Diabetes is one of the most common chronic diseases worldwide and is associated with premature death and disability. Over the past 3 decades, the prevalence of diabetes has more than doubled globally and is projected to rise further from 382 million in 2013 to 592 million in 2035. Optimal glycemic control helps to prevent and reduce complications of diabetes, including cardiovascular disease, kidney disease, blindness, neuropathy and limb amputation. However, maintaining optimal glycemic control is challenging.

Telemedicine is the use of telecommunications to deliver health services, expertise and information, is a promising but unproven tool for improving the quality of diabetes care. We summarized the effectiveness of different methods of telemedicine for the management of diabetes compared with usual care.

METHODS: We searched MEDLINE, Embase and the Cochrane Central Register of Controlled Trials databases (to November 2015) and reference lists of existing systematic reviews for randomized controlled trials (RCTs) comparing telemedicine with usual care for adults with diabetes. Two independent reviewers selected the studies and assessed risk of bias in the studies. The primary outcome was glycated hemoglobin (HbA1c) reported at 3 time points (≤ 3 mo, 4–12 mo and > 12 mo). Other outcomes were quality of life, mortality and episodes of hypoglycemia. Trials were pooled using random-effects meta-analysis, and heterogeneity was quantified using the I² statistic.

RESULTS: From 3688 citations, we identified 111 eligible RCTs (n = 23,648). Telemedicine achieved significant but modest reductions in HbA1c in all 3 follow-up periods (difference in mean at ≤ 3 mo: −0.57%, 95% confidence interval [CI] −0.74% to −0.40% [39 trials]; at 4–12 mo: −0.28%, 95% CI −0.37% to −0.20% [87 trials]; and at > 12 mo: −0.26%, 95% CI −0.46% to −0.06% [5 trials]). Quantified heterogeneity (I² statistic) was 75%, 69% and 58%, respectively. In meta-regression analyses, the effect of telemedicine on HbA1c appeared greatest in trials with higher HbA1c concentrations at baseline, in trials where providers used Web portals or text messaging to communicate with patients and in trials where telemedicine facilitated medication adjustment. Telemedicine had no convincing effect on quality of life, mortality or hypoglycemia.

INTERPRETATION: Compared with usual care, the addition of telemedicine, especially systems that allowed medication adjustments with or without text messaging or a Web portal, improved HbA1c, but not other clinically relevant outcomes among patients with diabetes.

Diabetes is one of the most common chronic diseases worldwide and is associated with premature death and disability. Over the past 3 decades, the prevalence of diabetes has more than doubled globally and is projected to rise further from 382 million in 2013 to 592 million in 2035. Optimal glycemic control helps to prevent and reduce complications of diabetes, including cardiovascular disease, kidney disease, blindness, neuropathy and limb amputation. However, maintaining optimal glycemic control is challenging.

Telemedicine is the use of telecommunications to deliver health services, including interactive, consultative and diagnostic services. Telemedicine interventions for diabetes can range from simple reminder systems via text messaging to complex Web interfaces through which patients can upload their glucose levels measured with a home meter and other pertinent data such as medications, dietary habits, activity level and medical history. Providers can review the data and provide feedback regarding medication adjustments and lifestyle modifications. Telemedicine has previously been shown to have clinical benefits for patients with severe asthma, chronic obstructive pulmonary disease, hypertension or chronic heart failure. It may also be helpful for providing care to people with diabetes, especially those unable to travel to health care facilities owing to large distances or disabilities. In particular, telemedicine may facilitate self-management, an important potential objective in diabetes care.

Previous reviews describing the effect of telemedicine on the management of diabetes have been published. However, some focused on only specific types of telemedicine (e.g., telemonitoring) or interventions delivered only by telephone. Given that this is a rapidly developing field, a large number of additional telemedicine interventions have been introduced in recent years.
tional clinical trials have recently been published, which suggests the value of an updated review. We did a systematic review and quantitative synthesis of randomized controlled trials (RCTs) comparing the impact of different methods of telemedicine with usual care on glycated hemoglobin (Hba1c) and health-related quality of life in people with diabetes mellitus.

Methods

We performed a systematic review of RCTs that compared telemedicine with usual care for the management of diabetes (type 1 and type 2). The review was reported according to an accepted guideline.21 We followed a written but unregistered protocol.

We included studies if they were RCTs (parallel, cluster or crossover); were published in English; enrolled adult patients with diabetes; compared telemedicine (some electronic form of provider-to-patient communication) with usual care; and reported the degree of metabolic control measured by Hba1c level. We excluded studies on gestational diabetes because of the different nature of the disease. We considered peer-reviewed full-text articles published until November 2015.

Literature search

The search strategy was designed by an expert librarian. We searched the following electronic databases through the Ovid interface: MEDLINE (1946–November 2015), Embase (1974–November 2015) and the Cochrane Central Register of Controlled Trials (November 2015). We also performed manual searches of the reference lists of existing systematic reviews. Because telemedicine is a broad term that can cover different interventions, we included all electronic forms of communication in our search. The search strategies are shown in Table A1 in Appendix 1 (available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.150885/-/DC1). Results of the search were transferred to Endnote software and were checked for duplicates.

Study selection

Two reviewers (N.W. and L.F.) independently screened the titles and abstracts of all unique citations. Studies with “diabetes,” “type 1” or “type 2” in the title or abstract that studied any kind of telemedicine intervention were selected for full-text review. Two independent reviewers (L.F. and a research assistant) assessed them using an inclusion/exclusion form based on a priori selection criteria for eligibility. Disagreements between the reviewers were resolved by meeting with a third reviewer (N.W.).

Data extraction

We used a standardized method to extract and record relevant properties of each trial into a database. Data from eligible trials were extracted by 1 reviewer (L.F.) and checked by another reviewer (Y.L.) using a standardized extraction sheet. We resolved any disagreements by discussion.

We extracted the following information from selected studies: trial characteristics (study name, year of publication, country, study design, duration and sample size); patient characteristics (age, sex, type of diabetes, diabetes duration, blood pressure, cholesterol, body mass index [BMI], smoking status and medications [insulin, oral hypoglycemic agents, lipid-lowering therapy]); telemedicine interventions; and outcomes.

We classified the telemedicine interventions by (a) form of communication from patient to provider, (b) form of communication from provider to patient, (c) type of provider (nurse, physician, allied health professional, clinical decision support system), (d) frequency of contact and (e) characteristics of any intervention. Forms of communication between provider and patient included telephone, smartphone application, email, text messaging (short message service [SMS]), Web portal (websites where patients upload blood glucose levels or other clinical data and share these with their health care providers, with or without provider-to-patient communication) and “smart” device or glucometer (any computerized device specifically developed to collect and transmit patients’ data to health care providers). Characteristics of any intervention included medication adjustment, exercise, general education about diabetes, blood pressure management and nutritional intervention.

Outcomes

The primary outcome was Hba1c level. Secondary outcomes were quality of life as measured by a validated instrument, mortality and incidence of hypoglycemia. Hypoglycemic events were classified as severe if they were reported as such or if they required assistance.

Risk-of-bias assessment

We assessed risk of bias using the Cochrane Collaboration’s tool33 and included other items (funding, intention to treat and interim analysis) also known to be associated with bias.34,40 Two reviewers (L.F. and a research assistant) assessed the trials independently and resolved any disagreements by meeting with a third reviewer (N.W.).

Data synthesis and analysis

We used Stata 13 (StataCorp) for all statistical analyses. We used the difference in means (MD) to pool continuous outcomes, and the risk ratio or the risk difference (when the events were rare) to pool dichotomous outcomes. Because of the differences expected between trials, we combined results using a random-effects model.41 We imputed missing standard deviations by substituting the baseline value from the same intervention group whenever possible; otherwise the median value from the systematic review was substituted.42 We pooled outcomes using 3 categories of time points (≤ 3 mo, 4–12 mo and > 12 mo). Dichotomous outcomes of Hba1c were pooled by the floored threshold value (e.g., < 6%, < 7%, < 8%, < 9%). We reported results from a quality-of-life instrument when data from at least 2 trials could be pooled. Heterogeneity was identified by visual inspection of the forest plots and by quantifying the I² statistic.43 We assessed publication bias using the Egger test44 and by visual inspection of the contour-enhanced funnel plot.45

We planned a priori to examine the association between population characteristics, intervention characteristics, risk-of-bias items (as specified earlier) and the effect of telemedicine on Hba1c for characteristics reported in 5 or more trials. We did univariable weighted (with the inverse of the trial variance) linear meta-regression to evaluate for effect modification on Hba1c at 4–12 months.46
In a post hoc analysis, we examined whether adjustment for potential confounders in the trial-level results modified the effect of telemedicine on HbA\textsubscript{1c}.

**Results**

Our literature search identified 3688 unique citations. After the screening of titles and abstracts, 517 potentially eligible studies were identified, of which 111 trials\textsuperscript{21,47–156} met our inclusion criteria (Figure 1). Disagreements occurred with 7% of the articles (k value = 0.82).

Characteristics of the trials are summarized in Table 1 (see end of article). Of the 111 included trials, 4 were published before 2000. Five were cluster RCTs, 3 were crossover trials, and the remainder were parallel RCTs. Forty-one trials (37%) were done in the United States, 14 (13%) in Korea and 7 (6%) each in Canada and Australia; 6 or fewer were done in each of the remaining countries.

The median number of study participants was 114 (range 10–2378) (Table 1). The median mean age at baseline was 56 years, and the median mean BMI at baseline was 31. The range of metabolic control at baseline varied substantially between trials (mean HbA\textsubscript{1c} 6.4%–10.9%); however, the mean HbA\textsubscript{1c} level in 71 (64%) of the trials was 8% or greater at baseline.

