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DIABETIC Medicine

SYSTEMATIC REVIEW

Diabetes self-management education and support delivered by mobile health (mHealth) interventions for adults with type 2 diabetes—A systematic review and meta-analysis

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Abstract

Background: Diabetes self-management education (DSME) and support (DSME/S) delivered via mobile health (mHealth) is potentially cost-effective, if proven effective.

Objectives: To assess the effectiveness of DSME, DSMS or DSME/S delivered by mHealth interventions compared to usual care (UC) or attention placebo control (APC) in adults with type 2 diabetes.

Methods: We searched (1) MEDLINE, (2) Embase, (3) PsycINFO, (4) Cochrane Central Register of Controlled Trials via the Cochrane Register of Studies Online, (5) ClinicalTrials.gov, and (6) World Health Organization International Clinical Trials Registry Platform from the year 2000 to January 31, 2023. We included RCTs comparing DSME/S delivered via mHealth versus UC or APC. Four authors independently selected trials, assessed risk of bias and extracted data. Primary outcome was HbA1c, outher outcomes secundairy. Meta-analysed with random-effects model was used.

Results: We included 43 trials involving 9328 participants; sample sizes ranging from 20 to 1119. Pooled effects on HbA1c were for DSME: mean difference (MD) of −4 mmol/mol (−0.3%), 95% CI −6 mmol/mol (−0.6%) to −1 mmol/mol (−0.1); $p = 0.002$; DSMS MD −4 mmol/mol (−0.4%), 95% CI 7 mmol/mol (−0.6%) to −2 mmol/mol (−0.2); $p < 0.001$; and DSME/S MD of −2 mmol/mol (−0.2%) for HbA1c, 95% CI −3 mmol/mol (−0.3%) to −0 mmol/mol (−0.0%); $p < 0.001$. We found uncertain effects on other outcomes.

Conclusions: mHealth interventions delivering self management education with or without support to adults with type 2 diabetes appear to have a modest beneficial effect on HbA1c. Only a few trials investigated patient-reported outcomes.

KEYWORDS

adults, education, meta-analysis, mHealth, self-management, support, type 2 diabetes

1 | INTRODUCTION

Diabetes self-management education (DSME) provides individuals with type 2 diabetes with the knowledge, abilities and skills necessary for diabetes self-management.[1] To implement and sustain the targeted behaviour, people should also receive diabetes self-management support (DSMS), defined as "activities that assist the person with diabetes in implementing and sustaining the behaviours needed to manage his or her condition on an ongoing basis".[2] DSME and DSMS together are referred to as DSME and support, which forms the essential basis for self-management in individuals with type 2 diabetes.[2]

Traditionally, DSME/S has been delivered via face-to-face contact between individuals with type 2 diabetes and healthcare providers. However, the number of diabetes monitoring visits is limited and therefore, healthcare providers are only able to provide individuals with DSME/S a few times per year. This may lead to an overwhelming amount of information for individuals during the diabetes monitoring visits. Additionally, in some countries, the number of healthcare providers cannot keep up with the increasing number of individuals with type 2 diabetes. These shortcomings have prompted the need for innovative and (cost-)effective solutions to support the healthcare providers in delivering DSME/S.

New technologies have the potential to deliver DSME/S and consequently improve diabetes self-management. A potential low-cost and easily accessible way to provide DSME/S may be by using mobile health (mHealth). mHealth is healthcare that is provided using mobile or electronic devices, such interventions can be personalised to the individual and integrated into daily life. A Cochrane Review on computer-based diabetes self-management interventions, published in 2013 (including any application that takes input from a patient and uses communication or processing technology to provide a tailored response that facilitates one or more aspects of diabetes self-management), found that computer-based interventions had small benefits on glycaemic control (low- to moderate-quality evidence); the effect size was larger in the mobile phone group.[3] Since then, mHealth interventions have continued to gain popularity, but their effects remain uncertain. Due to the continuous introduction of new applications (apps) and the removal of existing ones, it is challenging to determine the precise number of mHealth apps globally. However, by 2021, the count surpassed 350,000,[4] with diabetes being one of the most commonly addressed conditions by these apps.[5] Although randomised controlled trials (RCTs) have evaluated a few of these interventions,[6] most apps are not supported by evidence, making it hard to choose one that is suitable to facilitate DSME/S. Evidence on the effectiveness of mHealth interventions may help people with type 2 diabetes and their healthcare providers to make better decisions regarding their use.

What's new?

The continuous introduction of new applications (apps) for diabetes self-management education and support delivered gives an opportunity to support healthcare providers if these apps are provided in a unidirectional way. This systematic review and meta-analysis showed that unidirectional diabetes self-management education and support delivered is effective in reducing HbA1c.

This systematic review aims to assess the effectiveness of DSME, DSMS or both delivered by mHealth interventions versus usual care (UC) or attention placebo control (APC) in adults with type 2 diabetes.

2 | METHODS

2.1 | Search strategies

Relevant publications discussing DSME, DSMS or both interventions were searched in six databases: (1) MEDLINE, (2) Embase, (3) PsycINFO, (4) Cochrane Central Register of Controlled Trials via the Cochrane Register of Studies Online, (5) ClinicalTrials.gov, and (6) World Health Organization International Clinical Trials Registry Platform. The search string was developed together with a skilled librarian and combined three groups of words; words related to the population, the intervention and the study design (i.e., RCT). Specific search strings are shown in Appendix A. The search was limited to publications published from 2000 and onwards. The last search was conducted on January 31, 2023. Other potentially eligible publications were identified by searching the reference lists of the included publications, systematic reviews, meta-analyses and health technology assessment reports. In addition, authors of included publications were contacted to identify any additional and/or missing information on the retrieved study and to identify further publications that may have been missed. The protocol of the systematic review was published before (CD012869).

2.2 | Study selection

Four authors (AMB, RV, AV, MH) independently screened the title and abstract of every publication

retrieved to determine its eligibility. The full-text of all potentially relevant publications was obtained and screened for eligibility. Any disagreements were resolved through consensus or by recourse to a fifth author (GR).

Several inclusion criteria were used to determine eligibility. First, publications were included when they investigated a mHealth intervention that provided: (a) DSME, (b) DSMS, or (c) DSME/S. Second, the intervention should target adults (aged 18 or older) with type 2 diabetes. Trials involving participants with comorbid disorders were eligible for inclusion as long as the primary focus of the intervention was DSME, DSMS or DSME/S. Trials involving a broader population (e.g., individuals with a chronic illness) were only included when the results for individuals with type 2 diabetes were presented separately. When these data were not available, a request was sent to the authors. Third, the study design was an RCT. Fourth, the mHealth intervention was eligible when the intervention was provided either via short message service (SMS), text messages, voice messages (including automated telephone calls) or via a smartphone application. All mobile devices were eligible vehicles for the intervention: mobile phones, smartphones, tablets and other mobile devices. Wearables were only included when the intervention was delivered directly to the wearable, or when the intervention was delivered to a mobile phone, smartphone or other mobile device that was connected to the wearable. Fifth, the comparator condition discussed was either UC or APC; the APC group does not receive the actual intervention but receives an intervention that covers the same amount of time and attention as the experimental group received[7]. Lastly, relevant outcome data should be discussed (see 'Coding').

Publications were excluded when they focused on personal communication by mobile devices only, such as telephone calls with healthcare providers. Also, non-automated interventions, such as tailored feedback on glucose values from healthcare providers, were excluded. Because we were looking for mHealth interventions that could cope with the worldwide increasing incidence of type 2 diabetes and the relative scarcity of healthcare providers, we excluded trials reporting on remote monitoring of patients and novel ways of patient-provider communication, but also trials that investigated mHealth interventions that were primarily data records/diaries. However, interventions with only contact between individuals with diabetes and healthcare providers in case of concern about health outcomes or values, were considered automated as such procedures can ensure safety. Publications investigating personal records, data entries or diaries, and trials investigating mHealth interventions targeting healthcare providers were also excluded. Additionally, non-peer-reviewed papers (e.g., thesis, books), study protocols, reviews and meta-analyses were excluded.

2.3 | Coding

A standardised coding form was used to extract all relevant data from each publication. The following data was extracted: (a) first author, (b) publication year, (c) study design, (d) study setting, including country, (e) trial period, (f) intervention characteristics and duration, (g) type of comparator (UC or APC), (h) sample characteristics (inclusion criteria, number of participants randomised, gender, age and diabetes duration), and (i) outcome measure(s) and results.

The following outcomes were collected. Glycosylated haemoglobin A1c (HbA1c) measured as % or mmol/mol. Body weight: measured in kilograms (kg) or as body mass index (BMI, in kg/m^2). Hypoglycaemic episodes: classified as mild (self-managed), moderate (daily activities interrupted but self-management) and severe (requiring assistance from others), or as trial authors' definition. Adverse events other than hypoglycaemic episodes, all-cause mortality, health-related quality of life/health status, diabetes treatment satisfaction, self-care behaviours, systolic and diastolic blood pressure, lipid profile (total cholesterol, high-density lipoprotein [HDL]-cholesterol, low-density lipoprotein [LDL]-cholesterol and triglycerides), fasting plasma glucose (FPG), and healthcare related costs were also analysed. HbA1c was the primary outcome. Taking the generally accepted minimally relevant difference into account, a mean difference (MD) of 4 mmol/mol (0.4%) was considered clinically relevant.

2.4 | Assessment of risk of bias in included studies

Three authors (AMB, RV, AV) independently assessed the risk of bias for each included publication using the Cochrane 'Risk of bias' assessment tool. The tool identifies the following seven domains: (a) random sequence generation (selection bias), (b) allocation concealment (selection bias), (c) blinding of participants and personnel (performance bias), (d) blinding of outcome assessment (detection bias), (e) incomplete outcome data (attrition bias), (f) selective reporting (reporting bias), and (g) other potential sources of bias. Per publication, each domain was rated as having a 'low', 'high' or 'unclear' risk. The risk was labelled as 'unclear' when insufficient information was provided to make the judgement. The domains performance bias, detection bias and attrition bias were rated separately for objective and subjective outcomes.

