rimal, R. N., Lee, J. S., Janneck, L. M., & Sciamanna, C. N. (2009). The effects of a computer-tailored message on secondary prevention in type 2 diabetes: a randomized trial. *Population Health Management*, *12*(4), 197–204. <https://doi.org/10.1089/pop.2008.0041>
- Agboola, S., Jethwani, K., Lopez, L., Searl, M., O’Keefe, S., & Kvedar, J. (2016). Text to Move: a randomized controlled trial of a text-messaging program to improve physical activity behaviors in patients with type 2 diabetes mellitus. *Journal of Medical Internet Research*, *18*(11), e307. <http://doi.org/10.2196/jmir.6439>
- Agboola, S., Lopez, L., Searl, M., O’Keefe, S., Kvedar, J., & Jethwani, K. (2013). {TEXT} {TO} {MOVE}—randomized controlled trial of personalized text messaging to improve physical activity in a diverse patient population with type 2 diabetes mellitus. *Journal of Mobile Technology in Medicine*, *2*(4s), 8.
- Ahlqvist, E., Storm, P., Karajamaki, A., Martinell, M., DorkhanM., Carlsson, A., et al. (2018). Novel subgroups of adult-onset diabetes and their association with outcomes: a data-driven cluster analysis of six variables. *Lancet Diabetes Endocrinology*, *6*(5), 361-369.
- Andreasen, A. (2002). Marketing social marketing in the social change marketplace. *Journal of Public Policy and Marketing*, *21*(1), 3-13.
- Arambepola, C., Ricci-Cabello, I., Manikavasagam, P., Roberts, N., French, D.P., & Farmer, A. (2016). The impact of automated brief messages promoting lifestyle changes delivered via mobile devices to people with type 2 diabetes: a systematic literature review and meta-analysis of controlled trials. *Journal of Medical Internet Research*, *18*, e86.
- Armanasco, A. A., Miller, Y. D., Fjeldsoe, B. S., & Marshall, A. L. (2017). Preventive health behavior change text message interventions: a meta-analysis. *American Journal of Preventive Medicine*, *52*(3), 391–402. <http://doi.org/10.1016/j.amepre.2016.10.042>
- Arora, S., Peters, A. L., Burner, E., Lam, C. N., & Menchine, M. (2014). Trial to examine text message–based mhealth in emergency department patients with diabetes (text-med): A randomized controlled trial. *Annals of Emergency Medicine*, *63*(6), 745–754.e6. <http://doi.org/10.1016/j.annemergmed.2013.10.012>
- Atlasti.com (2018). Atlas.ti 8.3 Qualitative analysis software. <https://atlasti.com>.

- Bergner, E. M., Nelson, L. A., Rothman, R. L., & Mayberry, L. (2017). Text messaging may engage and benefit adults with type 2 diabetes regardless of health literacy status. *Health Literacy Research and Practice, 1*, e192–e202.
- Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. West Sussex, UK: Wiley.
- Brunetti, L., & Kalabalik, J. (2012). Management of type-2 diabetes mellitus in adults: Focus on individualizing non-insulin therapies. *P & T: A peer-reviewed journal for formulary management, 37*(12), 687–696.
- Burner, E., Menchine, M., Taylor, E., & Arora, S. (2013). Gender differences in diabetes self-management: a mixed-methods analysis of a mobile health intervention for inner-city Latino patients. *Journal of Diabetes Science and Technology, 7*(1), 111–118.  
<http://doi.org/10.1177/193229681300700113>
- Burner, E. R., Menchine, M. D., Kubicck, K., Robles, M., & Arora, S. (2014). Perceptions of successful cues to action and opportunities to augment behavioral triggers in diabetes self-management: qualitative analysis of a mobile intervention for low-income Latinos with diabetes. *Journal of Medical Internet Research, 16*, e25-28.
- Burner, E, Lam, C., Deross, R., Kagawa-Singer, M., Menchine, M., & Arora, S. (2018). Using mobile health to improve social support for low-income Latino patients with diabetes: a mixed-methods analysis of the feasibility trial of text-med + fans. *Diabetes Technology & Therapeutics, 20*, 39-48.
- Cappella, J. N. (2006). Integrating message effects and behavior change theories: Organizing comments and unanswered questions. *Journal of Communication, 56*(SUPPL.), 265–279.  
<http://doi.org/10.1111/j.1460-2466.2006.00293.x>
- Capozza, K., Woolsey, S., Georgsson, M., Black, J., Bello, N., Lence, C. et al. (2015). Going mobile with diabetes support: a randomized study of a text message-based personalized behavioral intervention for type 2 diabetes self-care. *Diabetes Spectrum, 28*(2), 83–91.  
Retrieved from <http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/734/CN-01154734/frame.html>
- Cargo, M., Harris, J., Pantoja, T., Booth, A., Harden, A., Hannes, K. et al. (2018). Cochrane Qualitative and Implementation Methods Group guidance series—paper 4: methods for assessing evidence on intervention implementation. *Journal of Clinical Epidemiology, 97*, 59–69.
- Chen, X. Z., Yu, S. J., Li, C. Y., Zhan, X. X., & Yan, W. R. (2018). Text message-based intervention to improve treatment adherence among rural patients with type 2 diabetes mellitus: a qualitative study. *Public Health, 163*, 46-53.  
<http://doi.org/10.1016/j.puhe.2018.06.016>

- Cheng, H., Kotler, P., & Lee, N. R. (2011). *Social marketing for public health. Global trends and success stories.*, New York, NY: Jones & Bartlett Learning.
- Cho, H. (2012). Toward a theory of health communication design. In H. Cho (Ed), *Health communication message design* (pp. xv-xvi). Thousand Oaks, CA: Sage.
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112, 155–159. doi:10.1037/0033-2909.112.1.155
- Cole-Lewis, H., and Kershaw, T. (2010). Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic Reviews*, 32, 56–69.
- Critical Appraisal Skills Programme (2015). Critical Appraisal Skills Programme (CASP). <http://www.casp-uk.net>.
- Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: A scoping review. *Health Psychology Review*, 9(3):323-44
- de Jongh, T., Gurol-Urganci, I., Vodopivec-Jamsek, V., Car J., Atun, R. (2012). Mobile phone messaging for facilitating self-management of long-term illnesses. *Cochrane Database of Systematic Reviews*, 12. <http://doi.org/10.1002/14651858.CD007459.pub2>
- Deloitte (2017). Mobile consumer survey. Retrieved from <https://www2.deloitte.com/ph/en/pages/technology-media-and-telecommunications/articles/2017-sea-mobile-consumer.html>
- Diabetes Canada (2019). Promote self-management education. Retrieved from <http://guidelines.diabetes.ca/selfmanagementeducation/refguide>
- Diabetes UK (2009). Supported self-management. Retrieved from <https://www.diabetes.org.uk/professionals/position-statements-reports/diagnosis-ongoing-management-monitoring/supported-self-management>
- Dick, J.J., Nundy, S., Solomon, M.C., Bishop, K.N., Chin, M.H., & Peek, M.E. (2011). Feasibility and usability of a text message-based program for diabetes self-management in an urban African American population. *Journal of Diabetes Science Technology*, 5, 1246–1254.
- Dickinson, J. K., & Maryniuk, M. D. (2017). Building therapeutic relationships: choosing words that put people first. *Clinical Diabetes*, 35(1), 51-54.
- Dijkstra, A. (2008). The psychology of tailoring-ingredients in computer-tailored persuasion. *Social and Personality Psychology Compass*, 2(2), 765–784. <https://doi.org/10.1111/j.1751-9004.2008.00081.x>

- Dijkstra, A. (2016). Personalization/computer-tailoring in persuasive technology: tailoring ingredients target psychological processes. In Orji, R., Reisinger, M., Busch, M., Dijkstra, A., Stibe, A. and Tscheligi, M. (Eds), *Proceedings of the personalization in persuasive technology workshop, persuasive technology 2016*, Salzburg, Austria, 05-04-2016, published at <http://ceur-ws.org>.
- Dobson, R., Whittaker, R., Pfaeffli Dale, L., & Maddison, R. (2017). The effectiveness of text message-based self-management interventions for poorly controlled diabetes: A systematic review. *Digital Health.*, 3. <https://doi.org/10.1177/2055207617740315>
- Edgar, T., & Volkman, J. E. (2012). Using communication theory for health promotion: practical guidance on message design and strategy. *Health Promotion Practice*, 13(5), 587-590.
- Faridi, Z., Liberti, L., Shuval, K., Northrup, V., Ali, A., & Katz, D. L. (2008). Evaluating the impact of mobile telephone technology on type 2 diabetic patients' self-management: the NICHE pilot study. *Journal of Evaluation in Clinical Practice*, 14(3), 465–469. <http://doi.org/10.1111/j.1365-2753.2007.00881.x>
- Farmer, A. J., McSharry, J., Rowbotham, S., McGowan, L., Ricci-Cabello, I., & French, D. P. (2016). Effects of interventions promoting monitoring of medication use and brief messaging on medication adherence for people with Type 2 diabetes: a systematic review of randomized trials. *Diabetic Medicine*, 33(5), 565–579. <http://doi.org/10.1111/dme.12987>
- Faruque, L.I., Wiebe, N. & Ehteshami-Afsha, A. (2017). Effect of telemedicine on glycated hemoglobin in diabetes: A systematic review and meta-analysis of randomized trials. *Canadian Medical Association Journal*, 189(9): E341–E364.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: an introduction to theory and research*. Reading, MA: Addison-Wesley.
- Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine*, 36(2), 165–173. <http://doi.org/10.1016/j.amepre.2008.09.040>.
- Flemming, K., Booth, A., Hannes, K., Cargo, M., and Noyes, J. (2018). Cochrane Qualitative and Implementation Methods Group guidance series—paper 6: reporting guidelines for qualitative, implementation, and process evaluation evidence syntheses. *Journal of Clinical Epidemiology*, 97, 79–85. <https://doi.org/10.1016/j.jclinepi.2017.10.022>.
- Fortmann AL, Gallo LC, Garcia MI, Taleb M, Euyoque JA, Clark T, Skidmore J, Ruiz M, Dharkar-Surber S, Schultz J, Philis-Tsimikas A. (2017). Dulce Digital: an mHealth SMS-based intervention improves glycemic control in hispanics with type 2 diabetes. *Diabetes Care*, 40(10):1349–55. doi: 10.2337/dc17-0230.

- Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., Patel, V., & Haines, A. (2013). The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. *PLoS medicine*, *10*(1), e1001362. <https://doi.org/10.1371/journal.pmed.1001362>
- French, J., Gordon, R. (2015). *Strategic social marketing*. London, UK: Sage.
- Gatwood, J., Balkrishnan, R., Erickson, S. R., An, L.C, Piette, J. D., & Farris, K.B. (2014). Addressing medication nonadherence by mobile phone: Development and delivery of tailored messages. *Research in Social and Administrative Pharmacy*, *10*(6):809–23. <http://dx.doi.org/10.1016/j.sapharm.2014.01.002>
- Gatwood, J., Balkrishnan, R., Erickson, S. R., An, L. C., Piette, J. D., & Farris, K. B. (2015). Mobile phone use and perspectives on tailored texting in adults with diabetes. *Journal of Mobile Technology in Medicine*, *4*(3), 2–12. <https://doi.org/10.7309/jmtm.4.3.2>
- Gatwood, J., Balkrishnan, R., Erickson, S. R., An, L. C., Piette, J. D., & Farris, K. B. (2016). The impact of tailored text messages on health beliefs and medication adherence in adults with diabetes: A randomized pilot study. *Research in Social and Administrative Pharmacy*, *12*(1), 130–140. <http://doi.org/10.1016/j.sapharm.2015.04.007>
- Glanz, K., & Bishop, D. (2010). The role of behavioral science theory in development and implementation of public health interventions. *Annual Review of Public Health*, *31*, 399–418.
- Glanz, K., Rimer, B. K., & Lewis, F. M. (2002). The scope of health behavior and health education. In K. Glanz, K., B.K. Rimer, & F. M. Lewis (Eds.), *Health behavior and health education: Theory, research, and practice* (pp. 3–21). San Francisco, CA: Jossey-Bass.
- Georgsson, M., & Staggers, N. (2017). Patients' perceptions and experiences of a mHealth diabetes self-management system. *Computers, Informatics, Nursing*, *35*(3), 122-130.
- Hall, A. K, Cole-Lewis, H. B. J., & Bernhardt, J. M. (2015). Mobile text messaging for health: a systematic review of reviews. *Annual Review Public Health*, *36*(20), 393–415. <http://doi.org/10.1146/annurev-publhealth-031914-122855>.
- Harden, A., Thomas, J., Cargo, M., Harris, J., Pantoja, T., Flemming, K., ... Noyes, J. (2018). Cochrane Qualitative and Implementation Methods Group guidance series—paper 5: methods for integrating qualitative and implementation evidence within intervention effectiveness reviews. *Journal of Clinical Epidemiology*, *97*, 70–78. <https://doi.org/10.1016/j.jclinepi.2017.11.029>
- Hawkins, R. P., Kreuter, M., Resnicow, K., Fishbein, M., & Dijkstra, A. (2008). Understanding tailoring in communicating about health. *Health Education Research*, *23*(3), 454–466. <http://doi.org/10.1093/her/cyn004>

- Head, K. J., Noar, S. M., Iannarino, N. T., & Grant Harrington, N. (2013). Efficacy of text messaging-based interventions for health promotion: A meta-analysis. *Social Science and Medicine*, *97*, 41–48. <http://doi.org/10.1016/j.socscimed.2013.08.003>
- Higgins, J.P.T. & Green, S. (2011). *Cochrane handbook for systematic reviews of interventions*. Version 5.1.0. The Cochrane Collaboration. Retrieved from <http://handbook.cochrane.org>.
- Hood, M., Wilson, R., Corsica, J., Bradley, L., Chirinos, D., & Vivo, A. (2016). What do we know about mobile applications for diabetes self-management? A review of reviews. *Journal of Behavioral Medicine*, *39*, 981–994. <http://doi.org/10.1007/s10865-016-9765-3>
- Horner, G. N., Agboola, S., Jethwani, K., Tan-McGrory, A., & Lopez, L. (2017). Designing patient-centered text messaging interventions for increasing physical activity among participants with type 2 diabetes: qualitative results from the text to move intervention. *JMIR MHealth and UHealth*, *5*(4), e54. <https://doi.org/10.2196/mhealth.6666>
- Hozo, S. P., Djulbegovic, B., & Hozo, I. (2005). Estimating the mean and variance from the median, range, and the size of a sample. *BMC Medical Research Methodology*, *5*(13). <https://doi.org/10.1186/1471-2288-5-13>
- International Diabetes Federation (IDF) (2017). *IDF diabetes atlas*. 7th edition. Retrieved from <http://www.diabetesatlas.org>
- Jang, J., & Feng, B. (2017). The effects of gain- and loss-framed advice messages on recipients' responses to advice. *Journal of Language and Social Psychology*, *37*(2), 181–202. <https://doi.org/10.1177/0261927X17706961>
- Janz, N. K., & Becker, M. H. (1984). The health belief model: A decade later. *Health Education Quarterly*, *11*(1), 1–47. <https://doi.org/10.1177/109019818401100101>
- Kim, S. I., & Kim, H. S. (2008). Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes. *International Journal of Medical Informatics*, *77*(6), 399–404. <http://doi.org/10.1016/j.ijmedinf.2007.07.006>
- Kim, H. & Song, M. (2008). Technological intervention for obese patients with type 2 diabetes. *Applied Nursing Research*, *21*(2): 84–89.
- Kim, H. H. & Seo, H. J. (2014). HealthTwitter initiative: design of a social networking service based tailored application for diabetes self-management. *Healthcare Informatics Research*, *20*(3):226-230. <https://doi.org/10.4258/hir.2014.20.3.226>
- Kitsiou, S., Paré, G., Jaana, M., & Gerber, B. (2017). Effectiveness of mHealth interventions for patients with diabetes: An overview of systematic reviews. *PLoS One*, *12*(3):1–16
- Kotler, P. (2003). *Marketing management*. Upper Saddle River, N.J.: Pearson Prentice Hall.