The telemedicine interventions varied in a number of ways between the trials (Table 2 [see end of article]). Patients initiated communication with their health care providers in 3 ways: voice, text messaging and transmission of data. The trials used a large variety of platforms: Web portal (24%), customized “smart” device (14%), telephone for communication to provider (13%), smartphone application (8%), SMS (5%), email (3%), personal digital assistant (2%), automated voice reminder system (1%), computer software (1%), fax (1%), listserv (electronic mailing list to send group emails; 1%), customized patient-specific Web page (1%) or a call-me button (1%).

Health care providers initiated communication with patients in at least 4 ways: voice, text messaging, images and through clinical decision support systems. The platforms used were telephone (59%), clinical decision support system (32%; e.g., automated interactive voice (9%)), Web portal (22%), SMS (16%), email (7%), videocall (4%), computer software (3%), customized “smart” device (3%), customized patient-specific Web page (2%), video message (2%), letter (2%), smartphone application (1%) or listserv (1%). Providers were nurses (37%), care managers (10%), diabetes educators (11%), physicians (29%), allied health professionals (17%; including dietitians, nutritionists, physiologists, exercise trainers, psychologists and pharmacists), clinical decision support systems (32%) and non-specialized support (23%; including trained peers, members of research teams, counsellors and community health care workers).

Most (94%) of the interventions were interactive, whereby the patient could communicate with the provider, and the provider could communicate with the patient. Interactive telecommunication initiated by providers occurred in the following frequencies: at least daily (8%), weekly (26%), every 2 weeks (10%), monthly (16%) or less often (7%). Frequency of interaction was not reported in 33% of trials. Many of the interventions (45%) adjusted medication based on the data received. Other frequent components of the interventions included general diabetes education (76%), nutritional interventions (53%), exercise (49%) and blood pressure management (9%).

The risk-of-bias assessment of the trials is shown in Figure 2 and Table A2 in Appendix 1. Because blinding of participants is not feasible for telemedicine interventions, all trials were open label to the participants; thus, every trial included at least 1 element of risk of bias. However, we assessed for blinding of outcome assessors (present in 20% of trials). Seventy-eight trials (70%) reported and described an appropriate method of randomization, but only 30 (27%) reported an adequate allocation concealment process. The intention-to-treat principle was applied in 51 (46%) of the trials. Public funding was exclusively used in 57 trials (51%).

**Effect on HbA\textsubscript{1c}**

Thirty-nine trials (n = 3165) reported the effect of telemedicine on HbA\textsubscript{1c} at 3 months or less (Table 3 and Table A3 in Appendix 1). Eighty-seven trials (n = 15524) reported HbA\textsubscript{1c} at 4–12 months, and 5 trials (n = 1896) reported HbA\textsubscript{1c} beyond 12 months. The MDs were all significant and favoured telemedicine, although there was large heterogeneity (≤ 3 mo: −0.57%, 95% confidence interval [CI] −0.74% to −0.40%, I\textsuperscript{2} = 75%; 4–12 mo: −0.28%, 95% CI −0.37% to −0.20%, I\textsuperscript{2} = 69% [Figure 3]; and > 12 mo: −0.26%, 95% CI −0.46% to −0.06%, I\textsuperscript{2} = 58%). Inspection of the effect sizes identified 3 outlier trials\textsuperscript{67,98,154}.

![Figure 1: Selection of trials for analysis. RCT = randomized controlled trial.](image-url)
for which effects were larger than in the other trials. Exclusion of these 3 trials did not materially affect our results for the primary outcome (HbA1c at 4–12 mo), but it did reduce heterogeneity (−0.24%, 95% CI −0.31% to −0.16%, $P = 58\%$). Findings were similar when control of HbA1c was dichotomized at various thresholds (6.4%–6.5%, 7%–7.5%, 8% or 9%) and when we pooled results from the last time points from every available trial (Table A3 in Appendix 1, and Appendix 2 [available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.150885/DC1]).

The contour funnel plot of HbA1c was asymmetrical, consistent with publication bias (more small studies favouring telemedicine) (Figure 4). The bias estimate from the regression analysis was significant (Egger test: bias −0.95, $p = 0.02$). When the 3 outlier trials were removed, the bias estimate was not significant (bias −0.68, $p = 0.07$).

**Meta-regression analysis**
We explored a number of population and intervention characteristics using univariable meta-regression (Table 4). Both trial region and baseline HbA1c modified the effect of telemedicine on final HbA1c, but mean age, percent male, diabetes duration, BMI, insulin use, use of oral hypoglycemic therapy and diabetes type did not. European ($n = 26$) and North American trials (reference group, $n = 47$) reported similar MDs (difference in MD −0.08%, 95% CI −0.27% to 0.11%); however, trials from Asia ($n = 9$) reported significantly larger differences favouring telemedicine relative to North American trials (difference in MD −0.49%, 95% CI −0.77% to −0.22%).

Because most telemedicine platforms were used in fewer than 5 trials, it was not possible to use meta-regression to evaluate the relative merits of all platforms. Choice of patient-to-provider platform (smartphone application, Web portal, smart device, telephone) did not significantly modify the effect of telemedicine on HbA1c. However, choice of provider-to-patient platform (SMS text messaging, Web portal, clinical decision support system, telephone) significantly influenced the association between telemedicine and HbA1c, with both SMS text messaging and Web portal associated with greater benefit than telephone-based systems (difference in MD: SMS v. telephone −0.28%, 95% CI −0.52% to −0.05%; Web portal v. telephone −0.35%, 95% CI −0.56% to −0.14%). Interventions in which providers adjusted medication in response to data from patients were also associated with larger improvements in HbA1c (−0.23%, 95% CI −0.42% to −0.05%). Inclusion of interactive communication, exercise, general diabetes education, blood pressure management or nutritional interventions did not modify the benefit of telemedicine on HbA1c. Frequency of contact and type of provider did not significantly modify the association.

None of the items from the Cochrane risk-of-bias tool were significant effect modifiers, except for reporting loss to follow-up. Trials that partially reported loss to follow-up (i.e., no stated reasons for loss to follow-up, or loss was reported for the whole trial and not by group) showed a smaller difference in HbA1c than trials with fully reported loss to follow-up or trials that did not report loss to follow-up (difference in MD 0.30%, 95% CI 0.11% to 0.48%). Because there was no gradient of effect, there was no evidence that reporting versus not reporting loss to follow-up was a significant effect modifier.

**Effect on quality of life and mortality**
Few trials (27 trials) reported on quality of life. Among the 23 trials that reported an instrument used by at least one other trial, a total of 6 instruments were validated (Table 3). Telemedicine led to sig-
Table 3 (part 1 of 2): Pooled estimates of the effect of telemedicine on outcomes

| Outcome                  | Time point, mo | No. of trials and within-trial subgroups (no. of participants*) | $I^2$ statistic, % | Pooled estimate (95% CI) |
|--------------------------|----------------|-----------------------------------------------------------------|-------------------|--------------------------|
| Mortality                | ≤ 3            | 11 (1361)                                                       | 0                 | RD, %: 0.2 (–0.6 to 0.9) |
|                          | 4–12           | 42 (7197)                                                      | 0                 | RD, %: –0.2 (–0.6 to 0.2) |
|                          | > 12           | 4 (2376)                                                       | 0                 | RD, %: –0.3 (–1.6 to 1.0) |
| $\text{HbA}_1c$          | $\leq 3$       | 39 (3165)                                                      | 75                | MD, %: –0.57 (–0.74 to –0.40) |
|                          | 4–12           | 87 (15 524)                                                   | 69                | MD, %: –0.28 (–0.37 to –0.20) |
|                          | > 12           | 5 (1896)                                                     | 58                | MD, %: –0.26 (–0.46 to –0.06) |
| $\text{HbA}_1c < 6.4\%$  | 4–12           | 1 (248)                                                       | –                 | RR: 1.79 (0.98 to 3.27)   |
|                          | > 12           | 1 (80)                                                        | –                 | RR: 2.33 (0.997 to 5.46)  |
| $\text{HbA}_1c < 7\%, \leq 7\%$ | 4–12       | 7 (1016)                                                      | 91                | RR: 2.30 (1.21 to 4.38)   |
|                          | > 12           | 11 (1615)                                                     | 73                | RR: 1.46 (1.03 to 2.08)   |
| $\text{HbA}_1c < 8\%$  | 4–12           | 1 (137)                                                       | –                 | RR: 2.28 (1.42 to 3.67)   |
|                          | > 12           | 3 (602)                                                       | 72                | RR: 1.20 (0.90 to 1.61)   |
| $\text{HbA}_1c < 9\%$  | 4–12           | 1 (137)                                                       | –                 | RR: 1.31 (1.07 to 1.60)   |
| SF-36 (0–100)†          |               |                                                               |                   |                           |
|                          | ≤ 3            | 2 (295)                                                       | 0                 | MD: –1.06 (–3.19 to 1.07) |
|                          | 4–12           | 4 (784)                                                       | 63                | MD: 0.47 (–1.89 to 2.84)  |
|                          | ≤ 3            | 2 (295)                                                       | 42                | MD: 0.02 (–1.97 to 3.81)  |
|                          | 4–12           | 4 (784)                                                       | 0                 | MD: 0.08 (–1.16 to 1.32)  |
| Bodily pain              | ≤ 3            | 2 (309)                                                       | 86                | MD: 5.46 (–8.64 to 19.56) |
|                          | 4–12           | 6 (1166)                                                      | 19                | MD: 0.44 (–2.19 to 3.07)  |
| Health transition        | 4–12           | 1 (117)                                                       | –                 | MD: 3.00 (–6.00 to 12.00) |
| Mental health            | ≤ 3            | 2 (308)                                                       | 0                 | MD: –1.09 (–3.19 to 1.01) |
|                          | 4–12           | 7 (1285)                                                      | 62                | MD: 2.31 (–0.24 to 4.86)  |
| Physical functioning     | ≤ 3            | 2 (311)                                                       | 30                | MD: –3.98 (–7.34 to –0.62) |
|                          | 4–12           | 7 (1288)                                                      | 58                | MD: 1.06 (–1.52 to 3.64)  |
| Role emotional           | ≤ 3            | 2 (304)                                                       | 0                 | MD: –1.00 (–3.50 to 1.51) |
|                          | 4–12           | 6 (1161)                                                      | 80                | MD: 2.89 (–4.96 to 10.74) |
| Role physical            | ≤ 3            | 2 (307)                                                       | 0                 | MD: 0.30 (–2.38 to 2.97)  |
|                          | 4–12           | 6 (1164)                                                      | 62                | MD: 2.20 (–3.62 to 8.02)  |
| Social functioning       | ≤ 3            | 2 (311)                                                       | 0                 | MD: –2.22 (–4.34 to –0.10) |
|                          | 4–12           | 6 (1168)                                                      | 59                | MD: –0.27 (–3.78 to 3.24) |
| Vitality                 | ≤ 3            | 2 (310)                                                       | 0                 | MD: 0.50 (–1.98 to 2.98)  |
|                          | 4–12           | 6 (1167)                                                      | 69                | MD: 1.57 (–2.26 to 5.40)  |
| SF-12 (0–100)††          | 4–12           | 1 (35)                                                        | –                 | MD: –1.00 (–2.33 to 0.33) |
| Mental component summary | 4–12           | 3 (549)                                                       | 0                 | MD: 0.51 (–1.26 to 2.29)  |
|                          | > 12           | 1 (204)                                                       | –                 | MD: 2.37 (–2.15 to 6.89)  |
| Physical component summary | 4–12     | 3 (549)                                                       | 7                 | MD: –0.05 (–2.46 to 2.35) |
|                          | > 12           | 1 (204)                                                       | –                 | MD: 0.35 (–5.66 to 6.36)  |
significant improvement in the Problem Areas in Diabetes score (MD at 4–12 mo: 2.86, 95% CI 1.74 to 3.97, \( I^2 = 0\% \), 2 trials, \( n = 363 \)). Three scores or subscores showed significant worsening (SF-36 physical functioning ≤ 3 mo: MD −3.98, 95% CI −0.62 to −7.34, \( I^2 = 30\% \), 2 trials, \( n = 311 \); SF-36 social functioning ≤ 3 mo: MD −2.22, 95% CI −0.10 to −4.34, \( I^2 = 0\% \), 2 trials, \( n = 311 \); and EQ-5D at 4–12 mo: MD −0.01, 95% CI −0.01 to −0.01, 2 trials, \( n = 743 \)). There was no evidence of selective reporting of subscores for quality of life. However, the effect of telemedicine was not significant for most subscores, and the few statistically significant differences were likely not clinically relevant.\(^{157}\)