2.5 | Data analyses

When two or more publications reported data on a given outcome, an estimate of the effect size was calculated. For continuous outcomes measured on the same scale, the MD

with 95% confidence interval (CI) was used as an estimate of the effect size. The MD for the continuous outcomes was calculated using the mean, standard deviation (SD) and sample size reported at post-intervention. For dichotomous data, the risk ratio (RR) or Peto's odds ratio with 95% CI were used as an estimate of effect. Both were calculated using the frequency of the event in both conditions and the sample size. Peto's odds ratio was used for rare events, occurring at rates below 1%. A random effect model was used with due consideration to the whole distribution of effects and a prediction interval was presented.[8]

In case of missing data, the authors of the publication were contacted. When the mean or SD for outcomes was not obtained, we imputed these values by estimating the mean and variance from the median, range, sample size, and figures embedded in the manuscript.[9] Data from cross-over trials was included; however, only the data from the first period to avoid the risk of bias due to carry-over effects.[10] Besides investigating whether the effect of the intervention differed from pre- to post-intervention, subgroup analyses were done for the primary outcome HbA1c. These analyses make it possible to identify whether the effect differed for gender, age (<60 years versus ≥60 years), the proportion of people receiving insulin (<50% versus ≥50%), level of metabolic control (HbA1c >64 mmol/mol [>8.0%] versus HbA1c ≤64 mmol/mol [≤8.0%]), and type of control group (APC versus UC).

Heterogeneity was assessed using the Q and I^2 statistics. There is true variation in the effect size when the Q-statistic is significant, and the I^2 statistic indicates the amount of real variance.[11] A p-value of ≤. 05 was used to determine significance; however, when the number of studies or sample size was small, a value of ≤0.10 was used.[10] As an indication of publication bias, the funnel plots were visually inspected when there were 10 or more trials for any outcome. The software Review Manager version 5.4.1 was used for all the analyses.[12]

3 | RESULTS

The electronic database search yielded 3857 records after the removal of duplicates (see Figure 1). Of these, 3618 were excluded after screening on title and abstract. Of the remaining 239 records, 159 records were excluded. The main reason for exclusion after full-text evaluation was the ineligibility of the intervention. Another 18 trials were classified as potentially relevant and ongoing; 23 trials were included as potentially relevant studies awaiting classification. Via MEDLINE auto alerts, we identified four additional completed trials. A total of 43 trials (45 records) were considered relevant and were included in the qualitative/ meta-analysis (see Table 1). All references of the included studies are shown in Appendix D.

3.1 | Description of studies

Eight trials (nine records) investigated an intervention providing only DSME; six trials (7 records) compared DSME to UC,[13–19] two trials to APC.[20,21] Sixteen trials (17 records) studied only DSMS of which nine trials (10 records) compared DSMS to UC[22–31] and seven compared DSMS to APC.[32–38] Interventions consisting of a combination of DSME and DSMS were studied in 18 trials; 14 trials were performed using a UC control group[39–52] and four using an APC group.[53–56]

The trials were performed in Asia (n = 3600), North America (n = 2096), Africa (n = 1209), Europe (n = 1141), Oceania (n = 1110) and South America (n = 172), and both in primary and secondary care settings.

While most trials reported on clinical outcomes such as HbA1c, FPG and BMI, only a few investigated patient-reported outcomes such as treatment satisfaction, health-related quality of life/health status and self-care behaviour.

3.2 | Risk of bias in included studies

All of the included studies had some methodological weaknesses, see Figure 2,C1. Nineteen trials[19,28,30,31,46,47,51,52,55] reported sufficient information on both sequence generation and allocation concealment and were classified as low risk of selection bias.[15,17,23,26,32,41,42,45,53,54] Due to the nature of the interventions, which requires overt participation, blinding the participants was not possible. In two trials, the outcome assessor was blinded,[17,53] but in these trials, some outcomes were assessed by the participants who were not blinded (for example self-care behaviours). One of these two trials also reported blinding of the treating physicians.[17] In one trial, the outcome assessor of the primary outcome was blinded.[42] We classified the outcome 'all-cause mortality' as a low risk of performance bias since this outcome is unlikely to be influenced by blinding. Concerning detection bias (blinding of the outcome assessor), we judged most laboratory outcomes as low risk of bias. For other outcomes, the risk of detection bias differed per trial. In five studies all randomised participants completed the trial.[13,16,20,22,31] In the other trials, the percentage of randomised participants completing the trial ranged from 57.2%[43] to 98.1%.[42] One trial randomised eligible participants before they were contacted for participation and before the last two eligibility criteria could be applied, resulting in a percentage of randomised participants who completed the trial of only 19.4%.[25] Thirteen trials were classified as high risk of reporting bias because the authors did not report all outcomes that were pre-specified in the study protocol paper or trial register, or because the authors

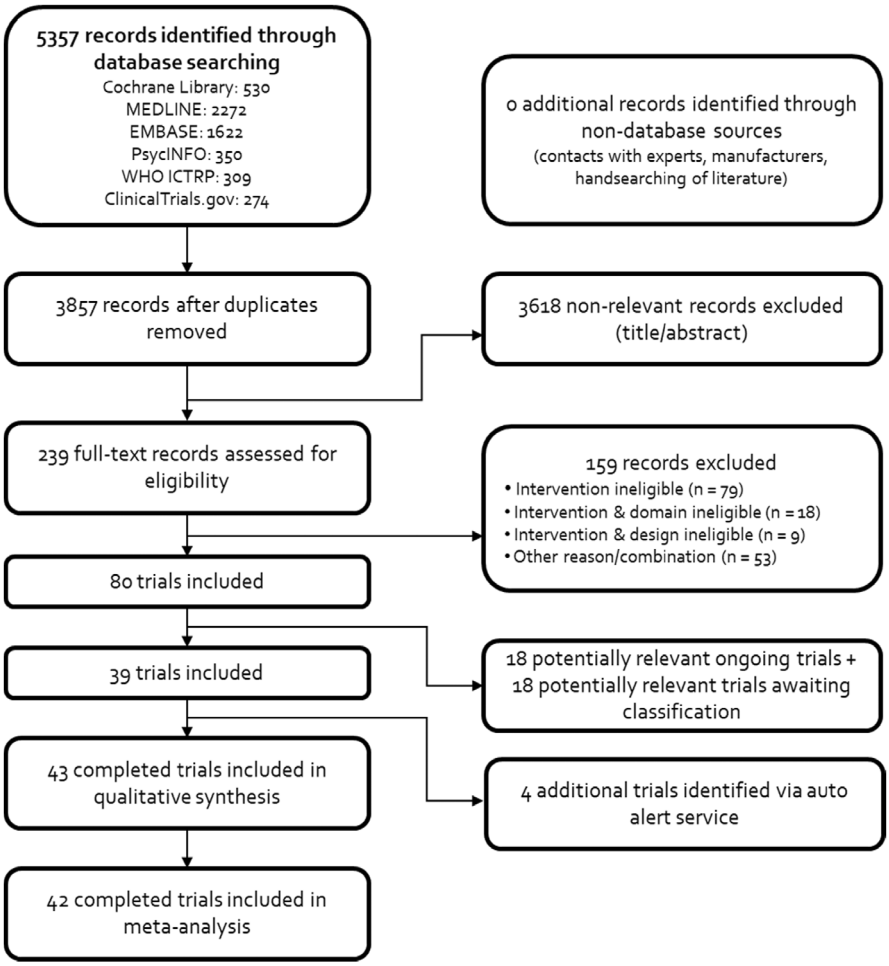

FIGURE 1 PRISMA flow diagram. The included trials were conducted between 2008 and 2023. In total, these trials included 9200 participants; the individual sample size ranged from 20[27] to 1119.[49] The duration of the intervention ranged from 1 week[55] to 12 months.[22,35] The duration of follow-up ranged from 2 weeks[16,18,27,37] to 2 years.[24] Further details on the interventions and characteristics of the study population can be found in Table 1.

did not report all outcomes that were pre-specified in the methods section of their paper.[21–25,32–35,39,44,45,54] Five trials provided insufficient information to judge whether there were other potential sources of bias.[13,16,25,32,44]

3.3 | Risk of bias in included studies

3.3.1 | mHealth interventions that provide DSME

HbA1c

There was a beneficial effect of mHealth interventions that provide DSME on HbA1c with a MD of −4 mmol/mol (−0.3%), 95% CI −6 mmol/mol (−0.6%) to −1 mmol/mol (−0.1%); $p = 0.002$; 8 trials; 1289 participants (see Figure 3). The 95% prediction interval was 10 mmol/mol (−1.0%) to 3 mmol/mol (0.3%). Taking the generally accepted minimally relevant difference of 0.4% into account, this MD can be considered clinically relevant. The studies had significant heterogeneity, $Q(5) = 10.62$ with $p = 0.060$. The amount of true variance was medium, with $I^2 = 53$. Subgroup analyses revealed no differences for gender, proportion of participants on insulin, metabolic control, and APC versus UC (see Appendix B, Table B1). Subgroup analysis for age could not be explored, because the subgroup ≥60 years was not represented.

Other outcomes

No statistically significant differences were found in the pooled analyses for BMI,[15–17,19] Morisky Medication Adherence Scale (MMAS),[13,15] lipid profile[14–16] and FPG.[13,14,16] There was no effect on weight in kilograms[19] health status[15] or systolic blood pressure.[15] Other outcomes of interest could not be pooled.[18,20]

3.3.2 | mHealth interventions that provide DSMS

HbA1c

There was a beneficial effect of mHealth interventions that provide DSMS on HbA1c with an MD of −4 mmol/mol (−0.4%), 95% CI −7 mmol/mol (−0.6%) to −2 mmol/mol (−0.2%); $p < 0.001$; 16 trials; 1326 participants (see Figure 3). The 95% prediction interval was −11 mmol/mol (−1.0%) to 2 mmol/mol (0.2%). Studies had significant heterogeneity (Q (13) = 30.62, $p = 0.004$), and true variance was considered medium ($I^2 = 58$). Subgroup analyses

TABLE 1 Characteristics of the included studies.