- Kotler, P. & Armstrong, G. (2010). *Principles of marketing*, Upper Saddle River, N.J: Pearson Prentice Hall.
- Kotler, P., & Zaltman, G. (1971). Social marketing: an approach to planned social change. *Journal of Marketing*, 35:3–12
- Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). Defining what works in tailoring: a meta-analysis of computer-tailored interventions for health behavior change. *Preventive Medicine*, 51(3-4), 214–221. <http://doi.org/10.1016/j.ypmed.2010.06.004>
- Kreuter, M.W., Strecher V.J, Glassman, B. (1999). One size does not fit all: the case for tailoring print materials. *Annual Behavioral Medicine*. 21(4):276-83.
- Kreuter, M. W., and Wray, R. J. (2003). Tailored and targeted health communication: strategies for enhancing information relevance. *American Journal of Health Behavior*, 27(SUPPL. 3). <http://doi.org/10.5993/AJHB.27.1.s3.6>
- Kuerbis, A., Mulliken, A., Muench, F., Moore, A.A. &, Gardner D.D. (2017). Older adults and mobile technology: Factors that enhance and inhibit utilization in the context of behavioral health. *Mental Health Addiction Research*, 2. <http://doi.org/10.15761/MHAR.1000136>
- Lenhart, A. (2012). Teens, smartphones, and texting. Pew Internet & American Life Project. Retrieved from: <http://pewinternet.org/Reports/2012/Teens-and-smartphones.aspx>.
- Lewin, S., Glenton, C., Munthe-Kaas, H., Carlsen, B., Colvin, C. J., Gülmezoglu, M., Noyes, J., Booth, A., Garside, R., ... Rashidian, A. (2015). Using qualitative evidence in decision making for health and social interventions: an approach to assess confidence in findings from qualitative evidence syntheses (GRADE-CERQual). *PLoS medicine*, 12(10), e1001895. doi:10.1371/journal.pmed.1001895
- Lim, S., Kang, S., Shin, H., Lee, H., Won, Y. J., Yu, S., ... Jang, H. (2011). Improved glycemic control without hypoglycemia in elderly diabetic patients using the ubiquitous healthcare service, a new medical information system. *Diabetes Care*, 34(2), 308–313. Retrieved from <http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/667/CN-00778667/frame.html>
- Lustria, M. L. A., Noar, S. M., Cortese, J., Van Stee, S. K., Glueckauf, R. L., and Lee, J. (2013). A meta-analysis of web-delivered tailored health behavior change interventions. *Journal of Health Communication*, 18(9), 1039–1069. <http://doi.org/10.1080/10810730.2013.768727>
- Mamykina, L., Heitkemper, E. M., Smaldone, A. M., Kukafka, R., Cole-Lewis, H., Davidson, P. G., ... Hripcsak, G. (2016). Structured scaffolding for reflection and problem solving in diabetes self-management: qualitative study of mobile diabetes detective. *Journal of the American Medical Informatics Association*, 23(1), 129–136. <https://doi.org/10.1093/jamia/ocv169>

- Mattson, M., & Basu, A (2010). The message development tool: A case for effective operationalization of messaging in social marketing practice. *Health Marketing Quarterly*, 27: 275–290
- Mayberry, L. S., Berg, C. A., Harper, K. J., and Osborn, C. Y. (2016). The design, usability, and feasibility of a family-focused diabetes self-care support mhealth intervention for diverse, low-income adults with type 2 diabetes. *Journal of Diabetes Research*, 2016. <https://doi.org/10.1155/2016/7586385>.
- Michie, S., Yardley, L., West, R., Patrick, K., & Greaves, F. (2017). Developing and evaluating digital interventions to promote behavior change in health and health care: recommendations resulting from an international workshop. *Journal of Medical Internet Research*, 19(6), e232. doi:10.2196/jmir.7126.
- Militello, L. K., Kelly, S. A., & Melnyk, B. M. (2012). Systematic review of text-messaging interventions to promote healthy behaviors in pediatric and adolescent populations: implications for clinical practice and research. *Worldviews Evidence Based Nursing*; 9(2): 66–77.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman D.G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. *PLoS Medicine*, 6(7): e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Morrison, L. G. (2015). Theory-based strategies for enhancing the impact and usage of digital health behaviour change interventions: A review. *Digital Health*. <https://doi.org/10.1177/2055207615595335>
- Morrison, L.G, Yardley, L., Powell, J., & Michie, S. (2012). What design features are used in effective e-health interventions? A review using techniques from Critical Interpretive Synthesis. *Telemedicine Journal and E-Health*, 18(2):137-144.
- Muench, F., & Baumel, A. (2017). More than a text message: dismantling digital triggers to curate behavior change in patient-centered health interventions. *Journal of Medical Internet Research*; 19(5): e147. <http://doi.org/10.2196/jmir.7463>.
- Muench, F., Van Stolk-Cooke, K., Morgenstern, J., Kuerbis, A. N., & Markle, K. (2014). Understanding messaging preferences to inform development of mobile goal-directed behavioral interventions. *Journal of Medical Internet Research*, 16(2), 1–14. <http://doi.org/10.2196/jmir.2945>
- Nelson, L. A., Mulvaney, S. A., Johnson, K. B., & Osborn, C. Y. (2017). mHealth intervention elements and user characteristics determine utility: a mixed-methods analysis. *Diabetes Technology & Therapeutics*, 19(1), 9–17. <https://doi.org/10.1089/dia.2016.0294>

- Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological Bulletin*, *133*(4), 673–693. <http://doi.org/10.1037/0033-2909.133.4.673>.
- Noar, S. M., Harrington, N. G., & Aldrich, R. S. (2009). The role of message tailoring in the development of persuasive health communication messages. *Communication Yearbook*, *33*(1947), 73–133. <http://doi.org/10.1080/23808985.2009.11679085>
- Noar, S.M., & Harrington, N. G. (2016). Tailored communications for health-related decision-making and behavior change. In M.A. Diefenbach, S. Miller-Halegoua and D.J. Bowen (Eds.), *Handbook of health decision science* (pp 251–263). New York, NY, US: Springer Science + Business Media, [http://dx.doi.org/10.1007/978-1-4939-3486-7\\_18](http://dx.doi.org/10.1007/978-1-4939-3486-7_18)
- Noyes, J., Booth, A., Cargo, M., Flemming, K., Garside, R., Hannes, K., ... Thomas, J. (2018). Cochrane Qualitative and Implementation Methods Group guidance series—paper 1: introduction. *Journal of Clinical Epidemiology*, *97*, 35–38. <https://doi.org/10.1016/j.jclinepi.2017.09.025>
- Noyes, J., Booth, A., Flemming, K., Garside, R., Harden, A., Lewin, S., ... Thomas, J. (2018). Cochrane Qualitative and Implementation Methods Group guidance series—paper 3: methods for assessing methodological limitations, data extraction and synthesis, and confidence in synthesized qualitative findings. *Journal of Clinical Epidemiology*, *97*, 49–58. <https://doi.org/10.1016/j.jclinepi.2017.06.020>
- Nundy, S., Dick, J. J., Solomon, M.C., Peek, M. E. (2013). Developing a behavioral model for mobile phone-based diabetes interventions. *Patient Education & Counseling*, *90*(1), 125–132. <https://doi.org/10.1016/j.pec.2012.09.008>
- O'Brien, M. J., Shuman, S. J., Barrios, D. M., Alos, V. A., & Whitaker, R. C. (2014). A qualitative study of acculturation and diabetes risk among urban immigrant Latinas: implications for diabetes prevention efforts. *The Diabetes Educator*, *40*(5), 616–625. <https://doi.org/10.1177/0145721714535992>
- O'Keefe, D. J. (2002). *Persuasion: theory and research*. 2nd ed. Thousand Oaks, CA: Sage Publications.
- O'Keefe, D. J. (2015). Message generalizations that support evidence-based persuasive message design: specifying the evidentiary requirements. *Health Communication*, *30*(2):106-13. doi: 10.1080/10410236.2014.974123.
- Orr, C. K. L., & Tao, D. (2014). Does the use of consumer health information technology improve outcomes in the patient self-management of diabetes? A meta-analysis and narrative review of randomized controlled trials. *International Journal of Medical Informatics*, *83*(5), 320–329. <http://doi.org/10.1016/j.ijmedinf.2014.01.009>

- Osborn, C., & Mulvaney, S. (2013). Development and feasibility of a text messaging and interactive voice response intervention for low-income, diverse adults with type 2 diabetes mellitus. *Journal of Diabetes Science and Technology*, 7(3), 612-623.
- Pal, K., Dack, C., Ross, J., Michie, S., May, C., Stevenson, F., Farmer, A., Yardley, L., Barnard, M., & Murray, E. (2018). Digital health interventions for adults with type 2 diabetes: qualitative study of patient perspectives on diabetes self-management education and support. *Journal of Medical Internet Research*, 20(2), e40. <https://doi.org/10.2196/jmir.8439>
- Peimani, M., Rambod, C., Omidvar, M., Larijani, B., Ghodssi-Ghassemabadi, R., Tootee, A., & Esfahani, E. N. (2016). Effectiveness of short message service-based intervention (SMS) on self-care in type 2 diabetes: A feasibility study. *Primary Care Diabetes*, 10(4), 251–258. <http://doi.org/10.1016/j.pcd.2015.11.001>
- Pelletier, L. G., & Sharp, E. (2008). Persuasive communication and proenvironmental behaviours: How message tailoring and message framing can improve the integration of behaviours through self-determined motivation. *Canadian Psychology/Psychologie Canadienne*, 49(3), 210–217. <http://doi.org/10.1037/a0012755>
- Petty, R.E. & Cacioppo, J.T. (1986). The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology*, 19: 123–205.
- Philis-Tsimikas, A., Fortmann, A., Lleva-Ocana, L., Walker, C., & Gallo, L. C. (2011). Peer-led diabetes education programs in high-risk Mexican Americans improve glycemic control compared with standard approaches. *Diabetes Care*, 34(9), 1926 LP-1931. Retrieved from <http://care.diabetesjournals.org/content/34/9/1926.abstract>
- Pollard, C. M., Howat, P. A., Pratt, I. S., Boushey, C. J., Delp, E. J., & Kerr, D. A. (2016). Preferred tone of nutrition text messages for young adults: focus group testing. *JMIR mHealth and uHealth*, 4(1), e1. <http://doi.org/10.2196/mhealth.4764>
- Rhee, E. (2015). Diabetes in Asians. *Endocrinology and Metabolism*, 30(3):263, <http://dx.doi.org/10.3803/EnM.2015.30.3.263>
- Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The strategic use of gain- and loss-framed messages to promote healthy behavior: How theory can inform practice. *Journal of Communication*, 56, S202–S220.
- Saffari M., Ghanizadeh, G., & Koenig, H. G. (2014). Health education via mobile text messaging for glycemic control in adults with type 2 diabetes: A systematic review and meta-analysis. *Prim Care Diabetes* [Internet]. *Prim Care Diabetes Europe*, 8(4):275–85.
- Sahin, C., Courtney, K. L., Naylor, P., & Rhodes, R. E. (2019). Tailored mobile text messaging interventions targeting type 2 diabetes self-management: A systematic review and a meta-analysis. *Digital Health*, <http://doi.org/10.1177/2055207619845279>.

- Sahin, C., Courtney, K. L., Naylor, P., and Rhodes, R. E. (2020). Patients' evaluations of text messaging studies for type 2 diabetes self-management: A systematic review and a thematic synthesis. Manuscript submitted for publication.
- Saranummi, N., Spruijt-Metz, D., Intille, S. S., Korhone, I., Nilsen, W. J., & Pavel, M. (2013). Moving the science of behavior change into the 21st century: Novel solutions to prevent disease and promote health. *Ieee Pulse*, 4, 22-25. <http://doi.org/10.1109/MPUL.2013.2271680>
- Sedgwick, P. (2013). Meta-analyses: how to read a funnel plot. *BMJ*, 346: f1342. <http://doi.org/10.1136/bmj.f1342>.
- Serrat O. (2017) The future of social marketing. In *Knowledge solutions* (pp. 119-128). Singapore: Springer. [https://doi.org/10.1007/978-981-10-0983-9\\_17](https://doi.org/10.1007/978-981-10-0983-9_17)
- Shams, M. (2018). Social marketing for health: theoretical and conceptual considerations. In M. Haider and H. N. Platter (Eds.), *Selected issues in global health communications*, IntechOpen, <http://doi.org/10.5772/intechopen.76509>. Retrieved from: <https://www.intechopen.com/books/selected-issues-in-global-health-communications/social-marketing-for-health-theoretical-and-conceptual-considerations>.
- Shaw, R., & Bosworth, H. (2014). Short message service (SMS) text messaging as an intervention medium for weight loss: a literature review. *Diabetes Technology and Therapeutics*, 16: S59–S60.
- Shen L, Bigsby E. (2013). The effects of message features. In: Dillard JP, Shen L, editors. *The SAGE handbook of persuasion: Developments in theory and practice* (pp. 20–35). Thousand Oaks, CA: Sage Publications.
- Sherifali, D., Berard, L.D., Gucciardi, E., MacDonald, B., & MacNeill, G. (2018). Self-management education and support. Diabetes Canada Clinical Practice Guidelines Expert Committee. *Canadian Journal of Diabetes*, 42, S36-S41.
- Shetty, A. S., Chamukuttan, S., & Nanditha, A. (2011). Reinforcement of adherence to prescription recommendations in Asian Indian diabetes patients using short message (SMS) -A pilot study. *Journal of Association of Physicians India*, 59:711-4., 59(November), 711–714. <http://doi.org/10.1056/NEJMoa1203858>
- Smith, E.A., & Senter, R. J. (1967). Automated readability index. Retrieved from: <https://apps.dtic.mil/dtic/tr/fulltext/u2/667273.pdf>
- Sousa, V. D., Zauszniewski, J. A., Musil, C. M., McDonald, P. E., Milligan, S. E. (2004). Testing a conceptual framework for diabetes self-care management. *Research and Theory for Nursing Practice*, 18(4):293-316.

- Spruijt-Metz, D. Nilsen, W. & Pavel, M. (2015). mHealth for behavior change and monitoring. In S. Adibi (Ed.), *mHealth. Multidisciplinary verticals* (pp. 120-128). Boca Raton, FL: CRC Press.
- Spruijt-Metz, D., O'Reilly, G. A., Cook, L., Page, K. A., & Quinn, C. (2014). Behavioral contributions to the pathogenesis of type 2 diabetes. *Current Diabetes Reports*, *14*(4), 475. <http://doi.org/10.1007/s11892-014-0475-3>.
- Suffoletto, B. (2016). Text message behavioral interventions: From here to where? *Current Opinion in Psychology*, *9*, 16–21. <http://doi.org/10.1016/j.copsyc.2015.09.012>.
- Suurmond, R, van Rhee, H, & Hak, T. (2017). Introduction, comparison, and validation of Meta-Essentials: a free and simple tool for meta-analysis. *Research Synthesis Methods*. 1-17. <http://doi.org/10.1002/jrsm.1260>.
- Tamban, C., Isip-Tan, I. T., & Jimeno, C. (2011). Use of short message services (SMS) for the management of type 2 diabetes mellitus: a randomized controlled trial. *Journal of the ASEAN Federation of Endocrine Societies* (Vol. 28). Retrieved from <http://www.asean-endocrinejournal.org/index.php/JAFES/article/view/68/132>.
- The World Bank Group (2018). New country classifications by income level: 2017-2018. Retrieved from <https://blogs.worldbank.org/opendata/new-country-classifications-income-level-2017-2018>.
- Thomas, J., and Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*, 45. <http://doi.org/10.1186/1471-2288-8-45>.
- Tong, A., Flemming, K., McInnes, E., Oliver, S., and Craig, J. (2012). Enhancing transparency in reporting the synthesis of qualitative research: ENTREQ. *BMC Medical Research Methodology*, *12*(1), 181. <https://doi.org/10.1186/1471-2288-12-181>.
- Watterson, J. L., Rodriguez, H. P., Shortell, S. M., and Aguilera, A. (2018). Improved diabetes care management through a text-message intervention for low-income patients: mixed-methods pilot study. *JMIR Diabetes*, *3*(4), e15. <https://doi.org/10.2196/diabetes.8645>.
- Yardley, L. (2017). Demonstrating the validity of qualitative research. *The Journal of Positive Psychology*, *12*(3), 295-296. <https://doi.org/10.1080/17439760.2016.1262624>.
- Yoo, H., Park, M., Kim, T., Yang, S., Cho, G., Hwang, T., ... Choi, K. (2009). A Ubiquitous chronic disease care system using cellular phones and the internet. *Diabetic Medicine*, *26*(6), 628–635.
- Yoon, K., & Kim, H. (2007). A short message service by cellular phone in type 2 diabetic patients for 12 months. *Diabetes Research and Clinical Practice*, *79*(2), 256–261. <http://doi.org/10.1016/j.diabres.2007.09.007>.

Zotero.org. (2018). Zotero 5.0 Citation manager. <https://www.zotero.org>.

**Appendix I.** Sources used to identify the studies in the review

Electronic databases	PubMed, CINAHL, ISI Web of Science, PsycINFO, Google Scholar, Cochrane Library, diabetesjournals.org, WHO Library (IMEMR, LILACS; VPRIM, WHOLIS, AIM, IMSEAR)
Key journal search	Journal of Medical Internet Research, The Journal of mHealth, Journal of Telemedicine and Telecare, Telemedicine and e-Health, International Journal of Medical Informatics, Journal of the American Medical Informatics Association, Journal of Healthcare Informatics Research, Journal of Innovation in Health Informatics
Reference lists search	Systematic reviews and meta-analyses (Arambepola et al., 2016; Dobson et al., 2017; Farmer et al., 2016; Hall, et al., 2015)

**Appendix II.** Electronic databases search results

Database	Provider	Search Period	Items Found
CINAHL	EBSCOHost	Inception to Jan 18, 2018	261
Google Scholar	Google	Inception to Jan 24, 2018	240
ISI WEB	Web of Science, Thomson Reuters	Inception to Jan 18, 2018	241
PsycINFO	OVIDSP	Inception to Jan 18, 2018	341
PubMed	NCBI	Inception to Jan 18, 2018	405
Cochrane Central Register of Controlled Trials	Cochrane Library via Wiley	Inception to Jan 24, 2018	644
Diabetesjournals.org	American Diabetes Association	Inception to Jan 29, 2018	20
IMEMR	World Health Organization	Inception to Jan 24, 2018	8
LILACS	World Health Organization	Inception to Jan 24, 2018	14
VPRIM	World Health Organization	Inception to Jan 24, 2018	13
Total			2187

**Appendix III.** PubMed search results

#	Search	Items Found
1	“diabetes mellitus” (MeSH term)	434.210
2	“type 2 diabet*” OR “type II diabet*” (Other terms/all fields)	154.181
3	“non insulin depend*” OR “noninsulin depend*” OR “non-insulin depend*” (Other terms/all fields)	12.158
4	“T2DM” OR “T2D” OR “TIIDM” OR “TIID” OR “MODM” OR “AODM” OR “MODY” (Other terms/all fields)	127.831
5	1 OR 2 OR 3 OR 4	459.757
6	“telemedicine” OR “computers, handheld” OR “cell phon*” OR “cell phone use” OR “text messaging” (Mesh terms)	38.648
7	“brief messag*” OR “multimedia message service” OR “MMS” OR “mobile video” OR “video” OR “message service” OR “m-health” (Other terms/all fields)	92.057
8	6 OR 7	127.542
9	5 AND 8	2228
10	Human filter applied	1935
11	Language filter applied- English	1848
12	Article types filter applied (Clinical Study, Clinical Trial, Clinical Trial, Phase I, Clinical Trial, Phase II, Clinical Trial, Phase III, Clinical Trial, Phase IV)	405

## **Appendix IV.** Guideline for identifying tailoring strategies

(Developed based on Noar & Harrington, 2016; Dijkstra, 2016; and Hawkins et al., 2008)

Please classify each article based on their tailoring strategies following these criteria:

### **1. Personalization:**

- a) If tailoring strategy is not specifically related to the content of the messages, rather focuses on arranging the timing and frequency of message delivery and feedback schedule according to needs and preferences of participants.
- b) If the message includes the name or other identifiers of the receiver but still delivering the standard messages to each patient (i.e., “Hello Jane (personalization), *regular blood glucose monitoring is very important for diabetes management* (standard message)
- c) If the message places the information in a meaningful context for a receiver using his/her cultural or demographic variables such as gender, age, ethnicity, residential status. Using photos, wording, logos, colors based on personal characteristics or preferences can be sources of personalization (i.e., *it is your time to make a difference in your community, Saanich Diabetes Awareness Group; The Lord has given us a powerful tool to monitor diabetes regularly!.; African Americans are more likely to have Type 2 diabetes, make sure that you are having enough physical activity each day*).
- d) If the messages are arranged based on the preferences or characteristics of participants such as using fear, guilt, warmth appeals, using statistics, textese, etc., or eliminating some content. For example, young people may prefer textese and humor in messages, but older people may prefer statistics, even the core message/take away is the same. It is about delivering the same message based on personal content preferences.