We pooled the mental health and physical health component summaries of the SF-36 and SF-12 instruments from 7 trials (\( n = 1333 \)): MD 0.55 (95% CI −0.83 to 1.92; \( I^2 = 29\% \)) and 0.06 (95% CI −1.01 to 1.13; \( I^2 = 0\% \)), respectively. We also pooled the global scores (after transformation to a 1–100 range, where 100 was optimal) from all 3 diabetes-specific instruments from 8 trials (14 within-trial subgroups, \( n = 1324 \)): MD 0.86 (95% CI −0.73 to 2.45; \( I^2 = 23\% \)). Because all of these findings were nonsignificant,\(^{157}\) there was no evidence to suggest that telemedicine enhanced quality of life.

Eleven trials (\( n = 1361 \)) reported all-cause mortality within 3 months, 42 trials (\( n = 7197 \)) reported mortality at 4–12 months, and 4 trials (\( n = 2376 \)) reported mortality beyond 12 months. The risk differences were all nonsignificant, without evidence of heterogeneity (≤ 3 mo: 0.2%, 95% CI −0.6% to 0.9%, \( I^2 = 0\% \), 6 deaths; 4–12 mo: −0.2%, 95% CI −0.6% to 0.2%, \( I^2 = 0\% \), 68 deaths; and > 12 mo: −0.3%, 95% CI −1.6% to 1.0%, \( I^2 = 0\% \), 351 deaths).

**Effect on hypoglycemia**

Five trials (\( n = 462 \)) reported participants with hypoglycemic episodes within 3 months, and 4 trials (\( n = 282 \)) reported participants with hypoglycemia at 4–12 months (Table 3). One trial (\( n = 92 \)) reported participants with severe hypoglycemia within 3 months, and 10 trials (\( n = 1259 \)) reported participants with severe hypoglycemia at 4–12 months. There was no evidence that telediagnosis reduced the risk of hypoglycemic episodes (risk difference for hypoglycemic episodes ≤ 3 mo: 0.0%, 95% CI −5.5% to 5.5%, \( I^2 = 63\% \), 8 deaths; and at 4–12 mo: −0.2%, 95% CI −0.6% to 0.2%, \( I^2 = 0\% \), 68 deaths; and > 12 mo: −0.3%, 95% CI −1.6% to 1.0%, \( I^2 = 0\% \), 351 deaths).

**Table 3 (part 2 of 2): Pooled estimates of the effect of telemedicine on outcomes**

| Outcome                                      | Time point, mo | No. of trials and within-trial subgroups (no. of participants*) | \( I^2 \) statistic, % | Pooled estimate (95% CI) |
|----------------------------------------------|----------------|------------------------------------------------------------------|------------------------|--------------------------|
| Diabetes Quality of Life (1–5)†             | ≤ 3            | 1 (98)                                                           | –                      | MD: −0.19 (−0.52 to 0.14) |
|                                               | 4–12           | 6 (184)                                                          | 0                     | MD: −0.003 (−0.10 to 0.09) |
| Diabetes-related worry                       | ≤ 3            | 2 (166)                                                          | 36                    | MD: 0.03 (−0.25 to 0.32)  |
|                                               | 4–12           | 4 (302)                                                          | 67                    | MD: 0.08 (−0.17 to 0.34)  |
| Impact of diabetes                            | ≤ 3            | 2 (166)                                                          | 59                    | MD: −0.01 (−0.31 to 0.28) |
|                                               | 4–12           | 4 (302)                                                          | 60                    | MD: 0.02 (−0.17 to 0.21)  |
| Satisfaction with life                        | ≤ 3            | 1 (68)                                                           | –                     | MD: 0.24 (−0.05 to 0.53)  |
|                                               | 4–12           | 4 (222)                                                          | 47                    | MD: 0.16 (−0.02 to 0.33)  |
| Social/vocational worry                       | ≤ 3            | 1 (98)                                                           | –                     | MD: −0.12 (−0.33 to 0.09) |
|                                               | 4–12           | 3 (249)                                                          | 54                    | MD: −0.05 (−0.29 to 0.20) |
| Diabetes Distress Scale (1–6)††              | 4–12           | 6 (777)                                                          | 0                     | MD: −0.01 (−0.17 to 0.15) |
| EQ-5D (0–1)††                                | 4–12           | 2 (743)                                                          | 0                     | MD: −0.01 (−0.11 to −0.01) |
| PAID (0–100)††                               | 4–12           | 2 (363)                                                          | 0                     | MD: 2.86 (1.74 to 3.97)   |
| Hypoglycemia (patient-years)                 | ≤ 3            | 3 (46)                                                           | 93                    | RR: 0.86 (0.66 to 1.12)   |
|                                               | 4–12           | 5 (848)                                                          |                      |                          |
| Severe hypoglycemia (patient-years)          | 4–12§          | 4 (427)                                                          | 92                    | RR: 0.59 (0.17 to 2.05)   |
| Hypoglycemia (% of patients affected)        | ≤ 3            | 5 (462)                                                          | 63                    | RD, %: 0.0 (−5.5 to 5.5)  |
|                                               | 4–12           | 4 (282)                                                          | 47                    | RD, %: 3.1 (−7.9 to 14.2) |
| Severe hypoglycemia                          | ≤ 3            | 1 (92)                                                           | –                     | RD, %: 0.0 (−4.2 to 4.2)  |
|                                               | 4–12           | 10 (1259)                                                        | 0                     | RD, %: −0.1 (−1.0 to 0.8) |

Note: CI = confidence interval, EQ-5D = European Quality of Life survey with 5 dimensions, HbA1c = glycated hemoglobin, MD = difference in means, PAID = Problem Areas in Diabetes, RD = difference in risk, RR = risk ratio or rate ratio, SF-12 = 12-item Short Form Health Survey, SF-36 = 36-item Short Form Health Survey, − = not applicable.\(^*\)

We used effective sample sizes in cluster trials and patient-years for rate ratios.\(^†\)

Large values indicate a better quality of life.\(^††\)

Small values indicate a better quality of life.\(^§\)