Author, year (design)	Setting, country, trial period	Intervention (duration) and comparator	Sample	Number of participants randomised	Female (%)	Age (years ±SD)	Diabetes duration (years ±SD)
Abaza 2017 (parallel RCT)	Outpatient clinic of teaching hospital, Egypt, 2014–2015	I: DSME/S via SMS (12 weeks) C: UC + paper-based DSME booklet	Children, adults and seniors with diabetes who own a smartphone and can read SMSs (trial register)	I: 45 C: 45	I: 52.9 C: 59.0	I: 51.2 ± 8.7 C: 51.8 ± 9.7	diabetes ≥1 year: I: 85.3% C: 82.1%
Adikusuma 2017 (parallel RCT)	Outpatient clinic of a hospital, Indonesia, NR	I: DSME via SMS (duration unknown) C: no SMS	Adults withT2DM who received oral antidiabetic medicine since at least six months	I: 25 C: 25	I: 44 C: 56	Age < 55 I: 40% C: 16%	I: NR C: NR
Agboola 2017 (parallel RCT)	Health centres affiliated with academic medical centre, USA, 2012–2013	I: DSME/S via tailored unidirectional and bidirectional text messages focused on physical activity (6 months) C: usual care plus step count tracking (pedometer and web portal)	English or Spanish speaking adults with T2DM with most recent HbA1c > 7.0%	I: 64 C: 62	I: 44 C: 60	I: 50.3 ± 10.5 C: 52.6 ± 12.6	I: NR C: NR
Arora 2014 (parallel RCT)	Emergency department of public hospital, USA, 2011–2012	I: DSME/S via text messages (6 months) C: UC	Individuals with T2DM able to speak/read English or Spanish with a HbA1c level ≥8%	I: 64 C: 64	I: 60 C: 69	I: 50.5 ± 10.3 C: 51.0 ± 10.2	I: 10.9 ± 10.4 C: 10.1 ± 6.5
Bailey 2020 (parallel RCT)	Recruited from local GP surgeries and diabetes support groups, UK, 2017	I: DSMS via smartphone app (8 weeks) C: UC	Adults with T2DM and in the first stage of drug treatment or using a diet and exercise management strategy only	I: 10 C: 10	I: 60 C: 30	I: 57 ± 7 C: 55 ± 6	I: NR C: NR
Bauer 2018 (parallel RCT)	4 hospitals, >100 outpatients offices, including 25 primary care offices, USA, NR	I: DSME/S via text messages (6 months) C: UC	Patients with T1DM or T2DM and painful peripheral neuropathy, able to speak English, use text-messages on their mobile telephones	I: 40 C: 29	I: 50 C: 55.2	I: 61.9 ± 9.9 C: 62.0 ± 10.2	I: 14.2 ± 10.1 C: 16.2 ± 10.8
Bee 2016 (parallel RCT)	Singapore General Hospital, Singapore, 2013–2015	I: DSMS via smartphone app for insulin titration (24 weeks) C: one face-to-face DSME/S session + paper-based insulin titration	Insulin-naive T2DM patients with HbA1c ≥7.5% despite ≥2 oral glucose-lowering drugs	I: 33 C: 33	I: NR C: NR	I: NR C: NR	I: NR C: NR
Boels 2019 (parallel RCT)	General practices and hospital outpatient clinics, The Netherlands, 2015–2017	I: DSME/S via text messages (6 months) C: UC	Dutch individuals with T2DM and an HbA1c > 53 mmol/mol (>7%) and used insulin since ≥3 months	I: 115 C: 115	I: 41.7 C: 37.4	I: 58.6 ± 8.2 C: 59.7 ± 6.8	I: 14.9 ± 8.3 C: 14.3 ± 7.7
Capozza 2015 (parallel RCT)	19 primary care clinics, USA, NR	I: DSME/S via tailored unidirectional and bidirectional text messages (180 days) C: UC	Nonpregnant Spanish or English speaking adults with T2DM and a HbA1c >8% in the past year	I: 58 C: 35	I: 60 C: 63	I: 52 ± 11.2 C: 54.5 ± 10.7	I: NR C: NR

TABLE 1 (Contninued)

Author, year (design)	Setting, country, trial period	Intervention (duration) and comparator	Sample	Number of participants randomised	Female (%)	Age (years ±SD)	Diabetes duration (years ±SD)
Chen 2018 (parallel RCT)	Five hospitals, China, 2015–2016	I: DSME/S via text messages (1 week) C: Oral reminders	Individuals with diabetes mellitus	I: 119 C: 114	I: 47.9 C: 50.9	I: 59.7 ± 11.3 C: 58.7 ± 9.5	Diabetes ≥10 years: I: 37.0% C: 38.6%
Dincer 2020 (parallel RCT)	Outpatient clinic of a university hospital, Turkey, 2016–2017	I: DSME via a mobile application (1 month) C: UC	Adults diagnosed with T2DM for at least 6 months without a diabetic food wound	I: 65 C: 65	I: 47.7 C: 50.8	I: 49.5 ± 17.4 C: 54.7 ± 13.6	Months mean (min-max): I: 120 (1–504) C: 132 (1–540)
Dobson 2018 (parallel RCT)	Primary and secondary care centres, New Zealand, 2015–2017	I: DSME/S via tailored unidirectional and bidirectional messages (3–9 months) C: UC	English speaking adults (≥ 16 years) with T1DM and T2DM and an HbA1c >8% the past 9 months with access to a mobile phone	I: 183 C: 183	I: 50 C: 53	I: 47 ± 15 C: 47 ± 15	I: 13 ± 11 C: 12 ± 9
Faridi 2008 (cluster RCT)	Two community health centres (part of a primary care network), USA, NR	I: DSMS via messages based on uploaded data (3 months) C: UC and step count tracking using a pedometer	Adults with T2DM since at least one year, controlled by diet or oral medication for at least 3 months with a BMI >25 and HbA1c < 8%	I: 15 C: 15	I: 60.0 C: 66.7	I: 55.3 ± 8.7 C: 56.7 ± 10.6	I: NR C: NR
Farmer 2021 (parallel RCT)	Primary care clinic and a hospital-based outpatient clinic, South Africa and Malawi, 2016–2018	I: DSME/S via text messages (12 months) C: UC	Adults with T2DM who take oral glucose-lowering medication	I: 558 C: 561	I: 69.9 C: 69.9	I: 56.8 ± 11.6 C: 57.4 ± 11.1	Mean years and IQR: I: 5.0 (2.5–10) C: 5.2 (3–10)
Galindo 2021 (cross-over trial)	Hospital and endocrinology clinic, Georgia, 2017–2019	I: DSMS via an insulin pen cap (26 weeks) C: Masked device without notifications	Adults with T2DM, HbA1c levels between 7% and ≤12% and self-injecting insulin for more than 3 months	I: 40 C: 40	I: 43 C: 68	I: 54.5 ± 9.7 C: 57.0 ± 12.2	Mean years and IQR: I: 10 (4.5–18.5) C: 10 (5.0–15.0)
Gatwood 2016 (parallel RCT)	Recruited from health system's electronic health record system and at a diabetes health fair, USA, 2012–2013	I: DSME/S via tailored text messages focused on medication adherence (90 days) C: standard care and a monthly "check-in" text message	Adults aged 21–64 with diabetes and HbA1c ≥ 8%, taking at least one anti-diabetic medication, report missing at least one dose within the past 30 days	I: 37 C: 38	I: 50 C: 50	I: 47.5 ± 12.1 C: 46.4 ± 11.6	I: NR C: NR
Goodarzi 2012 (parallel RCT)	The Karaj Diabetes Association, Iran, 2011	I: DSME via SMS (12 weeks) C: no educational messages	Individuals with T2DM for more than 1 year, aged >30 years with an HbA1c level >7%	I: 50 C: 50	I: 79.1 C: 76.3	I: 51.0 ± 10.3 C: 56.7 ± 9.8	Median: I: 6.0 C:10.0

(Continues)

TABLE 1 (Contninued)

Author, year (design)	Setting, country, trial period	Intervention (duration) and comparator	Sample	Number of participants randomised	Female (%)	Age (years ±SD)	Diabetes duration (years ±SD)
Gunawardena 2019 (parallel RCT)	Endocrinology clinic, Sri Lanka, 2017–2018	I: DSMS via a smartphone app based on uploaded data (6 months) C: UC	Adults with T2DM and an HbA1c level ≥8.0%	I: 35 C: 32	I: 37 C: 43	I: 52 ± 12 C: 53 ± 11	I: 11 ± 6 C: 11 ± 7
Haider 2019 (parallel RCT)	Tertiary hospital, Australia, NR	I: DSME/S via semi-personalized text messages (6 months) C: UC	Adults with documented CVD	I: 111 C: 118	I: 17 C: 17	I: 60.2 ± 9 C: 58.5 ± 8.8	I: NR C: NR
Holmen 2014 (parallel RCT)	General practices, Norway, 2011–2013	I1: DSMS via a smartphone app based on uploaded data (12 months) I2: I1 + health counselling for the first 4 months (12 months) C: UC by the GP	Adults with T2DM with an HbA1c level ≥7.1%	I: 51 I2: 50 C: 50	I1: 33.3 I2: 50.0 C: 40	I1: 58.6 ± 11.8 I2: 57.4 ± 12.2 C: 55.9 ± 12.2	I1: 11.2 ± 7.3 I2: 9.6 ± 8.4 C: 9.4 ± 5.5
Hsia 2022 (parallel RCT)	12 outpatient centres, US, 2021	I: DSME/S via an application (180 days) C: Control app	Adults with T2DM, HbA1c levels ≥7.0% and no change in antidiabetic medication four months prior to randomization	I: 326 C: 343	I: 54 C: 55	I: 57 ± 9 C: 58 ± 8	I: 11 ± 8 C: 11 ± 8
Huang 2019, (parallel RCT)	Tertiary outpatient clinic, Singapore, 2018	I: DSMS via an application (12 weeks) C: UC	Adults with T2DM and using insulin or oral hypoglycemic agents	I: 25 C: 26	I: 59.1 C: 42.1	I: 51.5 (min. 22 – max. 69) C: 52 (min. 28 – max. 67)	I: 11.1 ± 7.1 C: 18.3 ± 8.4
Islam 2015 (parallel RCT)	Outpatient department, Bangladesh, 2013–2015	I: DSME via SMS (6 months) C: UC	Adults with T2DM diagnosed within the previous 5 years on oral medication	I: 118 C: 118	I: 55.9 C: 52.5	I: 48.5 ± 9.2 C: 47.8 ± 10	I: 2.3 ± 2.6 C: 2.3 ± 2.2
Islam 2020 (parallel RCT)	Idem as Islam 2015	Idem	Idem	Idem	Idem	Idem	Idem I: 2.3 ± 2.6 C: 2.3 ± 2.2
Kerfoot 2017 (parallel RCT)	Veterans Affairs, USA, 2014–2015	I: DSME group-based game via mobile app or e-mail (6 months) C: online civics game + DMSE booklet	Veterans with diabetes, an active prescription for oral diabetes medications and a home-tested HbA1c ≥58 mmol/mol	I: 227 C: 229	I: 5.3 C: 7.0	I: 59.2 ± 10.3 C: 59.9 ± 9.4	I: NR C: NR
Kim 2010 (parallel RCT)	Outpatient clinic from a hospital, South Korea, 2008	I: DSMS via SMS for insulin titration (12 weeks) C: conventional titration scheme	Adults with T2DM, taking antidiabetic treatment >6 months, requiring a long-acting insulin therapy, with HbA1c between 7.0–12.0% and BMI <35 kg/m^2	I: 50 C: 50	I: 48.9 C: 51.1	I: 47.8 ± 9.6 C: 49.0 ± 10.7	I: 8.5 ± 6.4 C: 8.4 ± 6.2