### **2. Psychosocial and Behavioral Tailoring:**

- a) If the message includes objective reports on participants medical condition and/or repeat back their specific information (i.e., “*you’re currently eating 3 servings per day; today you’ve completed 75% of your daily physical activity; “your fruit and vegetable intake is well below the recommended level of 5-9 servings per day*)
- b) If message content is arranged to match some psychosocial variables such as self-efficacy, awareness, stage of change, intention, etc. in order to persuade

participants for behavior change. (i.e., “*you are particularly getting more calories when you eat in social situations. To achieve your goal to reduce your weight within the next 2 weeks, please try to avoid situations where you can have high-calorie meals*”

3. ***Combination of the Two:*** Both tailoring strategies can be used in combination with each other.

- As a young mother, you have a plenty of opportunities to be a better role model for your children (*personalization*), we have provided a list of possible strategies to help you achieve your weekly physical activity goal (*Psychosocial and behavioral tailoring*)
- If you are concerned about your heart health (*Personalization*), now it is time for you to increase your daily vegetable intake to 4 servings per day. Start today, you can do it! (*Psychosocial and behavioral tailoring*).

**Appendix V.** Pre-specified moderator variables and related hypotheses used in the meta-analysis

<b>Age</b>	Because text messaging and mobile phones are more relevant to young people (Lenhart, 2012), and young diabetes patients are more likely to follow treatment regimens and recommendations of their care providers than older patients (Saffari, Ghanizadeh, & Koenig, 2014), it is hypothesized that the studies focused on young adults will have a larger effect size than the ones targeting diverse populations.
<b>Ethnicity/Race</b>	Due to the personalization tailoring effect (Dijkstra, 2016), it is hypothesized that the studies tailored the message content for a particular ethnic or cultural group will have a larger effect size than the studies worked with diverse populations
<b>Gender</b>	Based on the findings of the Burner et al.'s 2013 study, it is hypothesized that the studies focused on male diabetes patients will have a larger effect size than those included female diabetes patients
<b>Study length</b>	Based on Fjeldsoe et al.'s 2009 study, it is hypothesized that studies with shorter intervention periods (up to 3 months) will have a larger effect size
<b>Study setting</b>	Based on Arambepola et al.'s 2016 study, it is hypothesized that the interventions conducted in low and middle-income settings will have larger effects sizes compared to the ones carried out in high-income settings.
<b>Study design</b>	It is hypothesized that randomized controlled trials will produce the largest effect size compared to other study designs
<b>Message direction</b>	Based on Hall et al.'s 2015 study, it is hypothesized that the studies used interactive (two-way) messages will have a larger effect size than the ones used non-interactive (one-way) messages.
<b>The frequency of messaging</b>	Based on Hall et al.'s 2015 study, it is hypothesized that the interventions used less frequent messaging (such as once in a week as opposed to multiple messages per day) will have a greater effect size.
<b>Choice of modality</b>	Based on Noar et al.'s 2007 study, it is hypothesized that the studies used mixed modalities (i.e., SMS and Web portal) will have a larger effect size than the ones used single modality (i.e., SMS).
<b>Tailoring strategies</b>	Based on Noar and Harrington's 2016 study, it is hypothesized that the studies employed advanced tailoring strategies, including psychosocial and behavioral variables, will have a larger effect size than the ones used basic tailoring strategies including personalization <ul style="list-style-type: none"> <li>○ For the meta-analysis, the interventions were classified into 2 categories to include a sufficient amount of studies in each group for comparison. Those applied personalization strategies were classified as "basic tailoring" (n=3) and the others that included psychosocial and behavioral tailoring variables were classified as "advanced tailoring" (n=8).</li> </ul>
<b>Message delivery</b>	Due to the personalization tailoring effect (Dijkstra, 2016), it is hypothesized that the interventions used non-automated message delivery will have a greater effect size than the ones used an automated message delivery

## Appendix VI. Excluded studies with reasons

Number	Reference	Reasons for exclusion
1.	Abegg, M., Nandagopal, R., Brown, R., & Rother, K. (2012). Partners for better health in adolescents with type 2 diabetes (“Buddy study”)–an update. <i>Diabetes</i> , <i>61</i> , A615-A616.	Other reasons (a summary report)
2.	Adikusuma, W., & Qiyaam, N. (2017). The effect of education through short message service (SMS) messages on diabetic patients adherence. <i>Scientia Pharmaceutica</i> , <i>85</i> (2), 23	Generic–no tailored messages were used
3.	Agboola, S., Lopez, L., Searl, M., O’Keefe, S., Kvedar, J., & Jethwani, K. (2013). TEXT TO MOVE–randomized controlled trial of personalized text messaging to improve physical activity in a diverse patient population with type 2 diabetes mellitus. <i>Journal of Mobile Technology in Medicine</i> , <i>2</i> (4s), 8–8.	Other reasons (a preliminary study, the completed study was chosen–Agboola et al., 2016)
4.	Ali, S., McDuffie, R., Liu, S., Avitabile, N., Banka, A., Shi, L., & Fonseca, V. (2012). A pilot and feasibility study of a fully automated closed loop, text message-based system to improve diabetes control. <i>Diabetes</i> , <i>61</i> , A220.	Other reasons (insulin dose adjustment study and summary report)
5.	Alkadi, K., & Roudsari, A. (2013). TeMaD system: Telecare for managing diabetes in Saudi Arabia. <i>Studies in Health Technology &amp; Informatics</i> , <i>183</i> , 57–62.	Not a randomized or controlled study
6.	Anzaldo-Campos, M. C., Contreras, S., Vargas-Ojeda, A., Menchaca-Díaz, R., Fortmann, A., Philis-Tsimikas, A., ... Menchaca-Díaz, R. (2016). Dulce Wireless Tijuana: A randomized control trial evaluating the impact of Project Dulce and short-term mobile technology on glycemic control in a family medicine clinic in Northern Mexico. <i>Diabetes Technology &amp; Therapeutics</i> , <i>18</i> (4), 240–251. <a href="https://doi.org/10.1089/dia.2015.0283">https://doi.org/10.1089/dia.2015.0283</a>	Simple reminder messages or prompts were used
7.	Arora, S., Burner, E., Lam, J., DeSantos, R., Goodman, A., & Menchine, M. (2013). Can a mobile health intervention (Textmed) reduce emergency department utilization and hospital admissions in patients with diabetes? <i>Academic Emergency Medicine</i> , <i>20</i> (5 suppl. 1), S296–s297.	Conference abstract/poster
8.	Arora, S., Burner, E., Lam, J., Santos, R., Meeks, A., & Menchine, M. (2013). Trial to examine text-message based mhealth in ed patients with diabetes (TEXT-MED). <i>Academic Emergency Medicine</i> , <i>20</i> (5 suppl. 1), S180.	Conference abstract/poster
9.	Baghiani Moghadam, M. H., Taheri, G., Fallah Zadeh, H., & Parsa, M. (2014). The effect of instructional designed SMS based on Health Belief Model (HBM) on adoption of self-care behavior of patients with type II diabetes. <i>Modern Care Journal</i> , <i>11</i> (1), 10–18.	Provides only English abstract, the full-text is Arabic
10.	Baker, L. C., Macaulay, D. S., Sorg, R. A., Diener, M. D., Johnson, S. J., & Birnbaum, H. G. (2013). Effects of Care Management and Telehealth: A Longitudinal Analysis Using Medicare Data. <i>Journal of the American Geriatrics Society</i> , <i>61</i> (9), 1560–1567. <a href="https://doi.org/10.1111/jgs.12407">https://doi.org/10.1111/jgs.12407</a>	Not a mobile phone-based text messaging study
11.	Baron, J., Hirani, S., & Newman, S. (2016). Challenges in Patient Recruitment, Implementation, and Fidelity in a Mobile Telehealth Study. <i>Telemedicine Journal and E-Health : The Official Journal of the</i>	Other reasons (not a full intervention report)

	<i>American Telemedicine Association</i> , 22(5), 400–409. <a href="https://doi.org/10.1089/tmj.2015.0095">https://doi.org/10.1089/tmj.2015.0095</a>	
12.	Baron, Justine S., Hirani, S., & Newman, S. P. (2017). A randomised, controlled trial of the effects of a mobile telehealth intervention on clinical and patient-reported outcomes in people with poorly controlled diabetes. <i>Journal of Telemedicine and Telecare</i> , 23(2), 207–216. <a href="https://doi.org/10.1177/1357633X16631628">https://doi.org/10.1177/1357633X16631628</a>	Not a mobile phone-based text messaging study
13.	Baron, Justine Sita, Hirani, S. P., & Newman, S. P. (2017). Investigating the behavioural effects of a mobile-phone based home telehealth intervention in people with insulin-requiring diabetes: Results of a randomized controlled trial with patient interviews. <i>Journal of Telemedicine and Telecare</i> , 23(5), 503–512. <a href="https://doi.org/10.1177/1357633X16655911">https://doi.org/10.1177/1357633X16655911</a>	Not a mobile phone-based text messaging study
14.	Bauer, V., Wang, C.-H., Goodman, N., Craig, T., Glosner, S., Juhn, M., ... Masi, C. (2017). Textmessaging to improve outcomes in patients with painful diabetic peripheral neuropathy (PDPN). <i>Journal of General Internal Medicine. Conference: 40th Annual Meeting of the Society of General Internal Medicine, SGIM 2017. United States</i> , 32(2 Supplement 1), S328.	Conference abstract/poster
15.	Bell AM, Fonda SJ, Walker MS, Schmidt V, Vigersky RA (2012) Mobile phone-based video messages for diabetes self-care support. <i>J Diabetes Sci Technol</i> 6: 310–319.	Other reasons (no separate results were provided for type 1 and Type 2 patients)
16.	Bin Abbas, B., Al Fares, A., Jabbari, M., El Dali, A., & Al Orifi, F. (2015). Effect of Mobile Phone Short Text Messages on Glycemic Control in Type 2 Diabetes. <i>International Journal Of Endocrinology and Metabolism</i> , 13(1). <a href="https://doi.org/10.5812/ijem.18791">https://doi.org/10.5812/ijem.18791</a>	Not a randomized/controlled study
17.	Brath H, Morak J, Kästenbauer T, Modre-Osprian R, Strohnert-Kästenbauer H, Schwarz M, Kort W, Schreier G. Mobile health (mHealth) based medication adherence measurement - a pilot trial using electronic blisters in diabetes patients. <i>Br J Clin Pharmacol</i> . 2013 Sep;76 Suppl 1:47–55. doi: 10.1111/bcp.12184.	Simple reminder messages/prompts were used
18.	Burchard, A., & Sadarangani, T. (2014). Telehealth as an Alternative to Traditional, In-Person Diabetes Self-Management Support. <i>Journal of Clinical Outcomes Management</i> , 21(11), 495–496.	Not a mobile phone-based text messaging study
19.	Burner, E., Scott, R., Rosas, J., McManus, J., Hicks, B., Menchine, M., ... Arora, S. (2015). Trial to examine text-message-based mHealth in emergency department patients with diabetes with friends and family supporters (text-med+fans). <i>Academic Emergency Medicine</i> , 22(5 suppl. 1), S88.	Conference abstract/poster
20.	Burner, E., Lam, C. N., DeRoss, R., Kagawa-Singer, M., Menchine, M., & Arora, S. (2017). Using Mobile Health to Improve Social Support for Low-Income Latino Patients with Diabetes: A Mixed-Methods Analysis of the Feasibility Trial of TExT-MED + FANS. <i>Diabetes Technology &amp; Therapeutics</i> , 20(1), 39–48. <a href="https://doi.org/10.1089/dia.2017.0198">https://doi.org/10.1089/dia.2017.0198</a>	Other reasons (control group has the same tailored content)
21.	Chen, L., Chuang, L.-M., Chang, C.-H., Wang, C.-S., Wang, I.-C., Chung, Y., ... Lai, F. (2013). Evaluating self-management behaviors of diabetic patients in a telehealthcare program: Longitudinal study over 18 months. <i>Journal of Medical Internet Research</i> , 15(12), 3–17. <a href="https://doi.org/10.2196/jmir.2699">https://doi.org/10.2196/jmir.2699</a>	Not a mobile phone-based text messaging study

22.	Cherrington, A. L., Agne, A. A., Lampkin, Y., Birl, A., Shelton, T. C., Guzman, A., & Willig, J. H. (2015). Diabetes Connect Developing a Mobile Health Intervention to Link Diabetes Community Health Workers With Primary Care. <i>JOURNAL OF AMBULATORY CARE MANAGEMENT</i> , 38(4), 333–345. <a href="https://doi.org/10.1097/JAC.0000000000000110">https://doi.org/10.1097/JAC.0000000000000110</a>	Other reasons (targeting healthcare providers only)
23.	Cho, J.-H., Kwon, H.-S., Kim, H.-S., Oh, J.-A., & Yoon, K.-H. (2011). Effects on diabetes management of a health-care provider mediated, remote coaching system via a PDA-type glucometer and the Internet. <i>Journal of Telemedicine and Telecare</i> , 17(7), 365–370. <a href="https://doi.org/10.1258/jtt.2011.100913">https://doi.org/10.1258/jtt.2011.100913</a>	Not a mobile phone-based text messaging study
24.	Cho, J.-H., Lee, H.-C., Lim, D.-J., Kwon, H.-S., & Yoon, K.-H. (2009). Mobile communication using a mobile phone with a glucometer for glucose control in Type 2 patients with diabetes: as effective as an Internet-based glucose monitoring system. <i>Journal of Telemedicine and Telecare</i> , 15(2), 77–82. <a href="https://doi.org/10.1258/jtt.2008.080412">https://doi.org/10.1258/jtt.2008.080412</a>	Other reasons (comparison group also received the same messages)
25.	Czesak, A., Cathcart, J., Hlaing, N., Chisholm, S., Allardice, B., Conway, N., ... Wake, D. (2016). Effects of educational text messages as an adjunct to face to face educational programmes for people with diabetes. <i>Diabetic Medicine.</i> , 33, 126.	Conference abstract/poster
26.	Dobson, R., Carter, K., Cutfield, R., Hulme, A., Hulme, R., McNamara, C., ... Whittaker, R. (2015). Diabetes Text-Message Self-Management Support Program (SMS4BG): A Pilot Study. <i>JMIR MHEALTH AND UHEALTH</i> , 3(1). <a href="https://doi.org/10.2196/mhealth.3988">https://doi.org/10.2196/mhealth.3988</a>	Not a randomized/controlled study
27.	Fatehi, F., Malekzadeh, G., AKHAVI, M. A., Rashidi, M., & Afkhami, A. M. (2010). The effect of short message service on knowledge of patients with diabetes in Yazd, Iran.	Only generic-no tailored messages were used
28.	Fischer, H. H., Moore, S. L., Ginosar, D., Davidson, A. J., Rice-Peterson, C. M., Durfee, M. J., ... Steele, A. W. (2012). Care by Cell Phone: Text Messaging for Chronic Disease Management. <i>American Journal of Managed Care</i> , 18(2), e42-7.	Not a randomized/controlled study
29.	Fisher, W., Orsama, A.-L., Lahteenmaki, J., Harno, K., Kulju, M., Wintergerst, E., ... Liukko, K. (2013). Remote patient reporting and automated mobile telephone feedback reduce {HbA}1c and weight in individuals with type 2 diabetes: results of pilot research. <i>Diabetes Technology and Therapeutics.</i> , 15, A8. Retrieved from <a href="http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/079/CN-01011079/frame.html">http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/079/CN-01011079/frame.html</a>	Not a mobile phone-based text messaging study
30.	Fortmann, A., Garcia, M., Ruiz, M., Gallo, L., Schultz, J., Carlson, A., ... Philis-Tsimikas, A. (2015). Acceptability and feasibility of an mHealth self-management intervention in underserved hispanics with poorly controlled type 2 diabetes. <i>Endocrine Reviews. Conference: 97th Annual Meeting and Expo of the Endocrine Society, ENDO 2015. United States. Conference Start: 20150305. Conference End: 20150308</i> , 36(no pagination). Retrieved from <a href="http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/863/CN-01293863/frame.html">http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/863/CN-01293863/frame.html</a>	Not a randomized/controlled study
31.	Fountoulakis, S., Papanastasiou, L., Gryparis, A., Markou, A., & Piaditis, G. (2015). Impact and duration effect of telemonitoring on	Other reasons (no separate results were