No data available for time point ≤ 3 mo.
| Study       | Year | Weight, % | MD (95% CI)                  |
|------------|------|-----------|------------------------------|
| Katalenich | 2015 | 1.11      | 0.20 (–0.32 to 0.72)         |
| Nicolucci  | 2015 | 1.72      | –0.34 (–0.58 to –0.10)       |
| Rasmussen  | 2015 | 0.75      | 0.50 (–0.25 to 1.25)         |
| Shahid     | 2015 | 1.74      | –0.73 (–0.96 to –0.50)       |
| Arora      | 2014 | 1.18      | –0.20 (–0.68 to 0.28)        |
| Chan       | 2014 | 1.66      | –0.01 (–0.28 to 0.26)        |
| Esmatjies  | 2014 | 1.24      | 0.10 (–0.36 to 0.56)         |
| Luley      | 2014 | 1.10      | –1.10 (–1.62 to –0.58)       |
| Lynch      | 2014 | 0.64      | –0.10 (–0.95 to 0.75)        |
| O’Connor   | 2014 | 1.78      | 0.10 (–0.11 to 0.31)         |
| Pressman   | 2014 | 1.26      | 0.00 (–0.45 to 0.45)         |
| Steventon  | 2014 | 1.55      | –0.23 (–0.55 to 0.09)        |
| Varney     | 2014 | 1.16      | –0.20 (–0.70 to 0.30)        |
| Crowley    | 2013 | 1.64      | –0.10 (–0.38 to 0.18)        |
| Eakin      | 2013 | 1.42      | 0.00 (–0.37 to 0.37)         |
| Gagliardino| 2013 | 1.50      | –0.20 (–0.54 to 0.14)        |
| Kirwan     | 2013 | 1.11      | –0.78 (–1.30 to –0.26)       |
| Lechter    | 2013 | 1.04      | 0.30 (–0.26 to 0.86)         |
| Mons       | 2013 | 1.45      | –0.13 (–0.49 to 0.23)        |
| Munshi     | 2013 | 1.36      | 0.16 (–0.24 to 0.56)         |
| Nagrebetsky| 2013 | 0.06      | –0.64 (–4.05 to 2.77)        |
| Orsama     | 2013 | 0.62      | –0.60 (–1.47 to 0.27)        |
| Plotnikoff | 2013 | 1.78      | 0.21 ( 0.00 to 0.42)         |
| Rossi      | 2013 | 1.64      | –0.20 (–0.48 to 0.08)        |
| Tang       | 2013 | 1.47      | –0.23 (–0.58 to 0.12)        |
| Van Dyck   | 2013 | 1.02      | –0.30 (–0.87 to 0.27)        |
| Bell       | 2012 | 0.95      | 0.20 (–0.41 to 0.81)         |
| Del Prato  | 2012 | 0.18      | –0.06 (–1.91 to 1.79)        |
| Glasgow    | 2012 | 1.38      | 0.06 (–0.33 to 0.45)         |
| Glasgow    | 2012 | 1.42      | 0.19 (–0.18 to 0.56)         |
| Jarab      | 2012 | 0.67      | –1.80 (–2.61 to –0.99)       |
| Marois     | 2012 | 0.40      | 0.49 (–0.66 to 1.64)         |
| Pacaud     | 2012 | 0.46      | –0.59 (–1.65 to 0.47)        |
| Pacaud     | 2012 | 0.45      | –0.31 (–1.38 to 0.76)        |
| Williams   | 2012 | 0.86      | –1.00 (–1.67 to –0.33)       |
| Avda       | 2011 | 1.49      | –0.69 (–1.03 to –0.35)       |
| Carter     | 2011 | 0.74      | –1.08 (–1.84 to –0.32)       |
| Charpentier| 2011 | 1.36      | –0.69 (–1.09 to –0.29)       |
| Choi       | 2011 | 1.47      | 0.10 (–0.25 to 0.45)         |
| Francis    | 2011 | 1.27      | –0.50 (–0.94 to –0.06)       |
| Frosch     | 2011 | 1.10      | –0.30 (–0.83 to 0.23)        |
| Keogh      | 2011 | 1.23      | –0.39 (–0.85 to 0.07)        |
| Kim        | 2011 | 0.75      | –0.51 (–1.26 to 0.24)        |
| Lim        | 2011 | 1.36      | –0.40 (–0.80 to 0.00)        |

Figure 3 (part 1 of 2): Differences in mean glycated hemoglobin levels at 4–12 months between telemedicine intervention groups and usual care groups. Values less than zero favour telemedicine. CI = confidence interval, MD = difference in means.
| Study            | Year | Weight, % | MD (95% CI)       |
|------------------|------|-----------|-------------------|
| Quinn125         | 2011 | 0.33      | -0.80 (-2.11 to 0.51) |
| Quinn125         | 2011 | 0.32      | -0.60 (-1.92 to 0.72) |
| Quinn125         | 2011 | 0.29      | -0.60 (-2.02 to 0.82) |
| Tildesley140     | 2011 | 0.86      | -0.30 (-0.97 to 0.37) |
| Wakefield145     | 2011 | 1.26      | 0.04 (-0.41 to 0.49)  |
| Wakefield145     | 2011 | 1.27      | 0.16 (-0.28 to 0.60)  |
| Walker142        | 2011 | 1.66      | -0.46 (-0.73 to -0.19) |
| Anderson199      | 2010 | 1.12      | -0.08 (-0.60 to 0.44) |
| Davis65          | 2010 | 0.52      | -0.40 (-1.38 to 0.58) |
| Heisler83        | 2010 | 1.33      | -0.49 (-0.90 to -0.08) |
| Lorig133         | 2010 | 1.79      | -0.07 (-0.27 to 0.13) |
| Rossi129         | 2010 | 1.51      | -0.10 (-0.43 to 0.23) |
| Stone136         | 2010 | 1.32      | -0.70 (-1.12 to -0.28) |
| Tildesley141     | 2010 | 0.89      | -0.80 (-1.44 to -0.16) |
| Dale64           | 2009 | 1.27      | 0.00 (-0.44 to 0.44)  |
| Holbrook84       | 2009 | 1.62      | -0.50 (-0.78 to -0.22) |
| Istepanian85     | 2009 | 1.11      | -0.30 (-0.82 to 0.22) |
| McCarrier108     | 2009 | 0.88      | -0.54 (-1.19 to 0.11) |
| Ralston126       | 2009 | 1.07      | -0.80 (-1.34 to -0.26) |
| Rodriguez-Idigoras128 | 2009 | 1.57      | 0.05 (-0.26 to 0.36)  |
| Schillinger131   | 2009 | 1.03      | -0.30 (-0.86 to 0.26) |
| Shea133          | 2009 | 1.91      | -0.20 (-0.33 to -0.07) |
| Kim98            | 2008 | 1.26      | -1.52 (-1.96 to -1.08) |
| Yoon154          | 2008 | 1.15      | -1.63 (-2.13 to -1.13) |
| Benhamou53       | 2007 | 1.73      | -0.12 (-0.35 to 0.11) |
| Bond72           | 2007 | 1.06      | -0.65 (-1.20 to -0.10) |
| Kim96            | 2007 | 0.89      | -0.66 (-1.31 to -0.01) |
| Harno51          | 2006 | 1.26      | -0.51 (-0.96 to -0.06) |
| Jansa86          | 2006 | 1.09      | 0.00 (-0.53 to 0.53)  |
| Farmer49         | 2005 | 1.02      | -0.30 (-0.87 to 0.27) |
| Glasgow77        | 2005 | 1.52      | 0.01 (-0.32 to 0.34)  |
| Maljian106       | 2005 | 1.56      | 0.30 (-0.01 to 0.61)  |
| McMahon109       | 2005 | 1.57      | -0.30 (-0.61 to 0.01) |
| Young105         | 2005 | 1.60      | -0.50 (-0.79 to -0.21) |
| Montor211        | 2004 | 0.56      | -0.40 (-1.33 to 0.53) |
| Wolf152          | 2004 | 1.15      | -0.20 (-0.70 to 0.30) |
| Biermann144      | 2002 | 0.69      | 0.30 (-0.50 to 1.10)  |
| Gomez78          | 2002 | 0.29      | -0.25 (-1.64 to 1.14) |
| Piette120        | 2001 | 1.63      | -0.10 (-0.38 to 0.18) |
| Piette121        | 2000 | 1.20      | -0.10 (-0.57 to 0.37) |
| Thompson139      | 1999 | 1.10      | -1.10 (-1.62 to -0.58) |
| Glasgow76        | 1997 | 1.45      | 0.00 (-0.36 to 0.36)  |
| Weinberger148    | 1995 | 0.80      | -0.60 (-1.31 to 0.11) |

Overall  
\( I^2 = 69\% \)  
\(-0.28 (-0.37 to -0.20) \)

Figure 3 (part 2 of 2): Differences in mean glycated hemoglobin levels at 4–12 months between telemedicine intervention groups and usual care groups. Values less than zero favour telemedicine. CI = confidence interval, MD = difference in means.
Interpretation

Compared with usual care, the addition of telemedicine appeared to improve HbA1c significantly in people with either type 1 or 2 diabetes. Although there was substantial heterogeneity, the pooled analyses showed that telemedicine lowered HbA1c by 0.57% within 3 months and by 0.28% beyond 4 months. The lower apparent magnitude of benefit with longer follow-up may reflect reduced adherence to the intervention. Nonetheless, the effect on HbA1c appears clinically relevant and is comparable to improvements associated with some oral antidiabetic agents (0.5%–1.25%), psychosocial interventions (0.6%, 95% CI –1.2% to –0.1%) or quality improvement strategies (0.42%, 95% CI 0.29% to 0.54%) among patients with diabetes. However, we did not find good evidence that telemedicine reduced the risk of hypoglycemia or mortality, although it is unlikely that benefits for the latter would have been observed given the short duration of the included trials. Although telemedicine may also improve patient satisfaction with care, we did not collect data to test this hypothesis, and thus this suggested benefit is speculative.

The meta-regression analyses suggested that telemedicine interventions that facilitated medication adjustments were more effective in improving glycemic control than interventions that did not allow such adjustments. This finding is consistent with medication adjustment by nurse or pharmacist (0.23%, 95% CI 0.05% to 0.42%) reported in a previous meta-regression analysis of quality improvement strategies, including case management. Our findings suggest that text messaging and Web portals may be especially effective mechanisms for linking providers to patients with diabetes. The use of SMS text messaging may be feasible to communicate and motivate patients, which could result in positive outcomes. Although the trials we studied required providers to generate the text messages, it may prove feasible and less expensive to generate such messages by means of automated algorithms.

There are various types of telemedicine interventions, including telehealth (clinical services provided at a distance), telecare (often applied to nonclinical aspects of care such as mobility and safety) and telemonitoring (remote collection and transmission of clinical data from patients to providers). We primarily included trials in which patients received clinical feedback or communication from providers using some technology or devices. Therefore, we cannot differentiate trials that focused on telemonitoring or telecare in our review. Among the included trials, telemedicine interventions ranged from simple messages providing generic management suggestions for patients to more comprehensive interventions permitting videoconferencing with a nurse case manager, and remote monitoring of glucose and blood pressure with electronic data captured in the electronic medical record. This wide variation in interventions likely contributed to some of the observed heterogeneity, which was only partly explained by meta-regression.