TABLE 1 (Contninued)

Author, year (design)	Setting, country, trial period	Intervention (duration) and comparator	Sample	Number of participants randomised	Female (%)	Age (years ±SD)	Diabetes duration (years ±SD)
Kumar 2018 (parallel RCT)	Outpatient departments of five health facilities, India, 2015–2016	I: DSME/S via tailored SMS (12 months) C: UC	Patients with diagnosed T2DM	I: 479 C: 476	I: 61.8 C: 68.5	I: 57.5 ± 10.8 C: 57.0 ± 10.7	I: NR C: NR
Kumar 2020 (parallel RCT)	Outpatient department of a tertiary hospital, India, 2019	I: DSMS via a mobile application (6 months) C: UC	Adults diagnosed with T2DM for at least 1 year and receiving insulin and/or oral hypoglycemic drugs	I: 150 C: 150	I: 40 C: 40	I: 55.73 ± 10.45 C: 73.56 ± 11.27	Median duration I: 8 years C: 10 years
Kumar 2021 (parallel RCT)	Idem as Kumar 2020	Idem	Idem	Idem	Idem	Idem	Idem
Lazo-Porras 2020 (parallel RCT)	Outpatient clinic of two public hospitals, Peru, NR	I: DSME/S via SMS and voice messaging (18 months) C: UC	Adults with T2DM and in risk group 2 or 3 using the diabetic foot risk classification system as specified by the International Working Group on the Diabetic Foot	I: 86 C: 86	I: 65.1 C: 60.5	I: 62.1 ± 9.8 C: 60.3 ± 9.2	I: 12.7 ± 7.9 C: 13.3 ± 8.5
Lee 2021 (parallel RCT)	Endocrinology outpatient clinic, South Korea, 2019–2020	I: DSMS via a mobile application (3 months) C: Education program presented by a nurse	Adults with T2DM, HbA1c levels ≥6.5% and treated with antidiabetic medication	I: 25 C: 25	I: 56.5 C: 56.0	I: 56.0 ± 8.1 C: 63.0 ± 8.5	I: 7.9 ± 6.3 C: 10.8 ± 8.0
Lee 2022 (parallel RCT)	Two university hospitals, Korea, 2019–2021	I: DSME/S via text messages and uploading self-care data (26 weeks) C: UC	Adults with T2DM, HbA1c levels ≥7.5% and a BMI of ≥18.5 kg/m2	I: 91 C: 87	I: 56 C: 57	I: 51.3 ± 13.1 C: 52.6 ± 12.1	I: 10.9 ± 8.3 C: 11.5 ± 8.2
Lim 2016 (parallel RCT)	Outpatient clinic from a hospital, South Korea, 2013–2014	I: DSMS via messages based on uploaded glucose and physical activity data (6 months) C: SMBG	Patients with T2DM ≥60 years with HbA1c 7.0–10.5%	I: 50 C: 50	I: 20 C: 30	I: 64.3 ± 5.2 C: 65.8 ± 4.7	I: 14.4 ± 9.5 C: 14.6 ± 8.4
Lim 2011 (parallel RCT)	Outpatient clinic from a hospital, South Korea, 2009–2010	I1: DSMS via SMS based on uploaded glucose data (6 months) I2: SMBG (6 months) C: UC	Patients with T2DM ≥60 years with HbA1c 6.5–10.5%	I1: 51 I2: 51 C: 52	I1: 52.9 I2: 54.9 C:59.6	I1:67.2 ± 4.1 I2: 67.2 ± 4.4 C: 68.1 ± 5.5	I1: 14.1 ± 10.1 I2: 15.4 ± 8.3 C: 15.8 ± 10.7
Peimani 2016 (parallel RCT)	Outpatient clinic of a research institute, Iran, NR	I1: DSME via tailored SMS (12 weeks) I2: DSME via non-tailored SMS (12 weeks) C: ND	Patients with T2DM owning a mobile phone and able to read text-messages	I1: 50 I2: 50 C: 50	I1: 46 I2: 44 C: 48	I1: 49.8 ± 9.8 I2: 53.3 ± 10.5 C: 54.6 ± 9.9	I1:8.1 ± 7.0 I2: 8.9 ± 6.6 C: 10 ± 7.5
Sadanshiv 2020 (parallel RCT)	Tertiary hospital, India, 2015–2016	I: DSME via automated text messages (6 months) C: UC	Adult working staff of the hospital diagnosed with T2DM	I: 161 C: 159	I: 42.2 C: 47.8	I: 48.7 ± 7.4 C: 47.9 ± 8.0	I: 5.3 ± 5.0 C: 5.0 ± 5.4

(Continues)

TABLE 1 (Contninued)

Author, year (design)	Setting, country, trial period	Intervention (duration) and comparator	Sample	Number of participants randomised	Female (%)	Age (years ±SD)	Diabetes duration (years ±SD)
Shetty 2011 (parallel RCT)	Diabetes centre, India, NR	I: DSME/S via tailored SMS (1 year) C: UC	T2DM aged 30–65 years with a diabetes duration of ≥5 years and HbA1c of 7.0–10.0%	I: 110 C: 105	I: NR C: NR	I: 50.1 ± 9.9 C: 50.5 ± 8.3	I: NR C: NR
Sokolovska 2020 (parallel RCT)	University of Latvia, Latvia, 2017–2018	I: DSMS via an application (4 months) C: Patients in the control group were not controlled until the end of the study	Adults with T2DM	I: 30 C: 26	I: 57.1 C: 73.3	I: 60.64 ± 7.4 C: 60.96 ± 8.8	I: 8.43 ± 6.97 C: 5.73 ± 4.04
Sugita 2017 (parallel RCT)	Recruited during 2 weeks stay in hospital, afterwards outpatients, Japan, 2013–2014	I: DSMS via text messages to improve medication adherence (6 months) C: Reminder messages	T2DM ≥18 years with HbA1c ≥6.5% with oral or injectable therapy with no symptoms of depression, hospitalised for diabetes education	I: 21 C: 20	I: 28.6 C: 30.0	I: 55.6 ± 10.6 C: 56.3 ± 10.0	I: NR C: NR
Tamban 2013 (parallel RCT)	Diabetes clinic, Philippines, 2008–2011	I: DSME via SMS (6 months) C: UC	T2DM aged 19–50 years who attended at least 1 lecture provided by a diabetes educator	I: 52 C: 52	I: 44.2 C: 51.9	I: 48 ± 8.1 C: 51 ± 6.2	I: 7.6 C: 7.9
Vervloet 2014 (parallel RCT)	40 pharmacies, the Netherlands, 2008–2011	I1: DSMS via SMS and electronic medication dispenser to improve medication adherence (6 months) I2: real-time medication monitoring (6 months) C: UC	T2DM aged 18–65 years with oral anti-diabetic medication ≥1 year (when combined with insulin: insulin ≥6 months) with a refill adherence <80%	I1: 207 I2: 208 C: 189	I1: 44.6 I2: 45.8 C: 49.1	I1: 54.9 ± 6.6 I2: 54.6 ± 6.9 C: 55.4 ± 7.8	I1: 10.6 ± 10.8 I2: 8.2 ± 8.6 C:8.7 ± 6.8
Waller 2021 (parallel RCT)	Recruited by health service providers and (social) media, Australia, 2017–2019	I: DSME/S via text messages (6 months) C: UC	Community dwelling adults with T2DM and HbA1c levels ≥7.0% (53 mmol/mol)	I: 197 C: 198	I: 48.7 C: 49.0	I: 62.1 ± 9.8 C: 61.8 ± 10.4	I: NR C: NR
Williams 2012 (parallel RCT)	Diabetes clinics at three major hospitals (majority), Australia, 2008–2010	I: DSME/S via tailored telephone calls C: UC	T2DM since ≥3 months, aged 18–70 years, with stable pharmacotherapy and HbA1c ≥ 7.5%	I: 60 C: 60	I: 38.3 C: 36.7	I: 58.4 ± 8.2 C: 56.4 ± 8.3	I: NR C: NR
Young 2017 (parallel RCT)	Primary care practices, USA, 2014–2016	I1: DSMS via messages on the meter based on uploaded blood glucose data I2: once daily SMBG C: no SMBG	T2DM not treated with insulin aged ≥30 years with HbA1c between 6.5%–9.5% within 6 months preceding screening	I1: 148 I2: 150 C: 152	I1: 55.4 I2: 55.3 C: 51.3	Median: I1: 61 I2: 63 C: 61	Median: I1: 6 I2: 6 C: 6

Abbreviations: BMI, body mass index; C, comparator; CVD, Cardiovascular disease; DSME, diabetes self-management education; DSME/S, diabetes self-management education and support; GP, general practitioner; HbA1c, glycated haemoglobin; I, intervention; ND: not defined; NR, not reported; RCT, randomised controlled trial; SD: standard deviation; IQR, Interquartile range; SMBG: self-monitoring of blood glucose; SMS: short-message service; T1DM, type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus; UC, usual care; USA, United States of America; UK, United Kingdom.