	HbA1c, BMI and cost in insulin-treated Diabetes Mellitus patients with inadequate glycemc control: A randomized controlled study. <i>HORMONES-INTERNATIONAL JOURNAL OF ENDOCRINOLOGY AND METABOLISM</i> , 14(4), 632–643.	provided for Type 1 and Type 2 diabetes patients)
32.	Glasgow, R., Christiansen, S., Kurz, D., King, D., Woolley, T., Faber, A., ... Dickman, J. (2011). Engagement in a diabetes self-management website: usage patterns and generalizability of program use. <i>Journal of Medical Internet Research</i> , 13(1), e9.	Not a mobile phone-based text messaging study
33.	Glasgow, R. E., Kurz, D., King, D., Dickman, J. M., Faber, A. J., Halterman, E., ... Ritzwoller, D. (2012). Twelve-month outcomes of an Internet-based diabetes self-management support program. <i>Patient Education and Counseling</i> . <a href="http://doi.org/10.1016/j.pec.2011.07.024">http://doi.org/10.1016/j.pec.2011.07.024</a>	Not a mobile phone-based text messaging study
34.	Goodarzi, M., Ebrahimzadeh, I., Rabi, A., Saedipoor, B., & Jafarabadi, M. (2012). Impact of distance education via mobile phone text messaging on knowledge, attitude, practice and self efficacy of patients with type 2 diabetes mellitus in Iran. <i>Journal of Diabetes and Metabolic Disorders</i> , 11(1), 1–8.	Only generic-no tailored messages were used
35.	Goodarzi, Mandana, Javadi Bora, M. A., & Farajollahi, M. (2015). Impact of education via mobile phone on knowledge, attitude, practice and {HbA}1C of patients with type 2 diabetes mellitus in {Karaj}-{Iran}. <i>Interdisciplinary Journal of Virtual Learning in Medical Sciences (IJVLS)</i> , 6(3), 8–19.	Only generic-no tailored messages were used
36.	Gopalan, A., Paramanund, J., Shaw, P. A., Patel, D., Friedman, J., Brophy, C., ... Volpp, K. G. (2016). Randomised controlled trial of alternative messages to increase enrolment in a healthy food programme among individuals with diabetes. <i>BMJ Open</i> , 6(11), e012009. <a href="https://doi.org/10.1136/bmjopen-2016-012009">https://doi.org/10.1136/bmjopen-2016-012009</a>	Not a mobile phone-based text messaging study
37.	Greenwood, D. A., Hankins, A. I., Parise, C. A., Spier, V., Olveda, J., & Buss, K. A. (2014). A Comparison of In-person, Telephone, and Secure Messaging for Type 2 Diabetes Self-Management Support. <i>Diabetes Educator</i> , 40(4), 516–525. <a href="https://doi.org/10.1177/0145721714531337">https://doi.org/10.1177/0145721714531337</a>	Not a mobile phone-based text messaging study
38.	Hanauer, D., Wentzell, K., Laffel, N., & Laffel, L. (2009). Computerized Automated Reminder Diabetes System (CARDS): e-mail and SMS cell phone text messaging reminders to support diabetes management. <i>Diabetes Technology &amp; Therapeutics</i> , 11(2), 99–106.	Simple reminder messages /prompts were used
39.	Heisler, M., Choi, H., Palmisano, G., Mase, R., Richardson, C., Fagerlin, A., ... An, L. C. (2014). Comparison of community health worker-led diabetes medication decision-making support for low-income Latino and African American adults with diabetes using e-health tools versus print materials: a randomized, controlled trial. <i>Annals of Internal Medicine</i> , 161(10 Suppl), S13–22. <a href="https://doi.org/10.7326/M13-3012">https://doi.org/10.7326/M13-3012</a>	Not a mobile phone-based text messaging study
40.	Heitkemper, E. M., Mamykina, L., Tobin, J. N., Cassells, A., & Smaldone, A. (2017). Baseline Characteristics and Technology Training of Underserved Adults With Type 2 Diabetes in the Mobile Diabetes Detective (MoDD) Randomized Controlled Trial. <i>DIABETES EDUCATOR</i> , 43(6), 576–588. <a href="https://doi.org/10.1177/0145721717737367">https://doi.org/10.1177/0145721717737367</a>	Other reasons (only participant characteristics were reported)

41.	Huang, J. S., Terrones, L., Tompane, T., Dillon, L., Pian, M., Gottschalk, M., ... Bartholomew, L. K. (2014). Preparing adolescents with chronic disease for transition to adult care: a technology program. <i>Pediatrics</i> , <i>133</i> (6), e1639-1646. <a href="https://doi.org/10.1542/peds.2013-2830">https://doi.org/10.1542/peds.2013-2830</a>	Other reasons (population included only Type 1 patients)
42.	Islam, S., Niessen, L., Ferrari, U., Ali, L., Seissler, J., & Lechner, A. (2015). Effects of mobile phone sms to improve glycemic control among patients with type 2 diabetes in Bangladesh: a prospective, parallel-group, randomized controlled trial. <i>Diabetes Care</i> , <i>38</i> (8), e112–e113.	Generic-no tailored messages were used
43.	Istepanian, R. S. H., Zitouni, K., Harry, D., Moutosammy, N., Sungoor, A., Tang, B., & Earle, K. A. (2009). Evaluation of a mobile phone telemonitoring system for glycaemic control in patients with diabetes. <i>Journal of Telemedicine and Telecare</i> , <i>15</i> (3), 125–128. <a href="https://doi.org/10.1258/jtt.2009.003006">https://doi.org/10.1258/jtt.2009.003006</a>	Not a mobile phone-based text messaging study
44.	Jadoon, N., Arshad, M., Hussain, M., & Sulehri, F. (2017). Effectiveness of mobile phone messaging in improving glycemic control: a pilot study. <i>Diabetic Medicine. Conference: Diabetes UK Professional Conference 2017. United Kingdom</i> , <i>34</i> , 129.	Conference abstract/poster
45.	Katalenich, B., Shi, L., Liu, S., Shao, H., McDuffie, R., Carpio, G., ... Fonseca, V. (2015). Evaluation of a Remote Monitoring System for Diabetes Control. <i>Clinical Therapeutics</i> , <i>37</i> (6), 1216–1225. <a href="https://doi.org/10.1016/j.clinthera.2015.03.022">https://doi.org/10.1016/j.clinthera.2015.03.022</a>	Simple reminders/prompts were used
46.	Katz, R., Nunlee-Bland, G., Magee, M., Cioletti, A., Cohen, J., Getaneh, A., ... Payne, D. (2015). Making mhealth work to manage diabetes: integrating mhealth with community health workers. <i>Diabetes</i> , <i>64</i> , A192-a193.	Conference abstract/poster
47.	Katz, R., Patel, S., Young, H., & Cohen, J. (2015). Enhancing diabetes and hypertension self-management: a randomized trial of a mhealth strategy in a community clinic setting. <i>Diabetes</i> , <i>64</i> , A192.	Conference abstract/poster
48.	Kim, C. S., Park, S. Y., Kang, J. G., Lee, S. J., Ihm, S. H., Choi, M. G., & Yoo, H. J. (2010). Insulin dose titration system in diabetes patients using a short messaging service automatically produced by a knowledge matrix. <i>Diabetes Technology &amp; Therapeutics</i> , <i>12</i> (8), 663–669. <a href="https://doi.org/10.1089/dia.2010.0031">https://doi.org/10.1089/dia.2010.0031</a>	Other reasons (insulin-dose adjustment study)
49.	Kim, G., Bae, J. C., Yi, B. K., Hur, K. Y., Chang, D. K., Lee, M.-K., ... Jin, S.-M. (2017). An information and communication technology-based centralized clinical trial to determine the efficacy and safety of insulin dose adjustment education based on a smartphone personal health record application: a randomized controlled trial. <i>BMC Medical Informatics and Decision Making</i> , <i>17</i> . <a href="https://doi.org/10.1186/s12911-017-0507-4">https://doi.org/10.1186/s12911-017-0507-4</a>	Other reasons (insulin-dose adjustment study)
50.	Kim H, Kim N, & Ahn S. (2006). Impact of a nurse short message service intervention for patients with diabetes. <i>Journal of Nursing Care Quality</i> , <i>21</i> (3), 266–271.	Not a randomized/controlled study
51.	Kim H. (2007). A randomized controlled trial of a nurse short-message service by cellular phone for people with diabetes. <i>International Journal of Nursing Studies</i> , <i>44</i> (5), 687–692.	Other reasons (a 3-month preliminary study, a 12-month study with full measures were used-Yoon & Kim, 2007)

52.	Kim, H.-S., & Jeong, H.-S. (2007). A nurse short message service by cellular phone in type-2 diabetic patients for six months. <i>Journal of Clinical Nursing</i> , 16(6), 1082–1087. <a href="https://doi.org/10.1111/j.1365-2702.2007.01698.x">https://doi.org/10.1111/j.1365-2702.2007.01698.x</a>	Other reasons (a 6-month study, a 12-month study with full measures were used-Yoon & Kim, 2007)
53.	Kim H, & Song M. (2008). Technological intervention for obese patients with type 2 diabetes. <i>Applied Nursing Research</i> , 21(2), 84–89.	Other reasons (a 6-month study, a 12-month study with full measures were used-Kim & Kim, 2008)
54.	Kumar, N., Kumar, P., Dixit, V., Khan, R., & Sharma, V. (2011). Evaluation of cellular phone utilization for adolescent diabetic patient care and management: a pilot study. <i>Pediatric Diabetes</i> , 12, 82.	Conference abstract/poster
55.	Kwon H, Cho J, Kim H, Lee J, Song B, Oh J, ... Yoon K. (2004). Development of web-based diabetic patient management system using short message service (SMS). <i>Diabetes Research &amp; Clinical Practice</i> , 66, S133-7.	Not a randomized/controlled study
56.	Lange, I., Campos, S., Urrutia, M., Bustamante, C., Alcayaga, C., Tellez, A., ... O'Connor, A. (2010). Effect of a tele-care model on self-management and metabolic control among patients with type 2 diabetes in primary care centers in Santiago, Chile. <i>Revista Médica de Chile</i> , 138(6), 729–737.	Only English abstract, the full-text is Spanish
57.	Lee, E., Lee, D., Choi, D., Park, J., Park, S.-W., & Park, C.-Y. (2016). The results of extended study of smart phone based the S-Diabetes Care programme in policyholders with type 2 diabetes. <i>Diabetologia, Conference: 52nd Annual Meeting of the European Association for the Study of Diabetes, EASD 2016. Germany. Conference Start: 20160912. Conference End: 20160916. 59(1 Supplement 1), S422-s423.</i>	Conference abstract/poster
58.	Lee, J. Y., Lee, S. W. H., Nasir, N. H., How, S., Tan, C. S. S., & Wong, C. P. (2015). Diabetes telemonitoring reduces the risk of hypoglycaemia during Ramadan: a pilot randomized controlled study. <i>Diabetic Medicine : A Journal of the British Diabetic Association</i> , 32(12), 1658–1661. <a href="https://doi.org/10.1111/dme.12836">https://doi.org/10.1111/dme.12836</a>	Not a mobile phone-based text messaging study
59.	Leu MG, Norris TE, Hummel J, Isaac M, & Brogan MW. (2005). A randomized, controlled trial of an automated wireless messaging system for diabetes. <i>Diabetes Technology &amp; Therapeutics</i> , 7(5), 710–718.	Not a mobile phone-based text messaging study
60.	Levy, Natalie, Moynihan, V., Nilo, A., Singer, K., Bernik, L. S., Etiebet, M.-A., ... Natarajan, S. (2015). The Mobile Insulin Titration Intervention (MITI) for Insulin Adjustment in an Urban, Low-Income Population: Randomized Controlled Trial. <i>Journal of Medical Internet Research</i> , 17(7), e180. <a href="https://doi.org/10.2196/jmir.4716">https://doi.org/10.2196/jmir.4716</a>	Other reasons (insulin-dose adjustment study)
61.	Limaye, T., Kumaran, K., Joglekar, C., Bhat, D., Kulkarni, R., Nanivadekar, A., & Yajnik, C. (2016). Efficacy of a virtual assistance-based lifestyle intervention in reducing risk factors for Type 2 diabetes in young employees in the information technology industry in India: IIMIT, a randomized controlled trial. <i>Diabetic Medicine</i> , (no pagination). Retrieved from <a href="http://onlinelibrary.wiley.com/doi/10.1111/dme.12836">http://onlinelibrary.wiley.com/doi/10.1111/dme.12836</a>	Other reasons (diabetes prevention study)

62.	Long, A. F., & Gambling, T. (2012). Enhancing health literacy and behavioural change within a tele-care education and support intervention for people with type 2 diabetes. <i>Health Expectations</i> , 15(3), 267–282. <a href="https://doi.org/10.1111/j.1369-7625.2011.00678.x">https://doi.org/10.1111/j.1369-7625.2011.00678.x</a>	Not a randomized/controlled study
63.	Markowitz, J. T., Cousineau, T., Franko, D. L., Schultz, A. T., Trant, M., Rodgers, R., & Laffel, L. M. B. (2014). Text messaging intervention for teens and young adults with diabetes. <i>Journal of Diabetes Science and Technology</i> , 8(5), 1029–1034. <a href="https://doi.org/10.1177/1932296814540130">https://doi.org/10.1177/1932296814540130</a>	Other reasons (no separate data were provided for Type 1 and Type 2 patients)
64.	Martin, S., Feldman, D., Blumenthal, R., Jones, S., Post, W., McKibben, R., ... Blaha, M. (2015). mActive: a randomized clinical trial of an automated mHealth intervention for physical activity promotion. <i>Journal of the American Heart Association</i> , 4(11). Retrieved from <a href="http://onlinelibrary.wiley.com/doi/10.1177/1932296814540130">http://onlinelibrary.wiley.com/doi/10.1177/1932296814540130</a>	Other reasons (not a Type 2 diabetes management study)
65.	Mayberry, L. S., Mulvaney, S. A., Johnson, K. B., & Osborn, C. Y. (2017). The MESSAGING for Diabetes Intervention Reduced Barriers to Medication Adherence Among Low-Income, Diverse Adults With Type 2. <i>Journal of Diabetes Science and Technology</i> , 11(1), 92–99. <a href="https://doi.org/10.1177/1932296816668374">https://doi.org/10.1177/1932296816668374</a>	Not a randomized/controlled study
66.	McFarland, M., Davis, K., Wallace, J., Wan, J., Cassidy, R., Morgan, T., & Venugopal, D. (2012). Use of home telehealth monitoring with active medication therapy management by clinical pharmacists in veterans with poorly controlled type 2 diabetes mellitus. <i>Pharmacotherapy</i> , 32(5), 420–426. <a href="https://doi.org/10.1002/j.1875-9114.2011.01038.x">https://doi.org/10.1002/j.1875-9114.2011.01038.x</a>	Not a randomized/controlled study
67.	Naghibi, S., Moosazadeh, M., Zhyaniard, A., Makrani, Z., & Cherati, J. (2015). Analyzing short message services application effect on diabetic patients' self-caring. <i>International Journal of Preventive Medicine</i> , 2015-august. Retrieved from <a href="http://onlinelibrary.wiley.com/doi/10.1177/1932296814540130">http://onlinelibrary.wiley.com/doi/10.1177/1932296814540130</a>	Generic-no tailored messages were used
68.	Nelson, L. A., Mulvaney, S. A., Gebretsadik, T., Ho, Y.-X., Johnson, K. B., & Osborn, C. Y. (2016). Disparities in the use of a mHealth medication adherence promotion intervention for low-income adults with type 2 diabetes. <i>JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION</i> , 317(1), 12–18. <a href="https://doi.org/10.1093/jama/ocv082">https://doi.org/10.1093/jama/ocv082</a>	Not a randomized/controlled study
69.	Nelson, L. A., Mulvaney, S. A., Gebretsadik, T., Johnson, K. B., & Osborn, C. Y. (2016). The MESSAGING for Diabetes (MED) intervention improves short-term medication adherence among low-income adults with type 2 diabetes. <i>Journal of Behavioral Medicine</i> , 39(6), 995–1000. <a href="https://doi.org/10.1007/s10865-016-9774-2">https://doi.org/10.1007/s10865-016-9774-2</a>	Not a randomized/controlled study
70.	Noh, J.-H., Cho, Y.-J., Nam, H.-W., Kim, J.-H., Kim, D.-J., Yoo, H.-S., ... Yoo, H.-J. (2010). Web-based comprehensive information system for self-management of diabetes mellitus. <i>Diabetes Technology &amp; Therapeutics</i> , 12(5), 333–337. <a href="https://doi.org/10.1089/dia.2009.0122">https://doi.org/10.1089/dia.2009.0122</a>	Not a mobile phone-based text messaging study
71.	Novak, L., Walker, S., Fonda, S., Schmidt, V., & Vigersky, R. (2013). The impact of a video phone reminder system on glycemic control in older adults with type 2 diabetes mellitus (T2DM) in a retirement home. <i>Diabetes</i> , 62, A217.	Conference abstract/poster