Although our study is, to our knowledge, more comprehensive than previous studies of telemedicine in diabetes, our results are generally consistent with prior work showing beneficial effects of telemedicine on HbA1c. Compared with other systematic reviews, the relatively large number of studies that we identified allowed more detailed exploration of factors that may influence the magnitude of benefits on HbA1c. We were also able to show that effects on HbA1c diminished but were sustained over time and that benefits were more pronounced with more interactive interventions (e.g., Web portals and text messaging).

Limitations

Weaknesses of our systematic review include limitations of the constituent trials (small sample size, lack of blinding and relatively short duration). However, evidence suggests that lack of blinding would be less likely to affect an objectively assessed outcome such as HbA1c. Although the trials we studied required providers to generate the text messages, it may prove feasible and less expensive to generate such messages by means of automated algorithms.

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### Table 4 (part 1 of 2): Association between population characteristics, intervention characteristics, risk-of-bias items and the effect of telemedicine on HbA1C at 4–12 mo

| Variable                      | No. of trials and within-trial subgroups | Difference in MD (95% CI) | p value | I² statistic, % |
|-------------------------------|------------------------------------------|---------------------------|---------|----------------|
| **Population characteristics**|                                          |                           |         |                |
| Continent                     |                                          |                           |         |                |
| North or South America        | 47                                       | 0 (ref)                   |         | 65             |
| Europe                        | 26                                       | -0.08 (-0.27 to 0.11)     | 0.4     |                |
| Asia                          | 9                                        | -0.49 (-0.77 to -0.22)    | 0.001   |                |
| Oceania                       | 5                                        | -0.16 (-0.55 to 0.23)     | 0.4     |                |
| Age (range 24–75 yr)          | 83                                       | 0.003 per 1 yr (-0.005 to 0.01) | 0.4 | 68             |
| Sex, male (range 20%–100%)    | 84                                       | 0.0002 per 1% (-0.005 to 0.005) | 0.9 | 70             |
| Duration of follow-up (range 2.6–24 yr) | 52                                       | 0.008 per 1 yr (-0.02 to 0.03) | 0.5 | 69             |
| Baseline HbA1C (range 6.4%–10.7%) | 87                                       | -0.06 per 1% (-0.16 to 0.04) | 0.3 | 68             |
| BMI score (range 23–38)       | 62                                       | 0.02 per 1 score (-0.01 to 0.05) | 0.2 | 71             |
| % using insulin (0%–100%)     | 59                                       | -0.00008 per 1% (-0.004 to 0.003) | 1.0 | 71             |
| % using OHA (range 44%–100%)  | 31                                       | 0.003 per 1% (-0.006 to 0.01) | 0.5 | 72             |
| **Type of diabetes mellitus** |                                          |                           |         |                |
| Type 2                        | 58                                       | 0 (ref)                   |         | 69             |
| Type 1                        | 11                                       | 0.05 (-0.22 to 0.33)      | 0.7     |                |
| Mixed                         | 9                                        | 0.20 (-0.09 to 0.50)      | 0.2     |                |
| Unknown                       | 9                                        | 0.13 (-0.14 to 0.41)      | 0.3     |                |
| **Intervention characteristics** |                                          |                           |         |                |
| Patient-to-provider communication |                                          |                           |         |                |
| Telephone                     | 14                                       | 0 (ref)                   |         | 69             |
| Smartphone application        | 7                                        | -0.25 (-0.71 to 0.21)     | 0.3     |                |
| Web portal                    | 23                                       | -0.16 (-0.44 to 0.12)     | 0.3     |                |
| Smart device                  | 23                                       | 0.06 (-0.23 to 0.36)      | 0.7     |                |
| Provider-to-patient communication |                                          |                           |         |                |
| Telephone                     | 51                                       | 0 (ref)                   |         | 67             |
| SMS text messaging            | 12                                       | -0.28 (-0.52 to -0.05)    | 0.02    |                |
| Web portal                    | 20                                       | -0.35 (-0.56 to -0.14)    | 0.001   |                |
| CDSS                          | 27                                       | 0.10 (-0.08 to 0.28)      | 0.3     |                |
| **Type of provider**          |                                          |                           |         |                |
| Nurse                         | 33                                       | 0 (ref)                   |         | 69             |
| CDSS                          | 27                                       | 0.07 (-0.12 to 0.27)      | 0.5     |                |
| Diabetes educator             | 11                                       | 0.10 (-0.21 to 0.40)      | 0.5     |                |
| Physician                     | 25                                       | 0.13 (-0.10 to 0.35)      | 0.3     |                |
| Allied health                 | 12                                       | 0.15 (-0.11 to 0.41)      | 0.3     |                |
| Care manager                  | 11                                       | 0.16 (-0.11 to 0.43)      | 0.2     |                |
| Nonspecialized support        | 19                                       | 0.17 (-0.05 to 0.40)      | 0.1     |                |
| **Frequency of contact**      |                                          |                           |         |                |
| Daily                         | 5                                        | 0 (ref)                   |         | 68             |
| Weekly                        | 19                                       | -0.09 (-0.49 to 0.30)     | 0.6     |                |
| Every 2 wk                    | 11                                       | -0.05 (-0.48 to 0.38)     | 0.8     |                |
| Monthly                       | 15                                       | 0.05 (-0.36 to 0.45)      | 0.8     |                |
received and the populations studied. The variation may have contributed to the observed heterogeneity, and it may explain why some trials found positive effects of telemedicine and others found no benefit. However, we used meta-regression to identify which types of telemedicine interventions were particularly efficacious. The potential benefits of SMS text messaging and Web portals when used in conjunction with tailored (patient-specific) suggestions for medication adjustment suggest that these forms of intervention should be the highest priority for future uptake.

Third, as with all meta-regression analyses using summary data rather than individual participant data, our findings are vulnerable to the ecological fallacy (i.e., findings at the population level do not always translate correctly to individuals) and from limited statistical power.

Fourth, we did not collect data on the effects of telemedicine on satisfaction of care or its cost-effectiveness.163

Finally, we found some evidence of publication bias, which suggests that some small negative trials might exist, but they were not

| Variable | No. of trials and within-trial subgroups | Difference in MD (95% CI) | p value | $I^2$ statistic, % |
|----------|----------------------------------------|--------------------------|---------|------------------|
| Less frequently than monthly | 6 | 0.37 (–0.09 to 0.83) | 0.1 |  |
| Not reported | 29 | 0.11 (–0.27 to 0.49) | 0.6 |  |
| **Additional components** | | | | |
| Interactive | 82 | 0.03 (–0.34 to 0.40) | 0.9 | 68 |
| Medication adjustment | 40 | –0.23 (–0.42 to –0.05) | 0.01 |  |
| Exercise | 41 | –0.11 (–0.39 to 0.18) | 0.5 |  |
| General education | 65 | –0.21 (–0.44 to 0.02) | 0.1 |  |
| Blood pressure management | 8 | –0.002 (–0.31 to 0.30) | 1.0 |  |
| Nutrition | 41 | 0.08 (–0.21 to 0.37) | 0.6 |  |
| **Risk of bias** | | | | |
| Randomization not described appropriately | 24 | –0.03 (–0.23 to 0.17) | 0.8 | 69 |
| Inadequate or unclear allocation concealment | 60 | –0.07 (–0.25 to 0.11) | 0.5 | 69 |
| **Blinding** | | | | |
| Yes | 18 | 0 (ref) | 69 |  |
| No | 12 | 0.12 (–0.19 to 0.43) | 0.4 |  |
| Unclear | 57 | 0.15 (–0.08 to 0.38) | 0.2 |  |
| **Loss to follow-up** | | | | |
| Reported | 55 | 0 (ref) | 65 |  |
| Not reported | 10 | –0.11 (–0.37 to 0.16) | 0.4 |  |
| Partially reported | 22 | 0.30 (0.11 to 0.48) | 0.003 |  |
| % loss to follow-up (range 0%–39%) | 76 | 0.005 per 1% (–0.006 to 0.02) | 0.4 | 67 |
| No selective reporting | 71 | –0.06 (–0.30 to 0.17) | 0.6 | 69 |
| **Funding** | | | | |
| Public | 45 | 0 (ref) | 69 |  |
| Private | 17 | –0.004 (–0.24 to 0.23) | 1.0 |  |
| Neither | 13 | 0.01 (–0.24 to 0.26) | 0.9 |  |
| Both | 12 | 0.14 (–0.17 to 0.45) | 0.4 |  |
| Not intention-to-treat analysis | 40 | –0.14 (–0.31 to 0.04) | 0.1 | 68 |
| Adjustment for potential confounders | 17 | 0.08 (–0.14 to 0.29) | 0.5 | 69 |

Note: BMI = body mass index, CDSS = computer decision support system, CI = confidence interval, HbA1c = glycated hemoglobin, MD = difference in means, OHA = oral hypoglycemic agents, ref = reference category, SMS = short message service.

Categories with < 5 studies were not included in the meta-regression analyses; heterogeneity in the primary analysis was 69%.
identified by our literature search. If this supposition were correct, it might lead to a slight overestimation of the efficacy of telemedicine interventions, but it would likely not affect our conclusion given that elimination of the outliers removed any significant publication bias.

Conclusion
Our systematic review showed that telemedicine may be a useful supplement to usual clinical care to control HbA1c, at least in the short term. Telemedicine interventions appeared to be most effective when they use a more interactive format, such as a Web portal or text messaging, to help patients with self-management.