Study ID	Sequence generation	Allocation concealment	Blinding of participants and personell: objective outcomes	Blinding of participants and personnel: subjective outcomes	Blinding of outcome assessment: objective outcomes	Blinding of outcome assessment: subjective outcomes	Incomplete outcome data: objective outcomes	Incomplete outcome data: subjective outcomes	Selective reporting
Abaza 2017	low	low	high	high	low	high	high	high	low
Adikusuma 2017	unsure	unsure	high	high	low	high	low	low	unsure
Agboola 2017	low	low	high	high	low	low	high	high	high
Arora 2014	low	unsure	high	high	low	high	high	high	high
Bailey 2020	low	unsure	high	high	low	unsure	low	low	low
Bauer 2018	unsure	unsure	high	high	low	high	high	high	high
Bee 2016	low	low	unsure	N.A.	low	N.A.	unsure	unsure	high
Boels 2019	low	low	high	high	low	high	low	low	low
Capozza 2015	low	low	high	N.A.	low	N.A.	high		unsure
Chen 2018	low	low	unsure	unsure	low	unsure	low	low	low
Dincer 2020	low	unsure	high	high	high	high	low	low	low
Dobson 2018	low	low	high	high	low	high	low	low	low
Faridi 2008	unsure	unsure	high	high	low	high	unsure	low	high
Farmer 2021	low	low	high	high	high	high	low	low	low
Gatwood 2016	low	unsure	high	high	low	unsure	N.A.	high	unsure
Goodarzi 2012	low	unsure	high	N.A.	low	N.A.	high	N.A.	low
ınawardena 2019	low	low	high	high	low	high	unsure	low	high
Haider 2019	low	low	high	N.A.	low	N.A.	low	N.A.	low
Holmen 2014	low	low	high	high	low	high	high	high	high
Hsia 2022	unsure	low	high	N.A.	high	N.A.	low	N.A.	low
Huang 2019	unsure	unsure	unsure	unsure	low	unsure	low	low	low
Islam 2020	low	low	high	high	low	unsure	low	low	low
Kerfoot 2017	low	unsure	high	high	low	low	low	low	high
Kim 2010	low	unsure	high	high	low	low	low	low	high
Kumar 2018	low	unsure	high	N.A.	low	N.A.	low	N.A.	low
Kumar 2020	low	low	N.A.	high	N.A.	high	N.A.	low	low
Kumar 2021	low	low	high	N.A.	low	N.A.	low	N.A.	low
Lazo-Porras 2020	low	low	high	N.A.	low	N.A.	low	N.A.	low
Lee 2022	low	low	high	high	low	high	low	low	low
Lee 2021	unsure	unsure	unsure	N.A.	low	N.A.	low	N.A.	low
Lim 2016	low	unsure	high	high	low	unsure	low	high	high
Lim 2011	unsure	unsure	high	high	low	high	low	unsure	high
Peimani 2016	low	unsure	high	high	low	high	low	low	unsure
Sadanshiv 2020	low	low	high	N.A.	low	N.A.	low	N.A.	low
Sokolovska 2020	low	unsure	high	N.A.	low	N.A.	high	N.A.	low
Sugita 2017	low	unsure	high	high	low	high	high	high	high
Tamban 2013	low	low	high	high	low	high	high	high	unsure
Vervloet 2014	low	unsure	N.A.	high	N.A.	low	N.A.	high	high
Waller 2021	low	low	high	high	low	high	low	low	low
Williams 2012	low	low	low	N.A.	low	high	low	N.A.	high
Young 2017	low	low	high	high	low	high	low	low	low

FIGURE 2 Risk of bias within studies. **Green** indicates a low risk of bias. **Red** indicates a high risk of bias. **Orange** indicates an unclear risk of bias. N.A. indicate that the trial did not report that particular outcome.

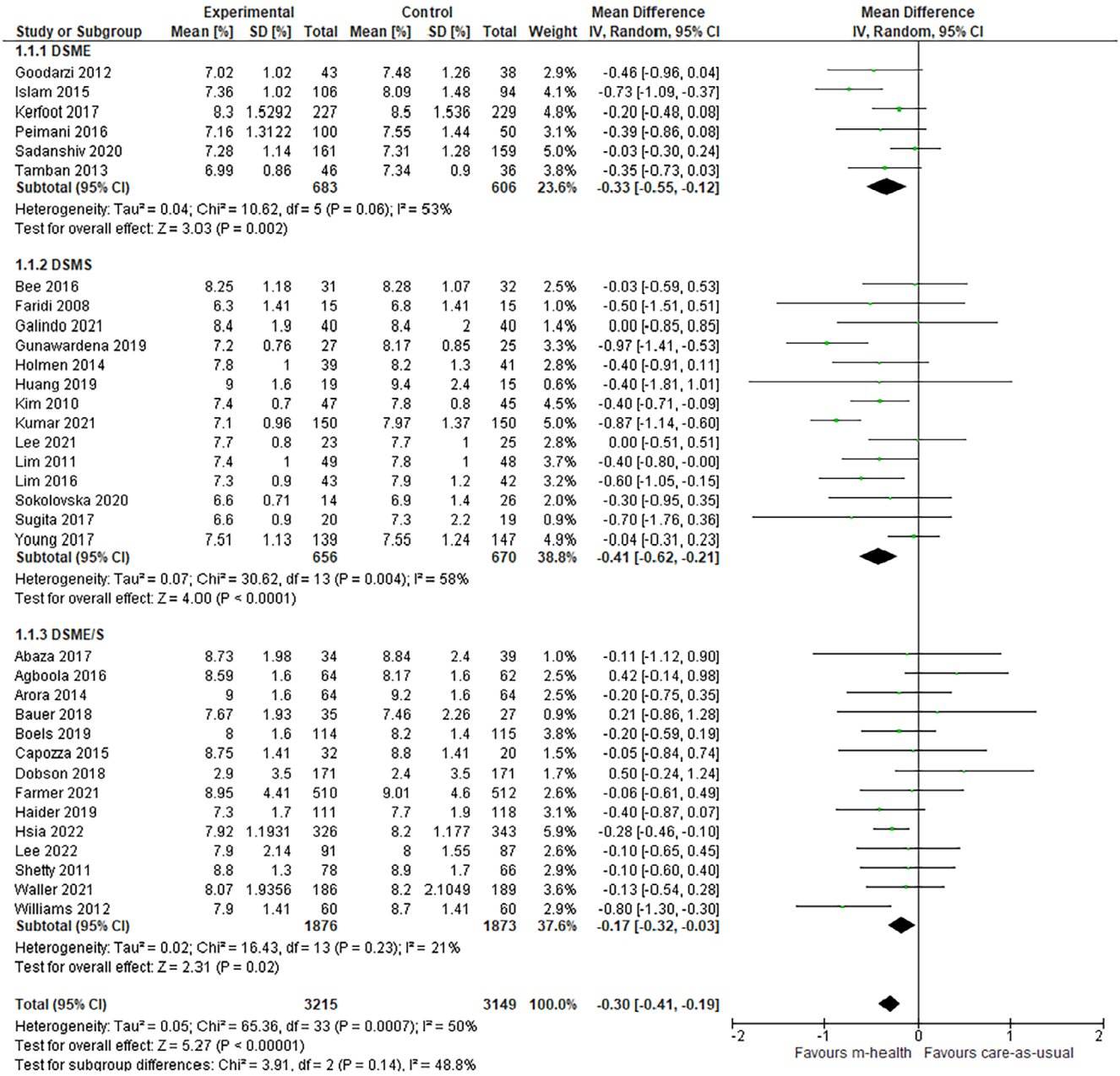

FIGURE 3 Forest plot showing the effect of DSME, DSMS and DSME/S on HbA1c.

revealed significant differences for gender ($p = 0.005$); specifically, the MD was largest in trials with less than 45% women (MD = −7 mmol/mol (−0.7%), 95% CI −10 mmol/mol (−1%) to −5 mmol/mol (−0.4%); 5 trials). No differences were found for age, the proportion of participants on insulin, metabolic control, and APC versus UC (see Appendix B, Table B2).

Other outcomes

A beneficial effect of DSMS on BMI was found, with MD of −1.11, 95% CI −1.88 to −0.35; $p = 0.004$; 8 trials; 511 participants.[22–24,27,29,34,36,38] No significant differences were found in the pooled analyses for weight in kilograms,[27,33,36,38] hypoglycaemic episodes,[24,26,32,34] health status,[23,26] or blood pressure.[22,27,34,36,38]

Pooled analyses across four studies showed an increase in the weekly frequency of self-monitoring blood glucose in the intervention group compared to UC (MD = 3.85, 95% CI 0.32–7.38, $p = 0.030$; 4 trials; 323 participants).[24,27,33,34] Pooled analyses of two studies[22,26] found no effect on specific self-care behaviour assessed with the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire (general diet, specific diet, exercise, blood glucose testing, foot care).

No effect was found on lipid profile, except for HDL-cholesterol. Specifically, DSMS had a positive impact on HDL-cholesterol with MD of 3.25 mg/dL (95% CI

0.84–5.67, $p < 0.008$, 5 trials; 360 participants).[24,29,34,36,38] For FPG, there was an MD of −9.19 mg/dL in favour of mHealth, 95% CI −15.94 to −2.44; $p = 0.008$; 8 trials; 535 participants.[24,27,32–34,36–38] Other outcomes of interest could not be pooled.[25,30,31]

3.3.3 | mHealth interventions that provide DSME/S

HbA1c

mHealth interventions that provide DSME/S resulted in an MD of −2 mmol/mol (−0.2%) for HbA1c, 95% CI −3 mmol/mol (−0.3%) to −0 mmol/mol (−0.0%); $p < 0.001$; 18 trials; 3636 participants; see Figure 3. The 95% prediction interval was −4 mmol/mol (−0.3%) to −1 mmol/mol (−0.1%).. Studies had no significant heterogeneity (Q (13) = 16.43, $p = 0.230$), and the amount of true variance was small ($I^2 = 21$). A small I^2 implies that a substantial portion of the variance arises from random error. Therefore, the subgroup analyses should be interpreted carefully. Subgroup analyses found no differences for gender, age, proportion of participants on insulin, metabolic control, and attention control versus UC control. (see Appendix B, Table B3).

Other outcomes

There were no statistically significant differences in the pooled results for BMI,[44,46,47,49,50,52] weight in kilograms,[52–54,56] hypoglycaemic episodes,[46,52,56] health status,[40,42,45,46] lipid profile[44,46,47,50,52,56] or FPG.[44,48,52,56] There were no significant effects in the pooled results of self-care behaviours,[39,40,42,46] except for medication adherence assessed with the MMAS. DSME/S had a positive impact on medication adherence with MD of 0.70 (95% CI 0.00–1.40; $p = 0.050$; 2 trials; 201 participants).[39,53] Pooled results showed that DSME/S had a significant positive impact on SBP (MD = −3.08 mmHg, 95% CI −5.60 to −0.56, $p = 0.020$; 5 trials; 2760 participants).[46–49,56]

Five trials reported no (serious) adverse events during the trial related to the intervention.[42,46,49,52,56] Concerning treatment satisfaction, one trial showed that the majority of participants (87%) were satisfied with the intervention,[52] one study found that satisfaction did not differ between the intervention and APC,[53] and one study found that the improvement in satisfaction with care was higher in the DSME/S group.[55] Cost-effectiveness was investigated in only one trial (120 participants) which resulted in uncertain cost-effectiveness.[45] Another trial intended to do a cost-effectiveness analysis but did not carry it out due to a lack of intervention effect on the main study outcome and quality of life.[49] Other outcomes of interest could not be pooled.[43,51]

3.4 | Assessment of publication bias

HbA1c was the only outcome that 10 or more trials reported on, specifically for mHealth interventions that provided either DSMS or DSME/S. Therefore, the funnel plots were inspected to identify potential publication bias. The funnel plots are included in Appendix C. The funnel plot of DSMS studies shows a symmetrical distribution, indicating an absence of publication bias (Figure C1). The funnel plot of DSME/S studies shows that the majority of trials are at the top of the graph, and the distribution is more to the right as the sample size decreases (Figure C2). This can be indicative of publication bias and the effect of DSME/S on HbA1c may need to be interpreted carefully.