72.	Nundy, S., Mishra, A., Hogan, P., Lee, S. M., Solomon, M. C., & Peek, M. E. (2014). How do mobile phone diabetes programs drive behavior change? Evidence from a mixed methods observational cohort study. <i>The Diabetes Educator</i> , 40(6), 806–819. <a href="https://doi.org/10.1177/0145721714551992">https://doi.org/10.1177/0145721714551992</a>	Not a randomized/controlled study
73.	Oh, J., Kim, H., Park, M., & Shim, H. (2011). Effects of Web-based health education on blood glucose and blood pressure improvement in postmenopausal women with impaired fasting blood glucose. <i>Journal of Korean Academy of Nursing</i> , 41(5), 724–731.	Only English abstract, full-te was Korean
74.	Olmen, J., Kegels, G., Korachais, C., Man, J., Acker, K., Kalobu, J., ... Schellevis, F. (2017). The effect of text message support on diabetes self-management in developing countries - A randomised trial. <i>Journal of Clinical and Translational Endocrinology</i> , 7, 33–41.	Generic, non-tailored messages were used
75.	Orsama, A.-L., Lahteenmaki, J., Harno, K., Kulju, M., Wintergerst, E., Schachner, H., ... Fisher, W. A. (2013). Active assistance technology reduces glycosylated hemoglobin and weight in individuals with type 2 diabetes: results of a theory-based randomized trial. <i>Diabetes Technology &amp; Therapeutics</i> , 15(8), 662–669. <a href="https://doi.org/10.1089/dia.2013.0056">https://doi.org/10.1089/dia.2013.0056</a>	Not a mobile phone-based text messaging study
76.	Osborn, C. Y., & Mulvaney, S. A. (2013). Development and feasibility of a text messaging and interactive voice response intervention for low-income, diverse adults with type 2 diabetes mellitus. <i>Journal of Diabetes Science and Technology</i> , 7(3), 612–622. <a href="https://doi.org/10.1177/193229681300700305">https://doi.org/10.1177/193229681300700305</a>	Other reasons (intervention development study)
77.	Ouyang, P., Stewart, K., Bedra, M., York, S., Valdiviezo, C., & Finkelstein, J. (2015). Text messaging to reduce inactivity using real-time step count monitoring in sedentary overweight females. <i>Circulation</i> , 131. Retrieved from <a href="http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/127/CN-01078127/frame.html">http://onlinelibrary.wiley.com/o/cochrane/clcentral/articles/127/CN-01078127/frame.html</a>	Conference abstract/poster
78.	Pfammatter, A., Spring, B., Saligram, N., Davé, R., Gowda, A., Blais, L., ... Ramalingam, S. (2016). mHealth intervention to improve diabetes risk behaviors in India: A prospective, parallel group cohort study. <i>Journal of Medical Internet Research</i> , 18(8), e207–e207. <a href="https://doi.org/10.2196/jmir.5712">https://doi.org/10.2196/jmir.5712</a>	Other reasons (diabetes prevention study and poster)
79.	Philis-Tsimikas, A., Fortmann, A., Garcia, I., Ruiz, M., & Schultz, J. (2016). Dulce digital: a randomized controlled sms intervention for latinos with type 2 diabetes. <i>Diabetes Technology and Therapeutics</i> , 18, A98.	Conference abstract/poster
80.	Quinn, C. C., Shardell, M. D., Terrin, M. L., Barr, E. A., Ballew, S. H., & Gruber-Baldini, A. L. (2011). Cluster-randomized trial of a mobile phone personalized behavioral intervention for blood glucose control. <i>Diabetes Care</i> , 34(9), 1934–1942. <a href="https://doi.org/10.2337/dc11-0366">https://doi.org/10.2337/dc11-0366</a>	Not a mobile phone-based text messaging study
81.	Raiff, B. R., Jarvis, B. P., & Dallery, J. (2016). Text-message reminders plus incentives increase adherence to antidiabetic medication in adults with type 2 diabetes. <i>Journal of Applied Behavior Analysis</i> , 49(4), 947–953. <a href="https://doi.org/10.1002/jaba.337">https://doi.org/10.1002/jaba.337</a>	Other reasons (No separate results for Type 1 and Type2 patients were provided)
82.	Ram, J., Selvam, S., Snehalatha, C., Nanditha, A., Simon, M., Shetty, A. S., ... Ramachandran, A. (2014). Improvement in diet habits, independent of physical activity helps to reduce incident diabetes among	Other reasons (diabetes prevention study)

	prediabetic Asian Indian men. <i>Diabetes Research and Clinical Practice</i> , 106(3), 491–495. <a href="https://doi.org/10.1016/j.diabres.2014.09.043">https://doi.org/10.1016/j.diabres.2014.09.043</a>	
83.	Ramachandran, A., Snehalatha, C., Ram, J., Selvam, S., Simon, M., Nanditha, A., ... Johnston, D. (2015). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomized controlled trial. <i>Diabetes Technology &amp; Therapeutics</i> , 17, S65-s66.	Conference abstract/poster
84.	Ramachandran, Ambady, Snehalatha, C., Ram, J., Selvam, S., Simon, M., Nanditha, A., ... Johnston, D. G. (2013). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomised controlled trial. <i>The Lancet. Diabetes &amp; Endocrinology</i> , 1(3), 191–198. <a href="https://doi.org/10.1016/S2213-8587(13)70067-6">https://doi.org/10.1016/S2213-8587(13)70067-6</a>	Other reasons (diabetes prevention study)
85.	Ramallo-Farina, Y., Garcia-Perez, L., Castilla-Rodriguez, I., Perestelo-Perez, L., Wagner, A. M., de Pablos-Velasco, P., ... Serrano-Aguilar, P. G. (2015). Effectiveness and cost-effectiveness of knowledge transfer and behavior modification interventions in type 2 diabetes mellitus patients--the INDICA study: a cluster randomized controlled trial. <i>Implementation Science : IS</i> , 10, 47. <a href="https://doi.org/10.1186/s13012-015-0233-1">https://doi.org/10.1186/s13012-015-0233-1</a>	Other reasons (study protocol)
86.	Rollo, M. E., Ash, S., Lyons-Wall, P., & Russell, A. (2011). Trial of a mobile phone method for recording dietary intake in adults with type 2 diabetes: evaluation and implications for future applications. <i>Journal of Telemedicine and Telecare</i> , 17(6), 318–323. <a href="https://doi.org/10.1258/jtt.2011.100906">https://doi.org/10.1258/jtt.2011.100906</a>	Not a mobile phone-based text messaging study
87.	Rotheram-Borus, M. J., Tomlinson, M., Gwegwe, M., Comulada, W. S., Kaufman, N., & Keim, M. (2012). Diabetes buddies: Peer support through a mobile phone buddy system. <i>The Diabetes Educator</i> , 38(3), 357–365. <a href="https://doi.org/10.1177/0145721712444617">https://doi.org/10.1177/0145721712444617</a>	Not a randomized/controlled group study
88.	Rubin, R., & Peyrot, M. (2013). Health-related quality of life and treatment satisfaction in the sensor-augmented pump therapy for A1c reduction 3 (STAR 3) trial. <i>Diabetes Technology &amp; Therapeutics</i> , 15(Suppl.1), S123-s124.	Conference abstract/poster
89.	Rubinstein, A., Miranda, J., Beratarrechea, A., Diez-Canseco, F., Kanter, R., Gutierrez, L., ... Ramirez-Zea, M. (2016). Effectiveness of an mHealth intervention to improve the cardiometabolic profile of people with prehypertension in low-resource urban settings in Latin America: a randomised controlled trial. <i>The Lancet. Diabetes &amp; Endocrinology</i> , 4(1), 52–63.	Other reasons (not a diabetes study)
90.	Ruiz, J. G., Andrade, A. D., Anam, R., Lisigurski, M., Karanam, C., & Sharit, J. (2014). Computer-based programmed instruction did not improve the knowledge retention of medication instructions of individuals with type 2 diabetes mellitus. <i>The Diabetes Educator</i> , 40(1), 77–88. <a href="https://doi.org/10.1177/0145721713508825">https://doi.org/10.1177/0145721713508825</a>	Not a mobile phone-based text messaging study
91.	Schultz, A., Markowitz, J., Cousineau, T., Franko, D., & Laffel, L. (2013). Mobile health (mHealth) intervention called BodiMojo using text messaging aimed at healthy lifestyles for youth with diabetes (DM): a pilot Randomized Controlled Trial (RCT). <i>Diabetes</i> , 62, A342.	Other reasons (No separate results for Type 1 and Type2 patients were provided)

92.	Sharaf, F., Midhet, F., & Al-Mohaimed, A. (2012). <i>Public Health Research</i> , 2(6), 197–203.	Not a randomized/controlled study
93.	Shariful Islam, S. M., Lechner, A., Ferrari, U., Seissler, J., Holle, R., & Niessen, L. W. (2016). Mobile phone use and willingness to pay for SMS for diabetes in Bangladesh. <i>Journal of Public Health (Oxford, England)</i> , 38(1), 163–169. <a href="https://doi.org/10.1093/pubmed/fdv009">https://doi.org/10.1093/pubmed/fdv009</a>	Other reasons (not a full study report)
94.	Sugita, H. (2017). Effect of text messages to improve health literacy on medication adherence in patients with type 2 diabetes mellitus: A randomized controlled pilot trial (vol 79, pg 316, 2017). <i>NAGOYA Journal of Medical Science</i> , 79(4), 567–568. <a href="https://doi.org/10.18999/nagjms.79.4.567">https://doi.org/10.18999/nagjms.79.4.567</a>	Conference abstract/poster
95.	Sugita, H., Shinohara, R., Yokomichi, H., Suzuki, K., & Yamagata, Z. (2017). Effect of text messages to improve health literacy on medication adherence in patients with type 2 diabetes mellitus: A randomized controlled pilot trial. <i>NAGOYA JOURNAL OF MEDICAL SCIENCE</i> , 79(3), 313–321. <a href="https://doi.org/10.18999/nagjms.79.3.313">https://doi.org/10.18999/nagjms.79.3.313</a>	Generic, no tailored messages were used
96.	Vervloet, M., Dijk, L., Bakker, D., Souverein, P., Santen-Reestman, J., Vlijmen, B., ... Bouvy, M. (2014). Short- and long-term effects of real-time medication monitoring with short message service (SMS) reminders for missed doses on the refill adherence of people with Type 2 diabetes: evidence from a randomized controlled trial. <i>Diabetic Medicine</i> , 31(7), 821–828.	Simple reminder messages/promots were used
97.	Vervloet M, van Dijk L, Santen-Reestman J, van Vlijmen B, van Wingerden P, Bouvy ML, & de Bakker DH. (2012). SMS reminders improve adherence to oral medication in type 2 diabetes patients who are real time electronically monitored. <i>International Journal of Medical Informatics</i> , 81(9), 594–604.	Simple reminder messages/promots were used
98.	Wakefield, B., Holman, J., Ray, A., Scherubel, M., Adams, M., Hillis, S., & Rosenthal, G. (2011). Effectiveness of home telehealth in comorbid diabetes and hypertension: a randomized, controlled trial. <i>Telemedicine Journal and E-Health</i> , 17(4), 254–261.	Not a mobile phone-based text messaging study
99.	Wakefield, B., Holman, J., Ray, A., Scherubel, M., Adams, M., Hills, S., & Rosenthal, G. (2012). Outcomes of a home telehealth intervention for patients with diabetes and hypertension. <i>Telemedicine Journal and E-Health</i> , 18(8), 575–579.	Not a mobile phone-based text messaging study
100.	Wakefield, B., Koopman, R., Keplinger, L., Bomar, M., Bernt, B., Johanning, J., ... Mehr, D. (2014). Effect of home telemonitoring on glycemic and blood pressure control in primary care clinic patients with diabetes. <i>Telemedicine Journal and E-Health</i> , 20(3), 199–205.	Not a mobile phone-based text messaging study
101.	Wakefield, B., Scherubel, M., Ray, A., & Holman, J. (2013). Nursing interventions in a telemonitoring program. <i>Telemedicine Journal and E-Health</i> , 19(3), 160–165.	Not a mobile phone-based text messaging study
102.	Waki, K., Fujita, H., Uchimura, Y., Omae, K., Aramaki, E., Kato, S., ... Ohe, K. (2014). DialBetics: a novel smartphone-based self-management support system for type 2 diabetes patients. <i>Journal of Diabetes Science and Technology</i> , 8(2), 209–215.	Not a mobile phone-based text messaging study
103.	Wong, C. K. H., Fung, C. S. C., Siu, S. C., Lo, Y. Y. C., Wong, K. W., Fong, D. Y. T., & Lam, C. L. K. (2013). A short message service (SMS) intervention to prevent diabetes in Chinese professional drivers with pre-	Other reasons (diabetes prevention study)

	diabetes: a pilot single-blinded randomized controlled trial. <i>Diabetes Research and Clinical Practice</i> , 102(3), 158–166.	
104.	Wongrochananan, S., Jiamjarasrangi, W., Tuicomepee, A., & Buranarach, M. (2013). The effectiveness of interactive multi-modality intervention on self-management support of type 2 diabetic patients in Thailand: a cluster-randomized controlled trial. <i>Journal of Diabetes</i> , 5, 151–152.	Simple reminder messages/prompts were used
105.	Wongrochananan, Suwaree, Tuicomepee, A., Buranarach, M., & Jiamjarasrangi, W. (2015). The effectiveness of interactive multi-modality intervention on self-management support of type 2 diabetic patients in Thailand: a cluster-randomized controlled trial. <i>International Journal of Diabetes In Developing Countries</i> , 35(2), S230–S236. <a href="https://doi.org/10.1007/s13410-015-0354-8">https://doi.org/10.1007/s13410-015-0354-8</a>	Simple reminder messages/prompts were used
106.	Wright, C., Slattery, S., Noncent, E., & Armstrong, C. (2012). Fitness now: a physician-run exercise program. <i>Journal of General Internal Medicine</i> , 27, S525.	Conference abstract/poster
107.	Wu, C. (2012). Multidisciplinary team approach for a peer-support based cardiac-diabetes self-management program. <i>Heart Lung and Circulation</i> , 21, S310-s311.	Conference abstract/poster
108.	Wu, C.-J. J., Sung, H.-C., Chang, A. M., Atherton, J., Kostner, K., & McPhail, S. M. (2017). Cardiac-diabetes self-management program for Australians and Taiwanese: A randomized blocked design study. <i>Nursing &amp; Health Sciences</i> , 19(3), 307–315. <a href="https://doi.org/10.1111/nhs.12346">https://doi.org/10.1111/nhs.12346</a>	Generic, no tailored messages were used
109.	Yarahmadi, A., Zare-Farashbandi, F., Kachue, A., Nouri, R., & Hassanzadeh, A. (2014). Effects of Non-Attendance Information Therapy on the Control of Glycosylated Hemoglobin (HbA1C) in Type 2 Diabetic Patients of Isfahan. <i>Modern Care Journal</i> , 11(4), 268–274.	Generic, no tailored messages were used
110.	Yoon, G., Ahn, H.-H., Park, B.-H., Yoo, D., & Park, S. (2012). The effects of weight loss by a low-calorie diet and a low-calorie plus exercise in overweight undergraduate students. <i>Korean Journal of Nutrition</i> , 45(4), 315–323.	Other reasons (not a diabetes management study)
111.	Zaker, M., & Ghavami, H. (2016). Effect of self-management educative package on quality of life among diabetic patients in urmia diabetes centers between in the years of 2013. <i>Journal of Urmia Nursing And Midwifery Faculty</i> , 13(10), 863–868.	Conference abstract/poster
112.	Zamanzadeh, V., Zirak, M., Hemmati, M. M., & Parizad, N. (2016). Distance education and diabetes empowerment: a single-blind randomized control trial. <i>Diabetes and Metabolic Syndrome: Clinical Research and Reviews</i> , (no pagination). Retrieved from <a href="http://onlinelibrary.wiley.com/doi/10.1002/dm2.1078">http://onlinelibrary.wiley.com/doi/10.1002/dm2.1078</a>	Generic, no tailored messages were used
113.	Zolfaghari, M., Mousavifar, S., & Haghani, H. (2012). Mobile phone text messaging and Telephone follow-up in type 2 diabetic patients for 3 months: a comparative study. <i>Journal of Diabetes and Metabolic Disorders</i> , 11(1). Retrieved from <a href="http://onlinelibrary.wiley.com/doi/10.1002/dm2.1078">http://onlinelibrary.wiley.com/doi/10.1002/dm2.1078</a>	Other reasons (retracted study)
114.	Zolfaghari, Mitra, Mousavifar, S. A., Pedram, S., & Haghani, H. (2012). The impact of nurse short message services and telephone follow-ups on diabetic adherence: which one is more effective? <i>Journal of Clinical</i>	Other reasons (retracted study)

	<i>Nursing</i> , 21(13–14), 1922–1931. <a href="https://doi.org/10.1111/j.1365-2702.2011.03951.x">https://doi.org/10.1111/j.1365-2702.2011.03951.x</a>	
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**Appendix VII.** Risk of bias assessment of interventions included in the review

Study ID	Selection Bias		Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias
	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Free from other source of bias
Agboola et al., 2016	Low risk  Computer-generated randomization	Low risk  Staff were blinded to treatment, and numbered opaque envelopes were used to identify the participants	High risk  Research assistants were not blinded to treatment assignments	Low risk  Assessment devices were used  Possible misclassification of outcome data in the control group	Low risk  Although a high attrition rate was reported (approximately 24%), loss to follow up were similar in both groups. No difference was observed between the participants dropped out or completed follow-up	Low risk  All the pre-specified outcomes in the the clinical trial registry were measured and reported	High risk  Patient self-reported assessment of the stage of change might lead to making wrong assessments and sending wrong messages in stages of change
Arora et al., 2014	Low risk  Computer generated randomization	Unclear risk  Allocation method was not reported	High risk  Neither personnel nor participants were blinded	High risk  A lack of blinding might lead to “social desirability bias wherein subjects might reply favorably because they think the investigator wants them to”	Low risk  Although a high attrition rate was reported (approximately 28% loss to follow up), the rates were similar in both groups.	High risk  Lack of reporting on entire secondary outcome measures indicated in the trial registry	High risk  Bias caused by a sampling method  Randomization of the low proportion of Spanish participants in the intervention group who in fact showed greater improvement might affect the results