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Table 1 (part 1 of 3): Trial and population characteristics by type of diabetes

| Type of diabetes; study | Country | RCT design | Sample size | Duration of follow-up, mo | Mean age, yr | Male, % | Mean duration of diabetes, yr | Mean baseline HbA1c | Mean BMI | % using insulin | % using OHA |
|------------------------|---------|------------|-------------|---------------------------|-------------|--------|-------------------------------|-------------------|---------|----------------|------------|
| **Type 1 diabetes**    |         |            |             |                           |             |        |                               |                   |         |                |            |
| Esmatjes,68 2014       | Spain   | Parallel   | 154         | 6                         | 32          | 45     | 17.2                          | 9.2               | 25      | 100            |            |
| Suh,70 2014            | Korea   | Parallel   | 57          | 3                         | 33          | 37     | 7.4                           | 9.5               | 93      | 23             | 100        |
| Kirwan,68 2013         | Australia | Parallel | 72          | 9                         | 35          | 39     | 18.9                          | 8.8               | –       | –              | –          |
| Rossi,69 2013          | Italy   | Parallel   | 127         | 6                         | 36          | 48     | 15.6                          | 8.5               | 24      | 100            |            |
| Charpentier,68 2011    | France  | Parallel   | 120         | 6                         | 34          | 36     | 15.8                          | 9.0               | 25      | 100            |            |
| Rossi,69 2010          | Italy, Spain, UK | Parallel | 130         | 6                         | 36          | 43     | 16.5                          | 8.3               | –       | 100            |            |
| McCarrier,68 2009      | US      | Parallel   | 78          | 12                        | 37          | 67     | –                             | 8.0               | –       | 100            | –          |
| Benhamou,68 2007       | France  | Crossover  | 31          | 12                        | 41          | 50     | 24.0                          | 8.3               | 24      | 100            |            |
| Jansa,69 2006          | Spain   | Parallel   | 40          | 12                        | 25          | 50     | 11.0                          | 8.7               | 23      | 100            | –          |
| Farmer,69 2005         | UK      | Parallel   | 93          | 9                         | 24          | 59     | 12.5                          | 9.2               | 25      | 100            |            |
| Montori,70 2004        | US      | Parallel   | 31          | 6                         | 43†         | 32     | 17.1†                         | 8.9               | 26†     | 100            |            |
| Gomez,70 2002          | Spain   | Crossover  | 10          | 6                         | 32          | 20     | 13.8                          | 8.31              | –       | 100            | –          |
| Ahring,68 1992         | Canada  | Parallel   | 42          | 3                         | 41          | 48     | 11.6                          | 10.9              | –       | 100            | –          |
| **Type 2 diabetes**    |         |            |             |                           |             |        |                               |                   |         |                |            |
| Nicolucci,66 2015      | Italy   | Parallel   | 302         | 12                        | 58          | 62     | 8.5                           | 8.0               | 29      | 9              | 100        |
| Rasmussen,65 2015      | Denmark | Parallel   | 40          | 6                         | 63          | 68     | 9.4                           | 8.5               | 31      | 38             | –          |
| Shahid,66 2015         | Pakistan | Parallel | 440         | 4                         | 49          | 61     | –                             | 10.0              | 27      | –              | –          |
| Arora,70 2014          | US      | Parallel   | 128         | 6                         | 38          | 23     | –                             | 10.0              | –       | ≤ 80           | ≤ 80       |
| Chan,70 2014           | China   | Parallel   | 628         | 12                        | 55          | 57     | 9.4                           | 8.2               | 27      | 35             | 85         |
| Heisler,66 2014        | US      | Parallel   | 188         | 3                         | 52          | 29     | 9.1                           | 8.3               | –       | 43             | 79         |
| Luley,66 2014          | Germany | Parallel   | 68          | 6                         | 58          | 49     | –                             | 7.6               | 35      | 31             | ≥ 68       |
| Lynch,66 2014          | US      | Parallel   | 61          | 6                         | 54          | 33     | 8.7                           | 7.6               | 36      | 43             | 82         |
| Pressman,66 2014       | US      | Parallel   | 225         | 6                         | 56          | 62     | –                             | 9.3               | 35      | –              | –          |
| Steventon,66 2014      | UK      | Cluster    | 513         | 12                        | 65          | 58     | –                             | 8.4               | 31      | 48             | ≥ 73       |
| Vareny,66 2014         | Australia | Parallel | 94          | 12                        | 62          | 68     | 12.9                          | 8.4               | 31      | 58             | ≥ 75       |
| Waki,66 2014           | Japan   | Parallel   | 54          | 3                         | 57          | 76     | 9.1                           | 7.1               | –       | 15             | 61         |
| Zhou,66 2014           | China   | Parallel   | 114         | 3                         | –           | –      | –                             | 8.3               | 24      | –              | –          |
| Alifa,66 2013          | Iran    | Parallel   | 62          | 3                         | 53          | –     | 8.7                           | 9.7               | 28      | –              | –          |
| Blackberry,66 2013     | Australia | Cluster | 473         | 18                        | 63          | 57     | 10†                          | 8.1               | 12%×5  | 24             | 90         |
| Crowley,66 2013        | US      | Parallel   | 359         | 12                        | 56          | 28     | –                             | 8.0               | –       | 51             | –          |
| Eakin,66 2013          | Australia | Parallel | 302         | 6                         | 58          | 56     | 5.0†                          | 7.11              | 33      | 14             | 81         |
| Gagliardino,66 2013    | Argentina | Parallel | 198         | 12                        | 61          | 49     | 6.0                           | 7.2               | 33      | –              | 91         |
| Mons,66 2013           | Germany | Parallel   | 204         | 18                        | 68†         | 61     | 9.0†                          | 8.1†              | –       | –              | –          |
| Nagrebetsky,66 2013    | UK      | Parallel   | 17          | 6                         | 58          | 71     | 2.6†                          | 8.1               | 33      | 0              | 100        |
| Orsama,66 2013         | Finland | Parallel   | 56          | 10                        | 62          | 54     | –                             | 7.0               | 32      | –              | –          |
| Plotnikoff,66 2013     | Canada  | Parallel   | 190         | 18                        | 62          | 51     | 9.3                           | 7.1               | 31      | 18             | –          |
| Tang,66 2013           | US      | Parallel   | 415         | 12                        | 54          | 60     | –                             | 9.3               | –       | –              | –          |
| Van Dyck,66 2013       | Belgium | Parallel   | 92          | 12                        | 62          | 69     | –                             | 7.3               | 30      | ≥ 44           | ≥ 44       |
| Bogner,66 2012         | US      | Parallel   | 182         | 3                         | 58          | 56     | 11.2                          | 7.1               | –       | –              | 100        |
| Del Prato,66 2012      | Italy   | Parallel   | 291         | 11                        | 58          | 52     | 10.9                          | 7.8               | 30      | 6              | 100        |
| Glasgow,66 2012        | US      | Parallel   | 463         | 12                        | 58          | 50     | –                             | 8.1               | 35      | –              | –          |
| Goodarzi,66 2012       | Iran    | Parallel   | 100         | 3                         | 54          | 22     | 8.01                          | 7.9               | 28      | 41             | 65         |
| Jarab,66 2012          | Jordan  | Parallel   | 171         | 6                         | 64          | 57     | 9.9                           | 8.41              | 33†     | 68             | –          |
| Maroisi,66 2012        | Australia | Parallel | 39          | 6                         | 63          | 53     | –                             | 7.7               | 33      | 17             | 77         |
Table 1 (part 2 of 3): Trial and population characteristics by type of diabetes