4 | DISCUSSION

4.1 | Summary of main results

We included 43 trials (45 records) with 9328 participants to assess the effects of DSME and support alone or combined, delivered by mobile health interventions in adults with type 2 diabetes mellitus.

The included trials covered a wide variety of mHealth interventions. Also, the aim of the trials varied widely: from improving HbA1c (43 trials) to improving lipid profiles (14 trials), blood pressure (11 trials) medication adherence (4 trials), to improving insulin titration or blood glucose self-monitoring (4 trials). mHealth interventions improved HbA1c by about 4 mmol/mol (0.4%), with the largest effect for DSMS and no significant overall risk of hypoglycaemic episodes. This effect was not only significant but also clinically relevant.

With DSME, no statistically significant differences were found on other outcomes. Based on eight trials, DSMS showed a significant decrease in BMI; and in four studies, the weekly frequency of self-monitoring blood glucose increased in the DSMS intervention group. Specifically, DSMS had a positive impact on HDL-cholesterol in four studies. Based on two trials medication adherence improved with DSME/S, and DSME/S had a significant positive impact on SBP (pooled analysis of 5 trials).

4.2 | Overall completeness and applicability of evidence

All but seven trials included participants with type 2 diabetes; five trials failed to report on the type of diabetes,[21,26,28,55,57] one trial investigated both type 1 diabetes and type 2 diabetes but performed a subgroup analysis

restricted to type 2 diabetes for HbA1c,[42] and one included both type 1 diabetes and type 2 diabetes with an unknown distribution.[43] Also the level of metabolic control varied widely: from a mean HbA1c of 46 mmol/mol (6.4%)[22] to 88 mmol/mol (10.2%)[39] at baseline.

Based on the variety of the different type 2 diabetes populations, treated both in primary and secondary care and with a wide range of diabetes control, we conclude that the results of our meta-analysis are applicable to the general type 2 diabetes population.

The outcome data of the included trials were fairly complete. Nevertheless, only nine out of the 19 authors who were contacted replied to our queries. To include the trials with missing data in our meta-analyses, we had to make the following imputations: (1) estimate the SD at follow-up by using the average of the pooled baseline SDs for HbA1c,[22,45] BMI,[22] SBP,[22] DBP[22] and SDSCA[22] and (2) estimate numbers from figures and use pooled baseline SD when applicable (HbA1c,[41] FPG,[33] weekly frequency of SMBG,[33] proportion of participants with hypoglycaemic episode,[24] and weekly frequency of exercise[34]).

The majority of studies poorly defined hypoglycaemia and thus in the majority of studies, it was unclear how hypoglycaemia was assessed. Only two out of seven studies (partly) reported the methodology; one study reported using a fingerprick to confirm[24] and one study used a query.[26] To determine the validity of the methods used, it is important for future studies to clearly define and report on the methodology.

4.3 | Quality of the evidence

Of the 43 included trials, 30 trials provided a sample size calculation,[14–21,23,26,29,35,39,42,43,45,46,48–51,53–61] of which 21 trials were able to analyse the target number of participants[15,17–20,23,26,29,39,42,46,48–51,54–58,60] one trial had an unknown number of participants analysed.[21] Fourteen trials were powered based on effect on HbA1c level of which nine trials assumed a modest difference in HbA1c level of 4 mmol/mol (0.4) to 5 mmol/mol (0.5%),[15,18,21,26,42,45,46,49,56] while others assumed much larger differences of approximately 11 mmol/mol (1%).[14,19,39,50,53]

With regard to performance bias, we decided to apply 'high risk of bias' to all objective outcomes, except for mortality, since disease control measures like HbA1c and lipid control are assumed to benefit of DSME/S and self-efficacy and might therefore be biased when participants are aware of their treatment allocation.

Comparing the published results to the published study protocol or to the trial register, some trials suffered from selective reporting. With regard to selection bias, most trials were classified as low risk of bias.

Taking the aforementioned, the overall certainty of the evidence was rated moderate for the objective outcome. While we were unable to investigate potential publication bias by funnel plots, it is important to note that we classified 18 trials as potentially relevant studies awaiting classification. Many of these studies were conference proceedings in 2022 ($n=13$), of which we were not able to find a full manuscript reporting the results.

4.4 | Agreements and disagreements with other studies or reviews

The Cochrane Review on computer-based diabetes self-management interventions, published in 2013, found an MD of −5 mmol/mol (−0.5%), 95% CI −8 mmol/mol (−0.7%) to 3 mmol/mol (−0.3%) in their subgroup analysis on mobile phone-based interventions.[3] This meta-analysis was based on three trials, of which we included only one in our systematic review.[24] It excluded interventions that were used only for communication between individuals with type 2 diabetes and healthcare providers.[3] Another meta-analysis included 13 trials investigating mHealth application, excluding phone calls and SMS, and found a mean HbA1c reduction in the intervention group of 4 mmol/mol (0.4%) 95% CI 1 mmol/mol (0.1%) to 8 mmol/mol (0.7%).[62] We, however, included SMS, but excluded trials investigating interventions with any non-automated feature, such as tailored feedback from healthcare providers.[63]

A similar finding was reported from a scoping review including 27 studies with different study designs and mixed diabetes types: an MD of −6 mmol/mol (−0.5%) 95% CI −9 mmol/mol (−0.8%) to 3 mmol/mol (−0.3%) HbA1c for type 2 diabetes in favour for the mHealth app.[64] Two other reviews studied the effectiveness of mHealth on self-management and disease control in type 2 diabetes in lower and middle-income countries.[65,66] One found that most included studies showed within-group HbA1c improvements (16 of 21 studies), but only seven of the seventeen studies with a control group found between-group differences in HbA1c.[65] A more recent systematic review focusing on mHealth intervention for type 2 diabetes in low and middle-income countries reported an HbA1c percentage difference of <3 mmol/mol (<0.3%) between the mHealth intervention and the comparison group ($n=10$ studies). Additionally, studies with longer intervention periods (12–18 months, $n=4$ studies) had higher effect sizes and percentage differences on HbA1c (1.52 to 2.92%).[66]

To summarise, in agreement with our systematic review, other reviews also found a statistically significant and clinically relevant HbA1c decrease by mHealth interventions. Like our review, other reviews found uncertain effects with regard to other outcomes especially the self

reported outcomes like self management and treatment satisfaction. Pooling of self-reported outcomes is challaging since these outcomes are less often included in studies, and when included difficult to pool due to a difference in assessment used.

4.5 | Implications for practice

mHealth interventions, those with education and those with support appear to have clinically relevant effects on HbA1c compared to UC and APC in adults with type 2 diabetes, without additional effect of the combination of automated education and support. Education alone had no significant other effects, whereas some interventions with DSMS or DSME/S seem to have beneficial effects on BMI, SBP and HDL-cholesterol, and uncertain effect on self-care behaviours. Since there were no adverse events, and no increase in the number of (severe) hypoglycaemic episodes, the use of a mHealth intervention in practice seems to be justified, even without sufficient evidence for its cost-effectiveness. mHealth interventions that provide support (either DSMS or DSME/S), seem most beneficial on other outcomese besides HbA1c and may focus on a specific self-care behaviour. Healthcare providers and individuals with type 2 diabetes should make an informed, shared decision on which mHealth intervention fits best regarding the individuals' needs and barriers, but also on whether a mHealth intervention is suited for that person at all (Tables B1, B2, B3 and Figures C1 and C2).

4.6 | Implications for research

The field of mHealth studies is dominated by pilot and feasibility studies. While these types of studies are important, in many cases no sufficiently powered RCT was conducted after the pilot trial. The same applies to the large number of trials awaiting classification. Therefore we suggest that if a pilot study shows effectiveness, researchers should always try to conduct an adequately sized/powered randomised clinical trial instead of developing a new mHealth intervention.

In many of the included trials, the methods section reporting on the intervention was poorly structured. In 2016, a guideline for reporting mHealth interventions was published by the WHO mHealth Technical Evidence Review Group[67] to improve the reporting of mHealth interventions, they developed a checklist on mHealth evidence reporting and assessment. The checklist provides a minimum set of information needed to define what the mHealth intervention is (content), where it is being implemented (context), and how it was implemented (technical features), to support replication of the intervention. We encourage future researchers to report about their mHealth intervention accordingly.

Only a few trials investigated patient-reported outcomes such as health-related quality of life and treatment satisfaction. Future research should include patient reported outcomes as well.

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CONFLICT OF INTEREST STATEMENT

The authors have nothing to report.

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APPENDIX A

Search strings used in the different databases.

MEDLINE.

Part I. Population

1. Exp Diabetes Mellitus, Type 2/
2. (MODY or NIDDM or T2D*).tw.
3. diabet*.tw.
4. or/1-3

Part II. Intervention

5. Cell Phones/.
6. Text Messaging/.
7. Smartphone/.
8. Mobile Applications/.
9. (mHealth or "m health").tw.
10. (telehealth or telecare).tw.
11. (eHealth or "e health").tw.
12. Digital health.tw..
13. (mobile adj (phone* or technolog* or app or apps or application* or communic* or health)).tw.
14. Smartphone?tw.
15. ((cell* or smart) adj phone?).tw.
16. Messaging.tw.
17. Texting.tw.
18. ((text or short) adj messag*).tw.
19. Sms.tw.
20. (health adj (app or apps or application)).tw.
21. or/5-20

Part I.+II.

22. 4 and 21

Part III. Cochrane RCT Filter (*sensitivity max.*).

23. Randomized controlled trial.pt.
24. Controlled clinical trial.pt.
25. Randomi?ed.ab.
26. Placebo.ab.
27. Drug therapy.fs.
28. Randomly.ab.
29. Trial.ab.
30. Groups.ab.
31. Or/23-30.
32. Exp animals/ not humans/.
33. 31 not 32.

Part IV: *Wong 2006 systematic reviews filter*.

34. meta analysis.mp,pt. or review.pt. or search*.tw.

Part I, II, III and IV and limit to 1995 onwards.

35. 22 and 33.
36. 22 and 34.
37. 35 or 36.
38. Limit 37 to yr="2000-Current".
39. Remove duplicates from 38.

Step 37: (diabetes component) AND (mobile apps component) AND (RCT OR review component).