Capozza et al., 2015	Low risk Computer-generated randomization	Low risk The web-based consent form was used for automatic allocation	Unclear risk The blinding method was not reported.	Unclear risk No sufficient information for blinding of outcome assessment	Low risk The attrition rate and reasons were similar in both groups.	High risk The data of A1C of post-test were not reported	High risk Possible generalizability problem due to sampling and sample size. A1C tests were not taken at recommended intervals
Faridi et al., 2008	Unclear risk Method not reported	Unclear risk Method not reported	High risk Neither participants nor personnel were blinded	Unclear risk Insufficient information to assess the risk	High risk A high proportion of intervention group did not adhere to the treatment completely	Unclear risk Insufficient information to assess the risk	High risk Bias caused by a small sample size
Fortmann et al., 2017	Low risk Randomly generated numbers sequence was used	Low risk Blocked random assignment with equal allocation was used	High risk Neither participants nor personnel were blinded	High risk Participants were not blinded to the outcome measure	High risk The attrition rate was higher in the IG compared to CG	Unclear risk Insufficient information to assess the risk	Unclear risk Insufficient information to assess whether an important risk of bias exists
Gatwood et al., 2016	Low risk Random number generator was used	Unclear risk Method not reported	Unclear risk No information about blinding was reported	Unclear risk Insufficient information to assess the risk	High risk Large proportions of participants in both groups excluded from the primary outcome analysis	Unclear risk Insufficient information to assess the risk	High risk Bias caused by study population, small sample size and short study duration  Adjustments to insulin dosing may not be accurately measured by PDC, leading to a bias in how adherence was measured
Kim & Kim 2008	High risk Pre-test-post-test control group design	High risk Pre-test-post-test control group design has higher	High risk Neither participants nor personnel were blinded	Unclear risk No sufficient information for blinding of	Low risk The attrition rate and reasons were	Low risk The study protocol is not available	High risk Bias caused by a small sample size

	has higher risks than RCTs	risks than RCTs	to the intervention	outcome assessment	similar in both groups.	but initial (3 months) report of the same trial also focused on the same outcomes	
Lim et al., 2016	Low risk  Block randomization method was applied	Unclear risk  Allocation method was not reported	Unclear risk  Insufficient information to judge the risk	Unclear risk  Insufficient information to judge the risk	Low risk  The proportion of the participants lost to follow-up were in the balance between the groups	High risk  Lack of reporting on entire outcome measures indicated in the trial registry	Unclear risk  Insufficient information to assess whether an important risk of bias exists
Peimani et al., 2015	Low risk  Permuted block randomization	Unclear  The method of allocation not specified	High risk  An investigator not blinded to the intervention	Unclear risk  Participants blinded but not the personnel	Low risk  All participants adhered to the treatments	Unclear risk  Insufficient information to assess the risk	High risk  More educated participants included in the sample
Shetty et al., 2011	Low risk  Computer-generated randomization	Unclear risk  Allocation method was not reported	Unclear risk  Insufficient information to judge the risk	Unclear risk  Insufficient information to judge the risk	High risk  High rates of attrition and imbalanced proportion of lost to follow-up in groups	High risk  Not all outcomes planned in the trial registry were reported	Unclear risk  Insufficient information to assess whether an important risk of bias exists
Tamban, et al., 2013	Low risk  Computer-generated randomization	Low risk  The allocation was done by a third party, Opaque envelopes were used	High risk  Patients were not blinded to the intervention and were instructed not to inform their attending physicians about their participation in the study as knowledge of this by the healthcare provider may influence the way he manages the patient	Low risk  Personnel were blinded to the treatment group	Low risk  Although imbalanced proportions of lost to follow up in the groups existed, intention to treat analysis was performed	Unclear risk  No sufficient information whether or not all intended outcomes were measured and reported	Unclear risk  Insufficient information to assess whether an important risk of bias exists

Yoo et al., 2009	Unclear risk Randomization method not reported	Unclear risk Allocation method not reported	High risk Neither participants nor personnel was blinded to the intervention	Unclear risk No sufficient information for blinding of outcome assessment	Low risk The size and the characteristics of the patients lost to follow-up were similar in both groups	Unclear risk Insufficient information to assess whether an important risk of bias exists	Unclear risk Insufficient information to assess whether an important risk of bias exists
Yoon & Kim, 2007	High risk Pre-test-post-test control group design, not a full randomization	High risk Pre-test-post-test control group design, not a full randomization	High risk Neither participants nor personnel was blinded to the intervention	Unclear risk No sufficient information for blinding of outcome assessment	Low risk The attrition rate and reasons were similar in both groups.	Low risk The study protocol is not available but initial (3 months) report of the same trial also focused on the same outcomes	High risk Bias caused by a small sample size

### Appendix VIII. Main results of the interventions included in the review

<b>Studies Using Personalization (n=4)</b>					
<b>Study, Reference</b>	<b>Diabetes Self-Management</b>				<b>Relevant behavioral/attitudinal outcomes</b>
	<b>Glycemic Control (HbA1C)</b>	<b>Physical Activity</b>	<b>Diet</b>	<b>Medication Adherence</b>	
<b>Arora et al, 2014</b>	No significant decrease was observed in the IG compared to the CG (the change in the median in IG: -1.05%; in CG: -0.60 %, the change between groups -0.45% at 95 % CI)	No significant change in either group (change in mean, IG:-0.3% while in CG:1.5% at 95% CI)	No significant change in either group (change in mean, IG: -0.7% while in CG:-0.8% at 95% CI)	Statistically significant increase in the intervention group (the change in mean, IG: 0.9 % compared to a decrease in CG= -0.1% at 95% CI)	<b>Self-efficacy and Knowledge:</b> No significant change was observed in either group. <b>Satisfaction:</b> Nearly 94% of participants enjoyed the intervention and all of them (100%) would recommend it to others
<b>Fortmann et al, 2017</b>	A statistically significant decrease was observed in the IG compared to CG at all measurement points (the change in the mean IG: 1.0 %; CG 0.2%; p=0.03 at post-trial)	Not measured	Not measured	Not measured	<b>Satisfaction:</b> 97% of the participants would recommend the program to a friend or family member with diabetes.
<b>Shetty et al, 2011</b>	Although no significant difference in the mean values in both groups was observed, the proportion of participants who can make a better control (HbA1C<8.0) was significantly higher (from 30.8% to 55.1%) than the control group (from 31.8% to 48.5%).	No significant change in either group. The proportion of IG participants who adhere to physical activity increased from 47% to 56% while in CG increased from 47% to 52%.	No significant change in either group. The proportion of IG participants who adhere to diet prescription changed from 60.3% to 58.4%.	No significant difference between the groups on various drug usages	<b>Acceptability:</b> Based on the preferred number of messages and message frequencies, a high level of acceptability was reported.

<b>Tamban et al, 2013</b>	The statistically significant decrease in 3 and 6 months in IG group (-0.68 % at 3 months, -0.82 % at 6 months, in means, compared to CG (-0.33% at 3 months, -0.52% at 6 months, in means)	Statistically significant improvement in IG at the last follow-up. A significant difference in mean numbers of minutes/exercise in IG (37.40, +-14.87) compared to CG (31.44, +-10.82, p=0.021)	Statistically significant improvement in IG at the last follow-up. A significant difference in mean numbers of meal/ day in IG (2.61, +-0.63) compared to CG (2.29, +-0.72, p=.0.018).	Not measured	Not a related measure was reported
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**Studies Using Psychosocial and Behavioral Tailoring (n=6)**

Study, Reference	Diabetes Self-Management				Relevant behavioral/attitudinal outcomes
	Glycemic Control (HbA1C)	Physical Activity	Diet	Medication Adherence	
<b>Faridi et al, 2008</b>	No statistically significant decrease in the IG was observed (the change in IG: -0.1%, in CG: 0.3%, in means)	No statistically significant change was reported	No statistically significant change was reported	Not measured	<b>Self-efficacy:</b> A statistically significant improvement in total self-efficacy scores in IG (-0.5% in mean) compared to no improvement in CG
<b>Kim &amp; Kim, 2008</b>	A statistically significant change in IG was observed at 12 months (8.16 % to 6.67%: -1.49% change in means) compared to an increase in CG (7.66 % to 8.19%, 0.54 % change in means)	Not measured	Not measured	Not measured	Not a related measure was reported

<b>Lim et al., 2016</b>	A statistically significant decrease in the IG after the follow-up (8.0 % to 7.3 %) compared to CG (8.1% to 7.9%). The proportion of participants with HbA1C<7% without hypoglycemia was larger in IG (26%) than in CG (12%).	A significant increase in exercise episodes per week in IG compared to no significant change in CG	Calorie intake significantly decreased in both groups, and the decrease was larger in IG (8.5%) compared to CG (2.4%)	Not measured	Not a related measure was reported
<b>Peimani et al., 2015</b>	No statistically significant change in either group (change in mean was -0.23% in tailored IG, -0.27% in non-tailored IG compared to change in mean 0.03% in CG)	Not measured	Not measured	Not measured	<b>Self-efficacy:</b> The scores in both IGs significantly differed from the baseline values but the changes in self-efficacy scores in both groups were smaller than the CG
<b>Yoo et al., 2009</b>	A statistically significant improvement in IG (from 7.6% to 7.1%) compared to an increase in CG (7.4% to 7.6%)	Not measured	Not measured	Not measured	Not a related measure was reported
<b>Yoon &amp; Kim, 2007</b>	A statistically significant improvement in IG (-1.32%) compared to an increase in CG (0.81%)	Not measured	Not measured	Not measured	Not a related measure was reported
<b>Studies Using the Combination of Tailoring Methods (n=3)</b>					
<b>Study, Reference</b>	<b>Diabetes Self-Management</b>				<b>Relevant behavioral/attitudinal outcomes</b>
	<b>Glycemic Control (HbA1C)</b>	<b>Physical Activity</b>	<b>Diet</b>	<b>Medication Adherence</b>	

<b>Agboola et al, 2016</b>	A significant change in IG from the baseline to follow-up (-43%) compared to CG (-21%) in 95% CI	Not a statistically significant change was observed in overall step counts at 6 months follow-up	Not measured	Not measured	<b>Satisfaction</b> (Measured in usability questionnaire): 94 % of participants would recommend the program to others
<b>Capozza et al, 2015</b>	Although both groups showed improvement, no statistically significant change was observed in either group. The change in means in IG was -0.50 % and 0.19 % in CG.	Not measured	Not measured	Not measured	<b>Satisfaction:</b> High satisfaction score (27.7.out of 32). 85% of the participants indicated increased knowledge in self-management of diabetes and 94% of participants would recommend the program to others
<b>Gatwood et al, 2016</b>	Not measured	Not measured	Not measured	No statistically significant change was observed in either group	<b>Health Belief:</b> No significant changes were observed in either group <b>Self-determination:</b> No significant changes were observed in either group

**Appendix IX.** Eligibility criteria for considering the studies in the review

	<b>Inclusion Criteria</b>	<b>Exclusion Criteria</b>
<b>Types of Studies</b>	<ul style="list-style-type: none"> <li>• Scholarly qualitative primary research</li> <li>• Qualitative data and research findings of mixed methods studies</li> <li>• Written in English</li> </ul>	<ul style="list-style-type: none"> <li>• Unpublished studies, conference abstracts or posters</li> <li>• Comments, letters, editorials, conceptual papers</li> </ul>
<b>Types of Participants</b>	<ul style="list-style-type: none"> <li>• People with Type 2 diabetes</li> <li>• The studies with a mixed population, such as individuals with Type 1 and Type 2 diabetes were only considered if separate data for Type 2 diabetes patients were provided</li> </ul>	<ul style="list-style-type: none"> <li>• Studies that focused on patients with Type 1 diabetes or gestational diabetes or diabetic retinopathy.</li> <li>• The studies whose participants included healthcare providers or other stakeholders rather than patients or consumers of health care services</li> </ul>
<b>Topic of Interest</b>	<ul style="list-style-type: none"> <li>• Studies included at least one of the self-management behaviors described by Diabetes Canada: diet (including nutrition, healthy eating, calorie intake), physical activity, medication adherence, or glycated hemoglobin monitoring (HbA1C).</li> <li>• Mobile phone-based text messaging interventions that involved the delivery of behavior change content through short message services (SMS), multimedia message services (MMS), or instant messaging using mobile messaging apps like WhatsApp.</li> </ul>	<ul style="list-style-type: none"> <li>• Mobile app or web-based interventions without any mobile-phone-based text messaging component to deliver behavior change messages</li> <li>• The studies used audio or voice message (including IVR) without using any mobile text messaging component</li> <li>• The studies whose messages included only the appointment and simple medication reminders (prompts) or instructions for medication use (i.e., insulin dose adjustment)</li> <li>• Cost-effectiveness studies and clinical trials</li> </ul>

**Appendix X.** Sources used to identify the studies in the review

<b>Electronic databases</b>	PubMed, CINAHL, ISI Web of Science, PsycINFO, Cochrane Library, diabetesjournals.org
<b>Key journal search</b>	Journal of Medical Internet Research, The Journal of mHealth, Journal of Telemedicine and Telecare, Telemedicine and e-Health, International Journal of Medical Informatics, Journal of the American Medical Informatics Association, Journal of Healthcare Informatics Research, Journal of Innovation in Health Informatics, Diabetes Technology & Therapeutics, Journal of Health Communication
<b>Reference lists search</b>	Systematic reviews and meta-analyses (Arambepola et al., 2016, Dobson et al., 2017, Farmer et al., 2016, Hall, et al., 2015)

**Appendix XI. Electronic databases search result**

<b>Database</b>	<b>Provider</b>	<b>Search Period</b>	<b>Items Found</b>
CINAHL	EBSCOHost	Inception to Oct 3, 2018	316
ISI WEB	Web of Science, Thomson Reuters	Inception to Oct 3, 2018	344
PsycINFO	OVIDSP	Inception to Oct 3, 2018	122
Pubmed	NCBI	Inception to Oct 2, 2018	427
Cochrane Central Register of Controlled Trials	Cochrane Library via Wiley	Inception to Oct 3, 2018	583
Diabetesjournals.org	American Diabetes Association	Inception to Oct 5, 2018	20
Total			<b>1812</b>

**Appendix XII. PubMed search results**

#	Search	Items Found
1	T2DM OR T2D OR TIIDM OR TIID OR MODM OR AODM OR MODY OR "non insulin depend*" OR "noninsulin depend*" OR "type 2 diabet*" OR "type II diabet*" OR "diabetes mellitus" [Mesh]	417.611
2	"Text Messaging"[Mesh] OR "Telemedicine"[Mesh]	25.271
3	"brief messag*" OR "message service" OR mhealth OR m-health OR "mobile phon*" OR "cell phon*"	46.577
4	#2 OR #3	47.396
5	#1 AND #4	1.672
6	Language filter applied: English	1.625
8	Studies with Human subject	1.426
9	Article types filter activated: Interview, Observational Study, Personal Narratives, Evaluation Studies, Controlled Clinical Trial, Clinical Trial, Clinical Study, Randomized Controlled Trial, Pragmatic Clinical Trial	427