| Type of diabetes; study | Country | RCT design | Sample size | Duration of follow-up, mo | Mean age, yr | Male, % | Mean duration of diabetes, yr | Mean baseline HbA1c | Mean BMI | % using insulin | % using OHA |
|-------------------------|---------|------------|-------------|---------------------------|--------------|--------|-------------------------------|-------------------|--------|----------------|-----------|
| Pacaud;118 2012 Canada | Parallel | 79 | 12 | 54 | 48 | - | 7.1 | - | - | - | - |
| Patja;119 2012 Finland | Cluster | 1129† | 12 | 65 | 57 | 10.0 | 7.6 | 32 | 29 | 45 | - |
| Williams;120 2012 Australia | Parallel | 120 | 6 | 57 | 63 | - | 8.8 | 34‡ | 43 | - | - |
| Avdal;121 2011 Turkey | Parallel | 122 | 6 | 52 | 49 | - | 8.1 | - | 100 | - | - |
| Carter;151 2011 US | Parallel | 74 | 9 | 51 | 36 | - | 8.9 | 36 | - | - | - |
| Cho;122 2011 Korea | Parallel | 79 | 6 | 50 | 66 | 3.5 | 6.8 | 24 | 33 | 84 | - |
| Farsaei;123 2011 Iran | Parallel | 172 | 3 | 53 | 34 | 10.6 | 9.1 | - | 43 | 88 | - |
| Franciosi;124 2011 Italy | Parallel | 62 | 6 | 49 | 74 | 3.4 | 7.9 | 31 | 0 | 100 | - |
| Frosch;125 2011 US | Parallel | 201 | 6 | 55 | 52 | 10.0 | 9.6 | 33 | - | - | - |
| Keogh;126 2011 Ireland | Parallel | 121 | 6 | 59 | 64 | 9.4 | 9.2 | 32 | 52 | 47 | - |
| Kim;127 2011 Korea | Parallel | 54 | 4 | 56 | 62 | 8.9 | 7.4 | 26 | - | 100 | - |
| Lim;128 2011 Korea | Parallel | 103 | 6 | 68 | 41 | 14.8 | 7.9 | 25 | 30 | > 62 | - |
| Quinn;129 2011 US | Cluster | 213 | 12 | 53 | 50 | 8.1 | 9.4 | 36 | - | - | - |
| Shetty;130 2011 India | Parallel | 215 | 12 | 50 | - | - | 9.0 | 28 | - | - | - |
| Tildesley;131 2011 Canada | Parallel | 50 | 12 | 60 | 63 | 19.0 | 8.7 | 33 | 100 | - | - |
| Wakefield;132 2011 US | Parallel | 302 | 12 | 68 | 98 | - | 7.2 | 33 | - | - | - |
| Anderson;133 2010 US | Parallel | 295 | 12 | 35 | 42 | - | 8.0 | 35 | - | - | - |
| Davis;134 2010 US | Parallel | 165 | 12 | 60 | 25 | 9.4 | 9.1 | 37 | 50 | 78 | - |
| Farsaei;135 2010 Iran | Parallel | 174 | 3 | 53 | 34 | 10.6 | 9.1 | - | 43 | 88 | - |
| Heisler;136 2010 US | Parallel | 245 | 6 | 62 | 100 | - | 8.0 | - | 56 | 44 | - |
| Kim;137 2010 Korea | Parallel | 100 | 3 | 48 | 50 | 8.5 | 9.8 | 24 | 21 | 97 | - |
| Lorig;138 2010 US | Parallel | 761 | 18 | 54 | 27 | - | 6.4 | - | - | - | - |
| Nesari;139 2010 Iran | Parallel | 61 | 3 | 52 | 28 | 28% > 10 yr | 9.0 | 28 | 0 | 100 | - |
| Stone;140 2010 US | Parallel | 150 | 6 | 59† | 99 | - | 9.5 | - | 58 | 76 | - |
| Tildesley;141 2010 Canada | Parallel | 50 | 6 | 59 | 62 | 18.8 | 8.7 | 33 | 100 | - | - |
| Dale;142 2009 UK | Parallel | 231 | 6 | 51–69‡ | 47 | 1–15‡ | 8.6 | - | 0 | - | - |
| Graziano;143 2009 US | Parallel | 120 | 3 | 62 | 55 | 12.9 | 8.7 | - | 54 | - | - |
| Holbrook;144 2009 Canada | Parallel | 511 | 6 | 61 | 51 | 9.3 | 7.1 | 32 | 17 | > 53 | - |
| Ralston;145 2009 US | Parallel | 83 | 12 | 57 | 51 | - | 8.1 | - | 39 | - | - |
| Rodriguez-Idigoras;146 2009 Spain | Parallel | 328 | 12 | 64 | 52 | 10.7 | 7.5 | 78% > 27 | 38 | 73 | - |
| Schillinger;147 2009 US | Parallel | 226 | 12 | 56 | 43 | 9.8 | 9.6 | 31 | 37 | 88 | - |
| Yoo;148 2009 Korea | Parallel | 123 | 3 | 58 | 59 | 6.6 | 7.5 | 26 | - | - | - |
| Kim;149 2008 Korea | Parallel | 40 | 12 | 47 | 47 | 6.2 | 7.9 | 25 | 32 | 68 | - |
| Quinn;150 2008 US | Parallel | 30 | 3 | 51 | 35 | 9.3 | 9.3 | 34 | 31 | 38 | - |
| Yoon;151 2008 Korea | Parallel | 60 | 12 | 47 | 43 | 6.6 | 7.8 | 24 | 31 | 69 | - |
| Kim;152 2007 Korea | Parallel | 80 | 3 | 48 | 65 | 7.8 | - | - | - | - | - |
| Kim;153 2007 Korea | Parallel | 60 | 6 | 47 | 43 | 6.6 | 7.8 | 24 | 8 | 69 | - |
| Cho;154 2006 Korea | Parallel | 80 | 30 | 53 | 61 | 6.8 | 7.6 | 23 | 23 | 79 | - |
| Kim;155 2006 Korea | Parallel | 51 | 3 | 55 | 53 | 7.3 | 7.9 | - | 0 | 65 | - |
| Glasgow;156 2005 US | Cluster | 886 | 12 | 63 | 49 | - | 7.3 | - | - | - | - |
| Young;157 2005 UK | Parallel | 591 | 12 | 67 | 58 | 6.0 | 7.9 | 30 | 21 | 55 | - |
| Kwon;158 2004 Korea | Parallel | 110 | 3 | 54 | 61 | 6.8 | 7.4 | 24 | - | - | - |
| Wolf;159 2004 US | Parallel | 147 | 12 | 53 | 40 | - | 7.7 | 38 | 24 | > 64 | - |
| Kim;160 2003 Korea | Parallel | 50 | 3 | 60 | 30 | 13.7 | 8.5 | 25 | 41 | 68 | - |
| Whitlock;161 2000 US | Parallel | 28 | 3 | 60 | 57 | - | 9.5 | - | - | - | - |
| Weinberger;162 1995 US | Parallel | 275 | 12 | 64 | 99 | 11.2 | 10.7 | - | 47 | - | - |
Table 1 (part 3 of 3): Trial and population characteristics by type of diabetes

| Type of diabetes; study | Country | RCT design | Sample size | Duration of follow-up, mo | Mean age, yr | Male, % | Mean duration of diabetes, yr | Mean baseline HbA1c | Mean BMI | % using insulin | % using OHA |
|------------------------|---------|------------|-------------|---------------------------|--------------|--------|-----------------------------|-------------------|---------|----------------|------------|
| Mixed type             |         |            |             |                           |              |        |                             |                   |         |                |            |
| Kaur,45 2015           | India   | Parallel   | 80          | 3                         | 50           | 54     | 5.5                         | 7.9               | 29      | 8              | 83         |
| Leichter,46 2013       | US      | Parallel   | 98          | 12                        | 48           | 56     | –                           | 7.5               | 33      | 65             | 58         |
| Munshi,47 2013         | US      | Parallel   | 100         | 12                        | 75           | 46     | 21.0                        | 9.2               | 32      | 89             | 52         |
| Bell,48 2012           | US      | Parallel   | 65          | 12                        | 58           | 55     | 13.0                        | 9.3               | 34      | > 44           | > 53       |
| Williams,49 2012       | Australia | Parallel | 80         | 12                        | 67           | 56     | –                           | 7.5†              | 32      | –              | –          |
| Istepanian,50 2009     | UK      | Parallel   | 137         | 9                         | 59           | –      | 12.5                        | 8.0               | –       | 42             | 68         |
| Bond,51 2007           | US      | Parallel   | 62          | 6                         | 67           | 55     | 17.0                        | 7.1               | –       | 94             | 45         |
| Harno,52 2006          | Finland | Parallel   | 175         | 12                        | –            | –      | –                           | 8.0               | 28      | –              | –          |
| Maljanian,53 2005      | US      | Parallel   | 507         | 12                        | 58           | 47     | –                           | 7.9               | 32      | –              | –          |
| Glasgow,54 1997        | US      | Parallel   | 98          | 12                        | 62           | 38     | 13.3                        | 7.9               | 30      | 67             | –          |
| Type unknown           |         |            |             |                           |              |        |                             |                   |         |                |            |
| Katalenich,55 2015     | US      | Parallel   | 98          | 6                         | –            | 40     | –                           | 8.3               | –       | 100            | 79         |
| Khanna,56 2014         | US      | Parallel   | 75          | 3                         | 52           | 59     | –                           | 9.1               | 34      | 33             | 90         |
| O’Connor,57 2014       | US      | Parallel   | 2378        | 12                        | 40–64‡       | 48     | –                           | 9.8               | –       | –              | –          |
| Moattari,58 2013       | Iran    | Parallel   | 522         | 3                         | 23           | 43     | –                           | 9.3               | –       | 100            | –          |
| Walker,59 2011         | US      | Parallel   | 527         | 12                        | 56           | 33     | 9.2                         | 8.6†              | 31      | 23             | 100        |
| Shea,60 2009           | US      | Parallel   | 1665        | 60                        | 71           | 37     | 11.1                        | 7.4               | 32      | 30             | 80         |
| McMahon,61 2005        | US      | Parallel   | 104         | 12                        | 64           | 100    | 12.3                        | 10.0              | 33      | 49             | 51         |
| Biermann,62 2002       | Germany | Parallel   | 48          | 8                         | 30           | –      | 9.9                         | 8.2               | –       | 100            | –          |
| Piette,63 2001         | US      | Parallel   | 292         | 12                        | 61           | 97     | –                           | 8.2               | 31      | 35             | 100        |
| Tsang,64 2001          | Hong Kong | Crossover | 20         | 6                         | 33           | 64     | 8.6                         | 8.7               | 24      | –              | –          |
| Piette,65 2000         | US      | Parallel   | 280         | 12                        | 55           | 42     | –                           | 8.7               | 34      | 38             | 100        |
| Thompson,66 1999       | Canada  | Parallel   | 46          | 6                         | 49           | 48     | 17.0                        | 9.5               | –       | 100            | –          |