(exp Diabetes mellitus, Type 2/ OR MODY.tw. OR NIDDM.tw. OR T2D.tw. OR diabet*.tw.) AND (Cell Phones/ OR Text Messaging/ OR Smartphone/ OR Mobile Applications/ OR mHealth.tw. OR "m health".tw. OR telehealth.tw. OR telecare.tw. OR eHealth.tw. OR "e health".tw. OR "digital health".tw. OR smartphone?tw. OR messaging.tw. OR texting.tw. OR SMS.ti,ab. OR (mobile.tw. adj (phone*.tw. OR technolog*.tw. OR app.tw. OR apps.tw. OR application*.tw. OR communic*.tw. OR health.tw.)) OR ((cell*.tw. OR smart.tw.) adj phone?tw.) OR (health.tw. adj (app.tw. OR apps OR application*.tw.))) AND ((randomized controlled trial.pt. OR controlled clinical trial.pt. OR randomi?ed.ab. OR placebo.ab. OR drug therapy.fs. OR randomly.ab. OR trial.ab. OR groups.ab. OR meta analysis.mp,pt. OR review.pt. OR search*.tw.) NOT (Exp animals/ NOT humans/)).

Embase

1. non insulin dependent diabetes mellitus/.
2. (MODY or NIDDM or T2D*).tw.
3. diabet*.tw.
4. or/1-3
5. exp mobile phone/
6. text messaging/
7. mobile application/

8. (mHealth or "m health").tw.
9. (telehealth or telecare).tw.
10. (eHealth or "e health").tw.
11. digital health.tw.
12. (mobile adj (phone* or technolog* or app or apps or application* or communic* or health)).tw.
13. smartphone?tw.
14. ((cell* or smart) adj phone?).tw.
15. messaging.tw.
16. texting.tw.
17. ((text or short) adj messag*).tw.
18. SMS.tw.
19. (health adj (app or apps or application)).tw.
20. or/5-19
21. 4 and 20

[22: Wong 2006 "sound treatment studies" filter – best optimization of sens. and spec. version]

22. random*.tw. or placebo*.mp. or double-blind*.tw.
23. 21 and 22
24. limit 23 to yr="2000-Current"
25. remove duplicates from 24

(diabetes component) AND (mobile apps component) AND (RCTs). (non insulin dependent diabetes mellitus/ OR MODY.tw. OR NIDDM.tw. OR diabet*.tw.) AND (exp mobile phone/ OR text messaging/ OR mobile application/ OR mHealth.tw. OR "m health".tw. OR telehealth.tw. OR telecare.tw. OR eHealth.tw. OR "e health".tw. OR "digital health".tw. OR smartphone?tw. OR messaging.tw. OR texting.tw. OR SMS.ti,ab. OR (mobile.tw. adj (phone*.tw. OR technolog*.tw. OR app.tw. OR apps.tw. OR application*.tw. OR communic*.tw. OR health.tw.)) OR ((cell*.tw. OR smart.tw.) adj phone?tw.) OR ((text.tw. OR short.tw.) adj messag*.tw.) OR (health.tw. adj (app.tw. OR apps OR application*.tw.))) AND (random*.tw. or placebo*.mp. or double-blind*.tw).

PsycINFO

1. Type 2 Diabetes/
2. (MODY or NIDDM or T2D*).tw.
3. diabet*.tw.
4. or/1-3
5. exp Mobile Devices/
6. Text Messaging/
7. (mHealth or "m health").tw.
8. (telehealth or telecare).tw.
9. (eHealth or "e health").tw.
10. digital health.tw.
11. (mobile adj (phone* or technolog* or app or apps or application* or communic* or health)).tw.
12. smartphone?tw.
13. ((cell* or smart) adj phone?).tw.
14. messaging.tw.
15. texting.tw.
16. ((text or short) adj messag*).tw.
17. SMS.tw.
18. (health adj (app or apps or application)).tw.
19. or/5-18
20. 4 and 19

[21: Eady 2008 "PsycInfo Search Strategies" filter—BS version]

21. Control*.tw. OR random*.tw. OR exp Treatment/
22. 20 and 21
23. Limit 22 to yr="2000-Current"
24. Remove duplicates from 23

(DE "Type 2 Diabetes" OR TX MODY OR TX NIDDM OR TI T2D* OR AB T2D* OR TX diabet*) AND (DE "Mobile Devices" OR DE "Mobile Phones" OR DE "Smartphones" OR DE "Text Messaging" OR DE "Mobile Applications" OR TX mHealth OR TX "m health OR TX telehealth OR TX telecare OR TX eHealth OR TX "e health" OR TX "digital health" OR TX smartphone* OR TX messaging OR TX texting OR TI SMS OR AB SMS OR (TX mobile N4 (TX phone* OR TX technolog* OR TX app OR TX apps OR TX application* OR TX communic* OR TX health)) OR ((TX cell* OR TX smart) N4 TX phone*) OR ((TX text OR TX short) N4 TX messag*) OR (TX health N4 (TX app OR TX apps OR TX application*))) AND (TX control* OR TX random* OR DE "Treatment" OR DE "Addiction Treatment" OR DE "Adjunctive Treatment" OR DE "Adventure Therapy" OR DE "Aftercare" OR DE "Alternative Medicine" OR DE "Anxiety Management" OR DE "Behavior Modification" OR DE "Bibliotherapy" OR DE "Caregiving" OR DE "Client Transfer" OR DE "Client Treatment Matching" OR DE "Cognitive Behavior Therapy" OR DE "Cognitive Stimulation Therapy" OR DE "Cognitive Techniques" OR DE "Computer Assisted Therapy" OR DE "Counseling" OR DE "Creative Arts Therapy" OR DE "Cross Cultural Treatment" OR DE "Disease Management" OR DE "Habilitation" OR DE "Health Care Services" OR DE "Horticulture Therapy" OR DE "Hospice" OR DE "Human Potential Movement" OR DE "Human Services" OR DE "Hydrotherapy" OR DE "Institutionalization" OR DE "Integrated Services" OR DE "Interdisciplinary Treatment Approach" OR DE "Intervention" OR DE "Involuntary Treatment" OR DE "Language Therapy" OR DE "Life Sustaining Treatment" OR DE "Maintenance Therapy" OR DE "Medical Treatment (General)" OR DE "Mental Health Programs" OR DE "Milieu Therapy" OR DE "Mind Body Therapy" OR

DE "Mindfulness-Based Interventions" OR DE "Movement Therapy" OR DE "Multimodal Treatment Approach" OR DE "Multisystemic Therapy" OR DE "Outpatient Treatment" OR DE "Pain Management" OR DE "Partial Hospitalization" OR DE "Personal Therapy" OR DE "Physical Treatment Methods" OR DE "Private Practice" OR DE "Psychoeducation" OR DE "Psychotherapy" OR DE "Rehabilitation" OR DE "Relaxation Therapy" OR DE "Respite Care" OR DE "Self-Help Techniques" OR DE "Sex Therapy" OR DE "Social Casework" OR DE "Sociotherapy" OR DE "Speech Therapy" OR DE "Spiritual Care" OR DE "Symptoms Based Treatment" OR DE "Therapeutic Processes" OR DE "Trauma-Informed Care" OR DE "Trauma Treatment" OR DE "Treatment Guidelines" OR DE "Treatment Outcomes" OR DE "Treatment Planning" OR DE "Video-Based Interventions").

Cochrane Central Register of Controlled Trials (Cochrane Register of Studies Online).

1. MESH DESCRIPTOR Diabetes Mellitus, Type 2 EXPLODE ALL TREES.
2. (MODY OR NIDDM OR T2D*):TI,AB,KY.
3. Diabet*:TI,AB,KY.
4. #1 OR #2 OR #3.
5. MESH DESCRIPTOR Cell Phones.
6. MESH DESCRIPTOR Text Messaging.
7. MESH DESCRIPTOR Smartphone.
8. MESH DESCRIPTOR Mobile Applications.
9. (mHealth OR "m health"):TI,AB,KY.
10. (telehealth OR telecare):TI,AB,KY.
11. (eHealth OR "e health"):TI,AB,KY.
12. Digital health:TI,AB,KY
13. (mobile ADJ (phone* OR technolog* OR app OR apps OR application* OR communic* OR health)):TI,AB,KY.
14. Smartphone?:TI,AB,KY.
15. ((cell* OR smart) ADJ phone?):TI,AB,KY.
16. Messaging:TI,AB,KY.
17. Texting:TI,AB,KY.
18. ((text OR short) ADJ messag*):TI,AB,KY.
19. SMS:TI,AB,KY.
20. (health ADJ (app OR apps OR application)):TI,AB,KY.
21. #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20.
22. #4 AND #21.
23. 2000 TO 2017:YR.
24. #22 AND #23.

(MODY OR NIDDM OR T2D OR diabet*) AND (mHealth OR "m health" OR telehealth OR telecare OR eHealth OR "e health" OR "digital health" OR smartphone? OR messaging OR texting OR SMS OR (mobile adj (phone* OR technolog* OR app OR apps OR application* OR communic* OR health)) OR ((cell* or smart) adj phone?) OR (health adj (app OR apps OR application*))).

ClinicalTrials.gov (Expert search).

Conditions: "type 2 diabetes" OR "diabetes type 2" OR "type II diabetes" OR "diabetes type II" OR "diabetes mellitus type 2" OR "diabetes mellitus type II" OR T2D OR T2DM OR "non insulin dependent" OR "NIDDM" OR "MODY". *Interventions*: "cell phone" OR "cell phones" OR "cellular phone" OR "cellular phones" OR "smart phone" OR "smartphone" OR "smart phones" OR "smartphones" OR "mobile phone" OR "mobile phones" OR messaging OR messages OR message OR texting OR SMS OR "mobile device" OR "mobile devices" OR "mobile application" OR "mobile app" OR mHealth OR "m health" OR eHealth OR "e health" OR "digital health" OR "mobile health" OR "health app" OR "health application". *Expert search*: ("type 2 diabetes" OR "diabetes type 2" OR "type II diabetes" OR "diabetes type II" OR "diabetes mellitus type 2" OR "diabetes mellitus type II" OR T2D OR T2DM OR "non insulin dependent" OR "NIDDM" OR "MODY") [DISEASE] AND ("cell phone" OR "cell phones" OR "cellular phone" OR "cellular phones" OR "smart phone" OR "smartphone" OR "smart phones" OR "smartphones" OR "mobile phone" OR "mobile phones" OR messaging OR messages OR message OR texting OR SMS OR "mobile device" OR "mobile devices" OR "mobile application" OR "mobile app" OR mHealth OR "m health" OR eHealth OR "e health" OR "digital health" OR "mobile health" OR "health app" OR "health application") [TREATMENT] AND ("cell phone" OR "cell phones" OR "cellular phone" OR "cellular phones" OR "smart phone" OR "smartphone" OR "smart phones" OR "smartphones" OR "mobile phone" OR "mobile phones" OR messaging OR messages OR message OR texting OR SMS OR "mobile device" OR "mobile devices" OR "mobile application" OR "mobile app" OR mHealth OR "m health" OR eHealth OR "e health" OR "digital health" OR "mobile health" OR "health app" OR "health application")

World Health Organization International Clinical Trials Registry Platform (Advanced search).