### Appendix XIII. Excluded studies with reason

Number	Reference	Reasons for exclusion
1.	Baron, J., Hirani, S., & Newman, S. (2016) Challenges in Patient Recruitment, Implementation, and Fidelity in a Mobile Telehealth Study. <i>Telemedicine Journal and E-Health</i> , 22, 400-409.	Not a text messaging intervention
2.	Baron, J.S, Hirani, S., & Newman, S. (2017) Investigating the behavioral effects of a mobile-phone based home telehealth intervention in people with insulin-requiring diabetes: results of a randomized controlled trial with patient interviews. <i>Journal of Telemedicine and Telecare</i> , 23, 503-512.	Not a text messaging intervention
3.	Bartlett, A.S, Bosken, L.; Clark, S. (2011) The effects of a combined aerobic and resistive exercise program with the use of telehealth monitoring in reducing the value of cardiovascular risk factors of individuals vulnerable to developing type 2 diabetes. <i>Cardiopulmonary Physical Therapy Journal</i> , 22, 39-40,	Poster/Conference Abstract
4.	Bentley, C., Otesile, O., Bacigalupo, R., Elliott, J., Noble, H., Hawley, M., <i>et al.</i> (2016) Feasibility study of portable technology for weight loss and HbA1c control in type 2 diabetes. <i>BMC Medical Informatics and Decision Making</i> , 16, 92.	Not a text messaging intervention
5.	Bin, Z., Mai-lan, L., Shu-qiang, X., Collet, J. C., Collet, J.-P., Lear, S. A., and Ping, L. (2012) Telehealth in the management of diabetes mellitus in China. <i>Chinese Medical Journal</i> , 125, 4307–4311.	Not a research study-review/opinion paper
6.	Burgiss, S., and Dimmick, S. L. (2003) Telehealth in home health care. <i>Care Management Journals</i> , 4, 110–116.	Not a text messaging intervention
7.	Carroll, A. E., DiMeglio, L. A., Stein, S., and Marrero, D. G. (2011) Using a cell phone-based glucose monitoring system for adolescent diabetes management. <i>Diabetes Educator</i> , 37, 59–66.	Not a research study-review/opinion paper
8.	Dang, S., Nedd, N., Rodriguez, A., Valdes, M., Ruiz, J., and Roos, B. (2002) Telemedicine care coordination (t-care) improves diabetes mellitus management in older veterans. <i>Gerontologist</i> , 42, 413–414.	Not a text messaging intervention
9.	Daoudi, A., Joubert, M., Franc, S., Fagour, C., Benhamou, P.-Y., Reznik, Y. <i>et al.</i> (2013) A Smartphone for adjustment of basal insulin dose and for coaching: benefits in terms of glycaemic control for type 2 diabetes patients. <i>Diabetologia</i> , 56, S426.	Not a qualitative study
10.	Davis, R., Hitch, A., Salaam, M., Herman, W., Zimmer-Galler, I., & Mayer-Davis, E. (2010) TeleHealth improves diabetes self-management in an underserved community. <i>Diabetes Care</i> , 33, 1712–7. (CN-01262485).	Not a qualitative study
11.	Dick, J. J., Nundy, S., Solomon, M. C., Bishop, K. N., Chin, M. H., and Peek, M. E. (2011) Feasibility and usability of a text message-based program for diabetes self-management in an urban African-American population. <i>Journal of Diabetes Science and Technology</i> , 5, 1246–1254.	Other (a preliminary study)
12.	Dobson, R., Carter, K., Cutfield, R., Hulme, A., Hulme, R., Hons, M., <i>et al.</i> (2015) Diabetes text-message self-management support program ( sms4bg ): a pilot study. <i>JMIR Mhealth Uhealth</i> , 3, e32	Not a qualitative study
13.	Free, C. (2013) Text messaging to prevent onset of type 2 diabetes. <i>Lancet Diabetes &amp; Endocrinology</i> , 1, 165–166.	Not a research study-review/opinion paper
14.	Fukuoka, Y., Kamitani, E., Bonnet, K., and Lindgren, T. (2011) Real-time social support through a mobile virtual community to improve	Other (prediabetes patients targeted)

	healthy behavior in overweight and sedentary adults: A focus group analysis. <i>Journal of Medical Internet Research</i> , 13, 134–143.	
15.	Gatwood, J., Balkrishnan, R., Erickson, S. R., An, L. C., Piette, J. D., and Farris, K. B. (2014). Addressing medication nonadherence by mobile phone: development and delivery of tailored messages. <i>Research in Social &amp; Administrative Pharmacy</i> , 10, 809–823.	Other (a preliminary study)
16.	Georgsson, M., Staggers, N., and Weir, C. (2016) A modified user-oriented heuristic evaluation of a mobile health system for diabetes self-management support. <i>Computers, Informatics, Nursing</i> , 34, 77–84.	Other (expert review)
17.	Goulden, P. A., Moriarty, M. S., Jackson, J., Hall, B., Ussery, D., Bursac, Z., et al. (2014) Effect of a telemedicine-based educational intervention on glucose control in type 2 diabetes in Arkansas. <i>Diabetes</i> , 63, A586.	Poster/Conference Abstract
18.	Holloway, B., Coon, P. J., Kersten, D. W., and Ciemins, E. L. (2011) Lifestyle and behavior. Telehealth in rural Montana: promoting realistic independent self-management of diabetes. <i>Diabetes Spectrum</i> , 24, 50–54.	Not a text messaging intervention
19.	Kardas, P., and Mazurkiewicz, M. (2013) Patients' assessment of point-of-care sensors for a telemedicine system for type 2 diabetes mellitus management: a focus-group study. <i>Diabetes Technology &amp; Therapeutics</i> , 15, A106–A107.	Poster/Conference Abstract
20.	Katz, R., Mesfin, T., and Barr, K. (2012) Lessons from a community-based mHealth diabetes self-management program: "it's not just about the cell phone." <i>Journal of Health Communication</i> , 17, 67–72.	Not a qualitative study
21.	Kim, S. G., Shin, D. H., Jeong, M. H., Park, J. R., Lee, Y. J., Yoo, H. J., et al. (2007) The effect of diabetes mobile phone-based telecare on glycemic control in subjects with type 2 diabetes. <i>Diabetes</i> , 56, A116–A117.	Poster/Conference Abstract
22.	Kim, S.I, and Kim H.S. (2008) Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes. <i>International Journal of Medical Informatics</i> , 77, 399–404.	Not a qualitative study
23.	Mathiesen, A. S., Thomsen, T., Jensen, T., Schiøtz, C., Langberg, H., and Egerod, I. (2017) The influence of diabetes distress on digital interventions for diabetes management in vulnerable people with type 2 diabetes: A qualitative study of patient perspectives. <i>Journal of Clinical and Translational Endocrinology</i> , 9, 41–47.	Not a text messaging intervention
24.	Mayberry, Lindsay S., Mulvaney, S., Johnson, K. B., & Osborn, C. Y. (2015) Texting intervention overcomes barriers to medication adherence among low-income, diverse adults with type 2 diabetes. <i>Diabetes</i> , 64, A224–A225.	Poster/Conference Abstract
25.	McMahon, K. L. (2016) Diabetes telehealth intervention comprising blood sugar data, home A1c, care continuity and motivational interviewing to effect behavior change in an adult type 2 diabetes population. <i>Diabetes Technology &amp; Therapeutics</i> , 18, A94.	Poster/Conference Abstract
26.	Michimi, A., Ellis-Griffith, G., Lartey, G., Ellis-Griffith, C., and Hunt, M. (2014) Variability between self-reported diabetes and measured glucose among health screening participants in South Central Kentucky. <i>Primary Care Diabetes</i> , 8, 31–38.	Not a qualitative study
27.	Miyamoto, S., Henderson, S., Young, H., Ward, D., and Santillan, V. (2013) Recruiting rural participants for a telehealth intervention on diabetes self-management. <i>Journal of Rural Health</i> , 29, 69–77.	Not a text messaging intervention
28.	Morton, K., Sutton, S., and Hardeman, W. (2015) A text-messaging and pedometer program to promote physical activity in people at high	Other (prediabetes patients were included)

	risk of type 2 diabetes: the development of the PROPELS follow-on support program. <i>JMIR Mhealth Uhealth</i> , 3, e105.	
29.	Nelson, L. A., LeSturgeon, L. M., Wallston, K. A., Bergner, E. M., and Mayberry, L. S. (2018) Disparities in mobile phone use among diverse patients with type 2 diabetes. <i>Annals of Behavioral Medicine</i> , 52, S727.	Poster/Conference Abstract
30.	Nelson, L. A., Mayberry, L. S., Wallston, K. A., Kripalani, S., Brown, C. K. G. A., Gregory, B. P., <i>et al.</i> (2016) Development and Feasibility of the REACH Tailored Text Messaging Intervention for Low-Income Adults with Type 2 Diabetes. <i>Diabetes</i> , 65, A207.	Poster/Conference Abstract
31.	Nelson, L. A., Mayberry, L. S., Wallston, K., Kripalani, S., and Osborn, C. Y. (2016) Development and usability of REACH: A tailored theory-based text messaging intervention for disadvantaged adults with type 2.	Other (a preliminary study)
32.	Nelson, L. A., Mulvaney, S. A., Ho, Y. X., Johnson, K. B., and Osborn, C. Y. (2015) Patient characteristics associated with engagement in a type 2 diabetes mhealth intervention. <i>Annals of Behavioral Medicine</i> , 49, S164.	Poster/Conference Abstract
33.	Nocella, J. M., Dickson, V. V., Cleland, C. M., and Melkus, G. D. (2014) Structure, process, and outcomes of care in a telehealth program for patients with type 2 diabetes. <i>Nursing Research</i> , 63, E101.	Poster/Conference Abstract
34.	Nundy, S., Mishra, A., Hogan, P., Lee, S. M., Solomon, M. C., and Peek, M. E. (2014) How do mobile phone diabetes programs drive behavior change? Evidence from a mixed methods observational cohort study. <i>The Diabetes Educator</i> , 40, 806–819.	Other (Type 1 and Type 2 patients were included, but no separate data were provided)
35.	Odnoletkova, I., Buysse, H., Nobels, F., Goderis, G., Aertgeerts, B., Annemans, L., & Ramaekers, D. (2016). Patient and provider acceptance of telecoaching in type 2 diabetes: a mixed-method study embedded in a randomised clinical trial. <i>BMC Medical Informatics and Decision Making</i> , 16, 142.	Not a text messaging intervention
36.	Osborn, C. Y., and Mulvaney, S. A. (2013) Development and feasibility of a text messaging and interactive voice response intervention for low-income, diverse adults with type 2 diabetes mellitus. <i>Journal of Diabetes Science and Technology</i> , 7, 612–622.	Other (a preliminary study)
37.	Patrick, K., Raab, F., Calfas, K. J., Norman, G. J., Gottschalk, M., James, S. F., and Covin, J. (2007) Cell phone text messaging use by adolescents in an intervention to prevent type 2 diabetes: Preliminary analyses. <i>Annals of Behavioral Medicine</i> , 33, S220.	Poster/Conference Abstract
38.	Peek, M. E., Mayberry, L., Lyles, C., Oldenburg, B., and Osborn, C. (2017) mHealth & internet interventions for disadvantaged people with type 2 diabetes: considerations & recommendations for research. <i>Annals of Behavioral Medicine</i> , 51, S1449–S1450.	Poster/Conference Abstract
39.	Pludwinski, S., Ahmad, F., Wayne, N., and Ritvo, P. (2016). Participant experiences in a smartphone-based health coaching intervention for type 2 diabetes: A qualitative inquiry. <i>Journal of Telemedicine &amp; Telecare</i> , 22, 172–178.	Not a text messaging intervention
40.	Po, Y. (2000) Telemedicine to improve patients' self-efficacy in managing diabetes. <i>Journal of Telemedicine and Telecare</i> , 6, 263–267.	Not a research study-review/opinion paper
41.	Podgrebelny, A., Zuev, M., Patrakeeva, E., Tiselko, A., Arbatskaya, N., Dosovitskaya, E., <i>et al.</i> (2013) The first m-health system for online observation and treatment of diabetes mellitus in Russia. <i>Diabetes Technology &amp; Therapeutics</i> , 15, A112–A113.	Poster/Conference Abstract
42.	Qiu, L., Tan, Y., Chen, L., Xu, W., Li, M., Weng, J., <i>et al.</i> (2015) Effectiveness of a text-message management system in the basal-	Poster/Conference Abstract

	supported oral therapy in Chinese type 2 diabetic patients with inadequate glycemic control when using oral anti-diabetic drugs. <i>DIABETES-METABOLISM RESEARCH AND REVIEWS</i> , 31, 48–49.	
43.	Quinn, C. (2014) Mobile health: patient engagement in diabetes care. <i>Diabetes Technology and Therapeutics</i> , 16, A32.	Poster/Conference Abstract
44.	Ralston, J. D., Revere, D., Robins, L. S., and Goldberg, H.I. (2004) Patients' experience with a diabetes support programme based on an interactive electronic medical record: qualitative study. <i>British Medical Journal</i> , 328, 1159–1162.	Poster/Conference Abstract
45.	Rentoumis, A., Angelidis, P., Fostiropoulos, L., Ntikoudi, A., Landis, G., Zacharopoulou, O., and Fappa, E. (2016) Enhancing the self management of type ii diabetes in elderly greeks using m- and e - health facilitated integrated care services and policy implications for Greece. <i>International Journal of Integrated Care</i> , 16, A353.	Poster/Conference Abstract
46.	Rotheram-Borus, M. J., Tomlinson, M., Gwegwe, M., Comulada, W. S., Kaufman, N., & Keim, M. (2012) Diabetes buddies: peer support through a mobile phone buddy system. <i>The Diabetes Educator</i> , 38, 357–365.	Not a qualitative study
47.	Shapiro, S., Stuckey, M., Sabourin, K., Munoz, C., & Petrella, F. U. (2011) Smartphone technology versus paper-based logs for type II diabetes prevention: psychological and behavioral outcomes. <i>Canadian Journal of Cardiology</i> , 27(5, 1), S180–S181.	Poster/Conference Abstract
48.	Shaw, R. J., Bosworth, H. B., Hess, J. C., Silva, S. G., Lipkus, I. M., Davis, L. L., and Johnson, C. M. (2013) Development of a theoretically driven mHealth text messaging application for sustaining recent weight loss. <i>Journal of Medical Internet Research</i> , 1, e5 .	Other (not included diabetes patients)
49.	Stamp, K., Allen, N. A., Lehrer, S., Zagarins, S., & Welch, G. (2012) Telehealth program for medicaid patients with type 2 diabetes lowers hemoglobin A1c. <i>Journal of Managed Care Medicine</i> , 15(4), 39–46.	Not a text messaging intervention
50.	Tao, H., Sun, X. Q., He, J. H., Yuan, X. X., and Huang, Z. R. (2014) An interactive telemedicine system improves diabetes management for type 2 diabetic patients in China. <i>DIABETES</i> , 63, A619.	Poster/Conference Abstract
51.	Thakkar, J., Barry, T., Thiagalingam, A., Redfern, J., McEwan, A. L., Rodgers, A., et al. (2016) Design considerations in development of a mobile health intervention program: the text me and textmeds experience. <i>JMIR MHealth and UHealth</i> , 4, e127.	Not a research study-review/opinion paper
52.	Toledo, F. G. S., Ruppert, K., Huber, K. A., and Siminerio, L. M. (2014) Efficacy of the telemedicine for reach, education, access, and treatment (TREAT) model for diabetes care. <i>Diabetes Care</i> , 37, e179-180.	Poster/Conference Abstract
53.	Travasso, C. (2013) Lifestyle advice by text messages helps prevent type 2 diabetes in high-risk men. <i>BMJ-British Medical Journal</i> , 347, f5750.	Not a research study-review/opinion paper
54.	Trief, P., Teresi, J., Izquierdo, R., Morin, P., Goland, R., Field, L. et al. (2007) Psychosocial outcomes of telemedicine case management for elderly patients with diabetes: the randomized IDEATel trial. <i>Diabetes Care</i> , 30, 1266-1268.	Not a text messaging intervention
55.	Trief, P.M, Teresi, J.A, Eimicke, J.P, Shea, S. and Weinstock, R. S. (2009) Improvement in diabetes self-efficacy and glycaemic control using telemedicine in a sample of older, ethnically diverse individuals who have diabetes: the IDEATel project. <i>Age &amp; Ageing</i> , 38, 219–225.	Not a text messaging intervention
56.	Verwey, R., van der Weegen, S., Spreeuwenberg, M., Tange, H., van der Weijden, T., and de Witte, L. (2014) A pilot study of a tool to	Not a text messaging intervention

	stimulate physical activity in patients with COPD or type 2 diabetes in primary care. <i>Journal of Telemedicine &amp; Telecare</i> , 20, 29–34.	
57.	Waki, K., Aizawa, K., Kato, S., Fujita, H., Lee, H., Kobayashi, H., <i>et al.</i> (2015) DialBetics with a multimedia food recording tool, foodlog: smartphone-based self-management for type 2 diabetes. <i>Journal of Diabetes Science and Technology</i> , 9, 534–540.	Not a text messaging intervention
58.	Waki, K., Fujita, H., Uchimura, Y., Aramaki, E., Omae, K., Kadowaki, T., and Ohe, K. (2012) DialBetics: smartphone-based self-management for type 2 diabetes patients. <i>Journal of Diabetes Science and Technology</i> , 6, 983–985.	Not a text messaging intervention
59.	Weinstock, R.S., Brooks, G., Palmas, W., Morin, P.C., Teresi, J. A., Eimicke, J. P. (2011) Lessened decline in physical activity and impairment of older adults with diabetes with telemedicine and pedometer use: results from the IDEATel study. <i>Age &amp; Ageing</i> , 40, 98–105.	Not a research study-review/opinion paper
60.	Weinstock, R.S., Izquierdo, R., Goland, R., Palmas, W., Teresi, J.A., Eimicke, J.P. <i>et al.</i> (2010) Lipid treatment in ethnically diverse underserved older adults with diabetes mellitus: statin use, goal attainment, and health disparities in the informatics for diabetes education and telemedicine project. <i>Journal of the American Geriatrics Society</i> , 58, 401–402.	Not a text messaging intervention
61.	Wu, C.-J. J., Chang, A. M., Courtney, M., and Ramis, M.-A. (2012) Using user-friendly telecommunications to improve cardiac and diabetes self-management programme: a pilot study. <i>Journal of Evaluation in Clinical Practice</i> , 18, 695–697.	Not a qualitative study

## Appendix XIV. Critical appraisal of included studies

(based on CASP, 2018)