Mobile* AND diabet* AND self OR.
Phone* AND diabet* AND self OR.
Smartphone* AND diabet* AND self OR.
Messag* AND diabet* AND self OR.
Texting* AND diabet* AND self OR.
SMS AND diabet* AND self OR.
App AND diabet* AND self OR.
Apps AND diabet* AND self OR.
Digital AND diabet* AND self OR.
Mhealth AND diabet* AND self OR.
Ehealth AND diabet* AND self OR.
Mobile* AND T2D* AND self OR.

Phone* AND T2D* AND self OR.
Smartphone* AND T2D* AND self OR.
Messag* AND T2D* AND self OR.
Texting* AND T2D* AND self OR.
SMS AND T2D* AND self OR.
App AND T2D* AND self OR.
Apps AND T2D* AND self OR.
Digital AND T2D* AND self OR.
Mhealth AND T2D* AND self OR.
Ehealth AND T2D* AND self.
(mobile* AND diabet* AND self) OR (phone* AND diabet* AND self) OR (smartphone* AND diabet* AND self) OR (messag* AND diabet* AND self) OR (texting* AND diabet* AND self) OR (SMS AND diabet* AND self) OR (app AND diabet* AND self) OR (apps AND diabet* AND self) OR (digital AND diabet* AND self) OR (mhealth AND diabet* AND self) OR (ehealth AND diabet* AND self) OR (mobile* AND T2D* AND self) OR (phone* AND T2D* AND self) OR (smartphone* AND T2D* AND self) OR (messag* AND T2D* AND self) OR (texting* AND T2D* AND self) OR (SMS AND T2D* AND self) OR (app AND T2D* AND self) OR (apps AND T2D* AND self) OR (digital AND T2D* AND self) OR (mhealth AND T2D* AND self) OR (ehealth AND T2D* AND self).

APPENDIX B

TABLE B1 Effect sizes (Mean Difference) of mHealth interventions that provided DSME on HbA1c by study characteristics.

	Random effect model			Heterogeneity		Test of difference	
Outcome	**k[a]**	**n[b]**	**MD (95% CI)[c]**	**Chi[d]**	**I[d]**	**Chi[e]**	***p***
HbA1c	6	1289	-0.33 (-0.55,-0.12)	10.62	53		
Gender						1.01	.600
<45% female	1	456	-0.20 (-0.48, 0.08)	-	-		
45-55% female	4	752	-0.36 (-0.69,-0.03)	9.74	69		
>55% female	1	81	-0.46 (-0.96, 0.04)	-	-		
Age[f]						-	-
<60 years	6	1289					
≥60 years	-	-					
Medication						1.49	.470
<50% treated with insulin	3	737	-0.45 (-0.80,-0.10)	5.27	62		
≥50% treated with insulin	1	82	-0.35 (-0.73, 0.03)	-	-		
Unknown	2	470	-0.15 (-0.49, 0.18)	1.68	41		
Metabolic control						0.56	.460
HbA1c ≤64 mmol/mol	4	633	-0.24 (-0.45,-0.02)	3.77	20		
HbA1c >64 mmol/mol	2	656	-0.45 (-0.97, 0.07)	5.23	81		
Control condition	5					0.75	0.39
Usual care	5	833	-0.37 (-0.65,-0.10)	10.05	60		
Attention placebo	1	456	-0.20 (-0.48, 0.08)	-	-		

Note: [a] k = number of studies; [b] n = number of participants; [c] MD (95% CI) = effect size Mean Difference with 95% confidence interval; [d] Q and I^2 = heterogeneity statistics; [e] Contrast between subgroups. [f] Subgroup analysis could not be run, because there were no studies in the category '≥60 years'.

TABLE B2 Effect sizes (Mean Difference) of mHealth interventions that provided DSMS on HbA1c by study characteristics.

	Random effect model			Heterogeneity		Test of difference	
Outcome	**k[a]**	**n[b]**	**MD (95% CI)[c]**	**Q[d]**	**I[d]**	**Q[e]**	***p***
HbA1c	14	1326	-0.41 (-0.62,-0.21)	12.91	77		
Gender						12.91	.005
<45% female	5	568	-0.69 (-0.95,-0.44)	6.39	37		
45-55% female	5	540	-0.17 (-0.35, 0.02)	3.69	0		
>55% female	3	155	-0.50 (-0.85,-0.15)	0.55	0		
Unknown	1	63	-0.03 (-0.59, 0.53)	-	-		
Age						0.15	.690
<60 years	10	558	-0.38 (-0.60,-0.17)	11.78	24		
≥60 years	4	768	-0.48 (-0.89,-0.06)	18.42	84		
Medication						0.99	.610
<50% treated with insulin	8	919	-0.50 (-0.81,-0.19)	23.26	70		
≥50% treated with insulin	4	320	-0.36 (-0.59,-0.12)	3.18	6		
Unknown	2	87	-0.19 (-0.80, 0.42)	1.35	26		
Metabolic control						2.54	.280
HbA1c ≤64 mmol/mol	6	838	-0.45 (-0.79,-0.12)	18.68	73		
HbA1c >64 mmol/mol	7	440	-0.45 (-0.72,-0.17)	8.97	33		
Unknown	1	48	0.00 (-0.51, 0.51)	-	-		
Control condition						0.96	.330
Usual care	8	919	-0.50 (-0.81,-0.19)	23.26	70		
Attention placebo	6	407	-0.31 (-0.52,-0.10)	5.31	6		

Note: [a] *k* = number of studies; [b] *n* = number of participants; [c] MD (95% CI) = effect size Mean Difference with 95% confidence interval; [d] *Q* and I^2 = heterogeneity statistics; [e] Contrast between subgroups.

TABLE B3 Effect sizes (Mean Difference) of mHealth interventions that provided DSME/S on HbA1c by study characteristics.

	Random effect model			Heterogeneity		Test of difference	
Outcome	**k[a]**	**n[b]**	**MD (95% CI)[c]**	**Q[d]**	**I[d]**	**Q[e]**	***p***
HbA1c	14	3749	-0.16 (-0.31,-0.01)	17.53	26		
Gender						3.08	.380
<45% female	4	640	-0.38 (-0.71,-0.05)	4.67	36		
45-55% female	4	1512	0.04 (-0.33, 0.42)	9.90	70		
>55% female	5	1453	-0.11 (-0.39, 0.17)	0.16	0		
Unknown	1	144	-0.10 (-0.60, 0.40)	-	-		
Age						0.12	.730
<60 years	11	3083	-0.15 (-0.33, 0.03)	15.04	34		
≥60 years	3	666	-0.21 (-0.51, 0.08)	1.38	0		
Medication						2.24	.330
<50% treated with insulin	5	2028	-0.30 (-0.52,-0.07)	5.28	24		
≥50% treated with insulin	2	571	0.08 (-0.59, 0.75)	2.68	63		
Unknown	7	1150	-0.09 (-0.30, 0.12)	5.40	0		
Metabolic control						0.50	.780
HbA1c ≤64 mmol/mol	1	62	0.21 (-0.86, 1.28)	-	-		
HbA1c >64 mmol/mol	9	1883	-0.15 (-0.38, 0.07)	14.62	45		
Unknown	4	1804	-0.18 (-0.42, 0.06)	1.17	0		
Control condition						0.38	.540
Usual care	11	2881	-0.19 (-0.36,-0.02)	10.90	8		
Attention placebo	3	868	-0.02 (-0.53, 0.48)	5.50	21		

Note: [a] *k* = number of studies; [b] *n* = number of participants; [c] MD (95% CI) = effect size Mean Difference with 95% confidence interval; [d] *Q* and I^2 = heterogeneity statistics; [e] Contrast between subgroups.

APPENDIX C

Funnel plots

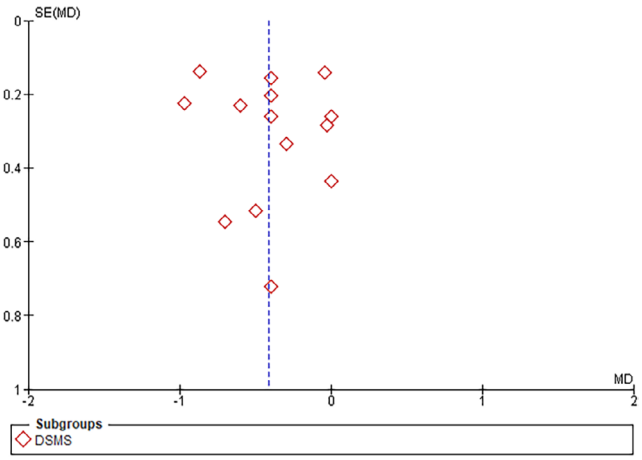

FIGURE C1 Funnel plot of standard error (SE) by mean difference (MD) of comparison DSMS on HbA1c.

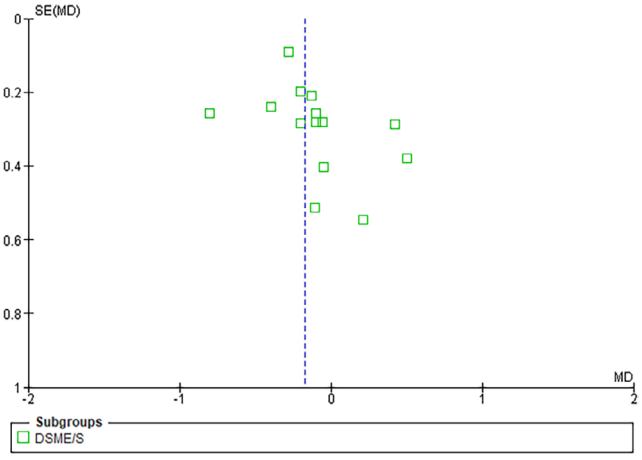

FIGURE C2 Funnel plot of standard error (SE) by mean difference (MD) of comparison DSME/S on HbA1c.

APPENDIX D

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