Critical Appraisal Questions	Aims & Objectives	Appropriate methodology	Appropriate research design	Appropriate recruitment strategy	Appropriate data collection?	Has the relationship between the 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?	How valuable is the research?	Overall appraisal
Bergner et al., 2017	Yes Study objectives were reported in detail	Yes Subjective experiences were examined	Yes Mixed methods research, qualitative phase as a follow-up	Yes Using small sample size and convenient sampling are common in qualitative research	Yes The procedure was explained in detail	Yes Personal interaction was limited due to telephone interviews	Yes Consent forms were obtained, and the University ethics approval was received	Yes A detailed description of the analysis process was provided	Yes Findings and key themes were reported in detail	Yes Strengths and implications were explained	High quality
Burner et al., 2013	Yes Study objectives were reported in detail	Yes The study was conducted to provide more explanations to prior research that requires qualitative analysis	Yes Mixed methods research, qualitative phase as a follow-up	Yes The recruitment process was explained in detail	Yes Data collection process was reported in detail	Yes Experienced and bilingual researcher moderated the sessions, used a structured guide and prevented discussion	Yes Participants' consents were taken	Yes Data analysis procedure was explained	Yes Findings and comparisons between patient groups were reported	Yes Contributions and limitations were reported	High quality

						from being stalled					
Burner et al., 2014	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		High quality
	Study objectives were reported	Qualitative analysis is needed to uncover patients' attitudes and behaviors toward the program	A qualitative study conducted and reported after a large trial	The recruitment process was explained (linked with the trial)	Data collection process was reported in detail	Experienced and bilingual researcher moderated the sessions, used a structured guide	The study was approved by the Institutional Review Board.	Grounded theory and coding process were explained in detail	Findings and themes were reported in detail	Contributions, implications, and limitations were reported	
Burner et al., 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	Study objectives were reported in detail	Patient experiences with the program were assessed in detail	Mixed methods research, qualitative phase as a follow-up	Recruitment strategy was reported in detail	Data collection process was reported	Experienced, bilingual researchers moderated the sessions	The University Institutional Review Board approval was obtained, and the trial was registered	Grounded theory and coding process were explained in detail	Findings and themes were reported	Contributions, implications, and limitations were reported	
Chen et al., 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	Study objectives were reported in detail	Patient perspectives were explored	A qualitative study	Randomization process and recruitment strategy was reported in detail	Data collection process was reported	Experienced researcher moderated the sessions, and another researcher took field notes	Consent forms were obtained, and the University Ethics Approval was gained	A detailed analysis process was reported	Themes were explained, and suggestions were made	Strengths and limitations were reported, implications were reported	
	Yes	Yes	Yes	Yes	NC	No	Yes	No	No	NC	

Fortmann et al., 2017	Study objectives were reported	Patients' experiences were examined	Mixed methods research, qualitative phase as a follow-up	Recruitment strategy was reported	Limited details were provided	No details were provided	Institutional Review Board approval was obtained, consent forms were signed	No details were reported	Limited details were shared about qualitative results	No details shared about the contribution of the qualitative results	Low quality
Gatwood et al., 2015	Yes Study objectives were reported in detail	Yes Participants' experiences were examined in detail	Yes Mixed methods research, qualitative phase as a follow-up	Yes Recruitment strategy was reported	Yes Data collection process were reported	NC Telephone interviews were conducted, and the notes were recorded on a structured form	Yes University Institutional Review Board Approval was obtained, research data were securely stored	No No details were reported	Yes Qualitative findings and themes were reported in detail	Yes Contributions and limitations were explained	Medium quality
Georgsson and Staggers, 2017	Yes	Yes	Yes	Not clear	Yes	Not clear	Yes	Yes	Yes	Yes	High quality
	Aims were presented	The study questions require using qualitative methodology	It is a follow-up study after a large trial	Random selection was made, but the sample was homogeneous	Procedures and tools were explained	Limited information was provided for the interview process	Consent forms were obtained	Details were provided, the theoretical framework was discussed	Themes, sub-themes and their link with theory were reported	Strengths and contributions were explained	
Horner et al., 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	The objectives were clearly described	Perceptions and experiences were	A follow-up study after a large trial	Recruitment procedure was clearly explained	Techniques and procedures were	Researchers were trained for the interviews	University Institutional Review Board Approval	Data analysis process was clearly explained	Themes were clearly and in detail	Unique characteristics of the study were explained	

		examined in detail			reported in detail	and discussions	was received		were explained		
Mamykina et al., 2016	Yes	Yes	Yes	Yes	Yes	Not Clear	Not clear	Yes	Yes	Yes	High quality
	Study objectives were reported in detail	Subjective experiences of participants were examined	A qualitative study of an ongoing trial	Recruitment procedure was clearly explained	Data collection process was reported in detail	The research team had no interaction with participants during the ongoing trial	A University Funded study	Data analysis procedure was explained	Themes were explained in detail	Contributions and limitations of the study were discussed	
Mayberry et al., 2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		High quality
	Study goals were reported in detail	Usability testing requires qualitative evaluations	A qualitative study including three round tests	Recruitment procedure was reported	Data collection process was reported in detail	Researchers were trained	Participants consents were obtained, and University Institutional Review Board Approval was received	Data analysis process was reported	Findings, changes, and themes were reported	Contributions and limitations were explained, implications were provided	
Nelson et al., 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	Study objectives were reported in detail	Subjective experiences were examined	Mixed methods research, qualitative phase as a follow-up	Recruitment strategy was reported	Data collection procedure was reported in detail	Trained researchers made the interviews and used a semi-structured guideline	University Institutional Review Board Approval was obtained, informed consent of participants was taken	Data analysis approach, coding process were clearly explained	Findings and recommendations were reported	Strengths, contributions, and limitations were reported	

Nundy et al., 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	Study objectives were reported in detail	Exploratory questions require qualitative study	A qualitative study	Recruitment procedures were reported	Techniques and procedures were reported in detail	Experienced researchers interviewed and used a topic guide	University Institutional Review Board Approval was obtained	Data analysis approach, coding process were clearly explained	Findings and their links with theoretical constructs were clearly explained	Strengths, limitations, and implications were reported	
Watterson et al., 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High quality
	Study rationale and objectives were reported	patients' experiences with the program were explored	Mixed methods research, qualitative phase as a follow-up	The recruitment process was explained	The procedure was reported in detail	Bilingual researchers were employed, and original Spanish questionnaires were used	Consent forms were obtained, and University Ethics Approval was gained	Data analysis, coding process was clearly explained	The findings and their links with the literature were reported	Contributions and future directions were reported	

**Appendix XV. CERQual assessment of confidence in the findings of the thematic synthesis**

Themes/Findings	Studies Contributing to the Review Finding	Assessment of Relevance	Assessment of Coherence	Assessment of Adequacy	Overall CERQual Assessment of Confidence
<b>Domain 1: Perspectives on interventions/programs</b>					
<b>MESSAGE CONTENT</b>					
<b>Tailoring &amp; personalization</b>	Burner et al., 2018 Burner et al., 2014 Gatwood et al., 2015 Horner et al., 2017 Nelson et al., 2017 Watterson et al., 2018 Chen et al., 2018 Bergner et al., 2017 Nundy et al., 2013	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, nine studies provided rich data	High confidence
<b>Message variability</b>	Gatwood et al., 2015 Nelson et al., 2017 Watterson et al., 2018 Chen et al., 2018 Horner et al., 2017 Burner et al., 2013	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, six studies provided rich data	High confidence
<b>Informative/educational content</b>	Chen et al., 2018 Gatwood et al., 2015 Georgsson and Staggers, 2017 Nelson et al., 2017 Bergner et al., 2017 Burner et al., 2013 Watterson et al., 2018	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, seven studies provided rich data	High confidence

<b>Simple and easy to read</b>	Georgsson and Staggers, 2017 Chen et al., 2018 Bergner et al., 2017 Mayberry et al., 2016	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, four studies provided rich data	High confidence
<b>Goal-oriented messages with attainable goals</b>	Burner et al., 2014 Burner et al., 2018 Horner et al., 2017 Mayberry et al., 2016 Watterson et al., 2018 Mamykina et al., 2016	Moderate concerns about relevancy, although the studies were from one setting, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, six studies provided rich data	High confidence
<b>Motivational content and feedback</b>	Bergner et al., 2017 Burner et al., 2018 Burner et al., 2014 Gatwood et al., 2015 Nelson et al., 2017 Watterson et al., 2018 Mamykina et al., 2016 Mayberry et al., 2016 Horner et al., 2017 Georgsson and Staggers, 2017 Nundy et al., 2013	Moderate concerns about relevancy, although the studies were from one setting, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, eleven studies provided very rich data	High confidence
<b>Authoritative sources</b>	Chen et al., 2018	Substantial concerns about the relevancy-one study from an authoritarian country setting	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided thin data	Low confidence
<b>MESSAGE DELIVERY</b>					
<b>Tailoring message timing and frequency</b>	Burner et al., 2018 Burner et al., 2014 Gatwood et al., 2015 Horner et al., 2017 Nelson et al., 2017 Watterson et al., 2018 Chen et al., 2018 Nundy et al., 2013	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, eight studies provided very rich data	High confidence

<b>Interactivity</b>	Horner et al., 2017 Watterson et al., 2018 Chen et al., 2018 Mayberry et al., 2016	Moderate concerns about relevancy, although the studies were from two settings, there were a diverse group of patient participants	Minor concerns about coherence, most data were consistent within and across the studies	Minor concerns about adequacy, four studies provided rich data	High confidence
<b>Human contact</b>	Nundy et al., 2013 Horner et al., 2017	Moderate concerns about relevancy. Although the studies were from one setting, there were a diverse group of patient participants	Moderate concerns about coherence, some data were consistent within and across the studies	Moderate concerns about adequacy, two studies provided not very powerful data	Moderate confidence
<b>ADDITIONAL FEATURES</b>					
<b>Personal log</b>	Georgsson and Staggers, 2017	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Social integration</b>	Georgsson and Staggers, 2017	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Voice integration</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were all in the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Calorie counter</b>	Georgsson and Staggers, 2017	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Glucose meter</b>	Georgsson and Staggers, 2017	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Link to resources</b>	Nelson et al., 2017	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Connection with care providers</b>	Gatwood et al., 2015	Substantial concerns about relevance, the study setting was from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>MESSAGE USEFULNESS</b>					

<b>Emotionally supported</b>	Bergner et al., 2017 Horner et al., 2017 Nelson et al., 2017 Watterson et al., 2018 Nundy et al., 2013 Mayberry et al., 2016 Georgsson and Staggers, 2017 Burner et al., 2018	Moderate concerns about relevancy. Although the studies were from one setting, there were diverse groups of patient participants	Minor concerns about coherence, all data were consistent within and across the studies	Minor concerns about adequacy, eight studies provided very rich data	High confidence
<b>Increased self-awareness and control</b>	Nundy et al., 2013 Bergner et al., 2017 Burner et al., 2014 Horner et al., 2017 Mamykina et al., 2016 Nelson et al., 2017 Georgsson and Staggers, 2017	Moderate concerns about relevancy. Although the studies were from one setting, there were diverse groups of patient participants	Minor concerns about coherence, all data were consistent within and across the studies	Minor concerns about adequacy, seven studies provided very rich data	High confidence
<b>Improved overall diabetes management</b>	Burner et al., 2014 Mamykina et al., 2016 Mayberry et al., 2016 Watterson et al., 2018 Nundy et al., 2013 Burner et al., 2013 Burner et al., 2018	Moderate concerns about relevancy. Although the studies were from one setting, there were diverse groups of patient participants	Minor concerns about coherence, all data were consistent within and across the studies	Minor concerns about adequacy, seven studies provided very rich data	High confidence
<b>Effective reminder</b>	Gatwood et al., 2015 Bergner et al., 2017 Georgsson and Staggers, 2017 Horner et al., 2017 Nundy et al., 2013 Mayberry et al., 2016 Burner et al., 2014 Nelson et al., 2017 Watterson et al., 2018 Burner et al., 2018	Moderate concerns about relevancy. Although the studies were from one setting, there were diverse groups of patient participants	Minor concerns about coherence, all data were consistent within and across the studies	Minor concerns about adequacy, ten studies provided very rich data	High confidence
<b>Improved communication with family/ doctors</b>	Burner et al., 2018 Georgsson and Staggers, 2017	Moderate concerns about relevancy. Although the studies were from one	Minor concerns about coherence, most data were	Minor concerns about adequacy, five studies provided very rich data	High confidence

	Mayberry et al., 2016 Nundy et al., 2013 Nelson et al., 2017	setting, there were diverse groups of patient participants	consistent within and across the studies		
<b>Domain 2: Perceptions about text messaging</b>					
<b>Barriers- poor eyesight</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Barriers-poor education level</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Barriers-medical jargon</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were from the USA.	Substantial concerns about coherence, not grounded in other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Barriers-monotonous content</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Barriers-too much frequency</b>	Chen et al., 2018	Substantial concerns about relevance, the study setting was in China while others were from the USA.	Substantial concerns about coherence, not consistent with other studies	Substantial concerns about adequacy, only one study offering thin data	Low confidence
<b>Benefits-convenient and accessible</b>	Bergner et al., 2017; Chen et al., 2018; Gatwood et al., 2015	Minor concerns about relevance, although there were only 2 settings, this finding is a well-known characteristic of text messaging	Minor concerns about coherence, data consistent within and across the studies	Minor concerns about adequacy, three studies together provided rich data	High confidence
<b>Benefits-ability to store and review information</b>	Bergner et al., 2017 Chen et al., 2018 Georgsson and Staggers, 2017 Gatwood et al., 2015 Mayberry et al., 2016 Watterson et al., 2018	Minor concerns about relevance, although there were 2 settings, this finding reflects a well-known characteristic of text messaging	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, five studies together provided rich data	High confidence

<b>Benefits- an informational/educational tool and a reminder</b>	Gatwood et al. 2015 Chen et al., 2018	Minor concerns about relevance, although there were 2 settings, this finding reflects a well-known characteristic of text messaging	Moderate concerns about coherence, partially consistent data within the studies	Moderate concerns about adequacy, only two studies both offering not very strong data	Moderate confidence
<b>Domain 3: Experiences with diabetes management</b>					
<b>Forgetfulness in taking/refiling medications</b>	Chen et al., 2018 Georgsson and Staggers, 2017 Bergner et al., 2017 Nundy et al., 2013	Minor concerns about relevance, although the studies were coming from only two settings (USA), this finding reflects a common attitude of diabetes patients	Minor concerns about coherence, data were consistent within and across the studies	Minor concerns about adequacy, four studies provided rich data	High confidence
<b>Worrying about the side effects of meds</b>	Chen et al., 2018	Substantial concerns about relevancy-only one study and from China	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided data	Low confidence
<b>Lack of knowledge of diabetes symptoms &amp; complications</b>	Chen et al., 2018 Nundy et al., 2013	Substantial concerns about relevancy-only two studies and different settings, one from the USA and the other from China	Moderate concerns about coherence, data were consistent within and across the studies	Moderate concerns about adequacy, two studies provided moderate data	Moderate confidence
<b>Lack of knowledge of the importance of BG monitoring</b>	Chen et al., 2018	Substantial concerns about relevancy-only one study and from China	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided thin data	Low confidence
<b>Being anxious about taking insulin/meds in front of friends/family</b>	Nelson et al., 2017	Substantial concerns about relevancy-only one US-based study	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided thin data	Low confidence
<b>Gender differences in dietary self-efficacy</b>	Burner et al., 2013	Substantial concerns about relevancy-only one US-based study	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided thin data	Low confidence

<b>Gender differences in the source of information</b>	Burner et al., 2013	Substantial concerns about relevancy-only one US-based study	Substantial concerns about coherence, data were not consistent with the other studies	Substantial concerns about adequacy, only one study provided thin data	Low confidence
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## Appendix XVI. Certificate of ethical approval



University of Victoria

University of Victoria  
Human Research Ethics Board  
Michael Williams Building, R. B202 PO Box 1700  
STN CSC  
Victoria, BC V8W 2Y2  
Tel: 250-472-4545

### Certificate of Ethical Approval: Amendments for Harmonized Minimal Risk Behavioural Study

Also reviewed and approved by:

• Island Health



<b>Principal Investigator:</b> Karen Courtney	<b>Primary Appointment:</b> University of Victoria, Faculty; Island Health Affiliated Researcher	<b>Board of Record REB Number:</b> BC19-0152	<b>REB Number:</b> H19-00598
<b>Study Title:</b> Designing Text Messages for Type 2 Diabetes			
<b>Approval Date:</b> October 25, 2019		<b>Expiry Date:</b> May 14, 2020	
<b>Research Team Members:</b>	Patti-Jean Naylor, University of Victoria, Faculty Ryan Rhodes, University of Victoria, Faculty Cigdem Sahin, University of Victoria, Graduate student		
<b>Sponsoring Agencies:</b>	N/A		
<b>Documents included in this approval:</b>	<b>Document Name</b>	<b>Version</b>	<b>Date</b>
	<b>Consent Forms:</b>		
	Participant consent form	3	October 23, 2019
	<b>Advertisements:</b>		
	Recruitment Materials-Online Post (Facebook)	3	October 23, 2019
Recruitment Materials-Poster	3	October 23, 2019	
Recruitment Materials-Online Post (General)	1	October 23, 2019	
This ethics approval applies to research ethics issues only and does not include provision for any administrative approvals required from individual institutions before research activities can commence.			
The Board of Record (as noted above) has reviewed and approved this study in accordance with the requirements of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2, 2014).			
The "Board of Record" is the Research Ethics Board delegated by the participating REBs involved in a harmonized study to facilitate the ethics review and approval process.			
The application for ethical review and the document(s) listed above have been reviewed and the			

procedures were found to be acceptable on ethical grounds for research involving human subjects.

This study has been approved either by the Board of Record's full REB or by an authorized delegated reviewer.

**Supplementary: Calculating the standard deviation at final follow-up**  
(for Capozza, et al., 2015)

The below formula<sup>1</sup> was used to calculate the final SD, and the relevant data were derived from Arambepola, et al., 2016.

$$SD_{E,change} = \sqrt{SD_{E,baseline}^2 + SD_{E,final}^2 - (2 \times Corr \times SD_{E,baseline} \times SD_{E,final})}$$

Intervention Group SDchange 15.2 = squareroot (2.1<sup>2</sup> + SD<sup>2</sup><sub>Final</sub> - (2x0.5 x 2.1x SD<sub>final</sub>)

**Intervention SD<sub>final</sub> = 17.3**

Control Group SDchange 12.4 = squareroot (1.8<sup>2</sup> + SD<sup>2</sup><sub>final</sub> - (2x0.5 x 1.8xSD<sub>final</sub>)

**Control SD<sub>final</sub> = 14.2**

1. From <http://handbook-5>

1.cochrane.org/chapter\_16/16\_1\_3\_2\_imputing\_standard\_deviations\_for\_changes\_from\_baselin  
e.htm