Note: BMI = body mass index, HbA1c = glycated hemoglobin, OHA = oral hypoglycemic agents, RCT = randomized controlled trial, “–” = not reported.
*The trials are ordered by type of diabetes, year and author.
†Only the diabetes subgroup is reported for Patja 2012.49
†Median.
**Table 2 (part 1 of 6): Telemedicine interventions**

| Study* (subgroup) | Provider      | Form of communication | Provider to patient | Patient to provider | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Exercise | Blood pressure management | General education |
|-------------------|---------------|-----------------------|---------------------|---------------------|----------------------|-----------------------|----------------------|----------------------|----------|---------------------------|------------------|
| Zhou,156 2014     | Diabetes team | Web portal            | SMS                 | Web portal          | –                    | Yes                   | –                    | Yes                  | Yes      | –                         | –                |
| Kirwan,99 2013    | Diabetes educator | Web portal         | SMS                 | Smartphone application | Weekly              | Yes                   | Yes                  | Yes                  | –        | –                         | Yes              |
| Moattari,110 2013 | Nurse Physician | Web portal           | SMS                 | Web portal          | Weekly              | Yes                   | –                    | Yes                  | –        | –                         | Yes              |
| Orsama,117 2013   | CDSS           | Web portal (CDSS)    | Web portal          | Smartphone application | Telephone          | Yes                   | –                    | –                    | –        | Yes                       | Yes              |
| Pacaud,118 2012   | Diabetes educator | Web portal (email)  | Web portal          | (email)             | –                    | Yes                   | Yes                  | –                    | –        | –                         | Yes              |
| Avdal,51 2011     | Nurse          | Web portal           | Web portal          | –                    | Yes                  | –                    | –                    | –                    | –        | –                         | Yes              |
| Carter,58 2011    | Nurse          | Web portal           | Videoconference     | Web portal          | Every 2 wk          | Yes                   | –                    | –                    | –        | –                         | Yes              |
| Cho,52 2011       | CDSS           | Web portal           | –                    | –                    | –                    | –                    | –                    | –                    | –        | –                         | –                |
| Quinn,115 2011    | CDSS           | Web portal           | Web portal          | –                    | Yes                  | –                    | –                    | –                    | –        | –                         | Yes              |
| Quinn,115 2011    | CDSS           | Web portal           | –                    | –                    | –                    | –                    | –                    | –                    | –        | –                         | Yes              |
| Quinn,115 2011    | CDSS           | Web portal           | –                    | –                    | –                    | –                    | –                    | –                    | –        | –                         | Yes              |
| Tildesley,140 2011| Physician      | Web portal           | –                    | –                    | Yes                  | Yes                  | –                    | –                    | –        | –                         | –                |
| Lorig,116 2010    | Trained peer Moderator/ Program administrator | Web portal | Web portal          | Weekly              | Yes                  | –                    | Yes                  | Yes                  | Yes      | –                         | Yes              |
| Lorig,116 2010    | Trained peer Moderator/ Program administrator | Web portal | Listserv            | Weekly              | Yes                  | –                    | Yes                  | Yes                  | Yes      | –                         | Yes              |
| McCarrier,108 2009 | CDSS            | Web portal           | Email               | Weekly              | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | –                         | Yes              |
| Ralston,110 2009  | CDSS            | Web portal           | –                    | –                    | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | –                         | Yes              |
| Shea,113 2009     | Care manager   | Web portal           | Videoconference     | Web portal          | Smart device         | Yes                  | –                    | Yes                  | –        | Yes                       | Yes              |
| Yoo,115 2009      | CDSS            | Web portal           | SMS                 | Smart device        | Twice daily          | Yes                  | –                    | Yes                  | Yes      | Yes                       | Yes              |
Table 2 (part 2 of 6): Telemedicine interventions

| Study* (subgroup) | Provider | Form of communication | Provider to patient | Patient to provider | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Exercise | Blood pressure management | General education |
|-------------------|----------|-----------------------|---------------------|---------------------|----------------------|-----------------------|-----------------------|----------------------|----------|--------------------------|------------------|
| Kim, 2008         | Nurse    | Web portal SMS        | Web portal          | Weekly              | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Yoon, 2008        | Nurse Physician | Web portal SMS      | Web portal          | Weekly              | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Bond, 2007        | Nurse Research team | Web portal         | Web portal          | –                   | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Kim, 2007         | Nurse Diabetes educator | Web portal SMS   | Web portal          | Weekly              | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Cho, 2006         | Nurse Physician Dietitian | Web portal                | Web portal          | Every 2 wk          | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| McMahon, 2005     | Nurse    | Web portal Telephone SMS | Web portal Smart devices | –                   | Yes                  | Yes                   | –                     | –                   | Yes      | –                        | Yes              |
| Kwon, 2004        | Nurse Physician Dietitian | Web portal Email | Web portal          | –                   | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Gomez, 2002       | CDSS Physician | Web portal SMS                  | Web portal (PDA) Telephone | Every 2 wk          | Yes                  | Yes                   | Yes                   | –                   | Yes      | –                        | Yes              |
| Arora, 2014       | CDSS     | SMS                    | –                   | Twice daily         | Yes                  | –                     | Yes                   | Yes                  | –        | Yes                      | –                |
| Nagrebetsky, 2013 | Nurse SMS Telephone | Smart device          | Monthly             | Yes                  | Yes                   | –                     | –                     | –                   | –        | –                        | –                |
| Rossi, 2013       | Physician SMS | SMS                       | –                   | Yes                  | Yes                   | –                     | –                     | –                   | –        | Yes                      | –                |
| Tang, 2013        | CDSS Care manager Dietitian | SMS                  | Web portal Smart device | –                   | Yes                  | Yes                   | Yes                   | Yes                  | Yes      | –                        | Yes              |
| Goodarzi, 2012    | Research team SMS | –                        | NA                  | Yes                  | –                     | –                     | –                     | –                   | –        | Yes                      | –                |
| Lim, 2011         | CDSS Nurse Physician Dietitian Exercise trainer | SMS | Smart device | – daily | Yes                  | Yes                   | –                     | –                   | Yes      | –                        | Yes              |
| Shetty, 2011      | Health care provider SMS | –                       | NA                  | Yes                  | –                     | Yes                   | Yes                   | Yes                  | –        | Yes                      | –                |
| Kim, 2010         | CDSS SMS Smart device | Daily               | Yes                  | Yes                   | –                     | –                     | –                     | –                   | Yes      | –                        | Yes              |
| Rossi, 2010       | Physician Dietitian SMS | SMS                  | –                   | Yes                  | Yes                   | Yes                   | Yes                   | –                   | –        | Yes                      | Yes              |
| Tildesley, 2010   | Physician SMS | SMS                       | Smart device        | –                   | Yes                  | Yes                   | –                     | –                   | –        | –                        | –                |
| Benhamou, 2007    | Physician SMS | PDA                   | Weekly             | Yes                  | –                     | –                     | –                     | –                   | –        | –                        | –                |
| Kim, 2007         | CDSS SMS | Web portal Smart device | –                   | Yes                  | –                     | Yes                   | Yes                   | Yes                  | –        | Yes                      | –                |
| Hanno, 2006       | Diabetes team SMS | Smart device          | –                   | Yes                  | –                     | Yes                   | Yes                   | Yes                  | –        | –                        | –                |
| Katalenich, 2015  | CDSS Automated text and voice reminder (CDSS) | –                 | Daily              | –                   | Yes                  | –                     | –                     | –                   | –        | –                        | –                |
| Nicolucci, 2015   | CDSS Nurse Automated text, email and voice reminder (CDSS) | Smart devices Call-me button | Monthly | Yes                  | –                     | –                     | –                     | –                   | Yes      | –                        | Yes              |
| Study* (subgroup) | Provider | Form of communication | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Exercise | Blood pressure management | General education |
|------------------|----------|----------------------|----------------------|----------------------|----------------------|----------------------|----------|--------------------------|-----------------|
| Khanna,91 2014   | CDSS     | Automated interactive voice (CDSS to telephone) | –                     | Yes                  | –                    | Yes                  | –        | –                        | –               |
| Glasgow,75 2012  | CDSS     | Automated interactive voice (CDSS to telephone) | Web portal           | Yes                  | –                    | Yes                  | Yes                  | –                        | Yes             |
| Glasgow,75 2012  | CDSS     | Automated interactive voice (CDSS to telephone) | Web portal           | Twice                | Yes                  | –                    | Yes                  | Yes –                   | Yes             |
| Graziano,94 2009 | CDSS     | Automated interactive voice (CDSS to telephone) | –                     | –                    | Yes                  | –                    | Yes                  | Yes –                   | Yes             |
| Holbrook,74 2009 | CDSS     | Automated voice reminder (Telephone) Letter | –                     | –                    | Yes                  | –                    | Yes                  | Yes –                   | Yes             |
| Schillinger,131 2009 | CDSS | Automated interactive voice (CDSS to telephone) | –                     | Weekly               | Yes                  | –                    | Yes                  | Yes –                   | Yes             |
| Piette,124 2001  | CDSS     | Automated interactive voice (CDSS to telephone) | –                     | Weekly               | Yes                  | Yes                  | –                    | – – – – – – – – – – – – Yes |
| Piette,123 2000  | CDSS     | Automated interactive voice (CDSS to telephone) | Telephone            | Weekly               | Yes                  | Yes                  | –                    | – – – – – – – Yes – – – – Yes |
| Pressman,133 2014 | Care manager | Smart device | Smart device | Weekly | Yes | – | – | – | – | – | Yes |
| Wakefield,146 2011 | CDSS Nurse Diabetes educator Physician | Smart device | Smart device | – | Yes | – | – | Yes | – | – | Yes |
| Stone,145 2010   | Nurse    | Smart device | Smart device | Monthly | Yes | Yes | – | – | – | Yes | Yes |
| Jansa,136 2006   | Diabetes team | Smart device | Smart device | Email Telephone Fax | 1.5 times per mo | Yes | Yes | Yes | Yes | – | Yes |
| Steventon,135 2014 | CDSS Nurse Support worker | Computer software | Smart device | Telephone | ~ daily† | Yes | Yes | – | – | – | Yes |
| Charpentier,90 2011 | Physician | Computer software | Smartphone application | Every 2 wk | Yes | Yes | – | – | – | – |
| Tsang,147 2001   | CDSS     | Computer software | PDA                 | Every 2 d | – | – | Yes | – | – | Yes |
Table 2 (part 4 of 6): Telemedicine interventions

| Study* (subgroup) | Provider | Form of communication | Provider to patient | Patient to provider | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Blood pressure management | General education |
|-------------------|----------|-----------------------|---------------------|---------------------|----------------------|----------------------|----------------------|---------------------|------------------------|-----------------|
| Rasmussen,127 2015 | Nurse, Physician | Videoconference | – | – | Yes | Yes | Yes | – | – |
| Davis,120 2010 | Nurse, Dietitian | Videoconference, Telephone | – | Monthly | Yes | – | Yes | Yes | – | Yes |
| Whitlock,146 2000 | Care manager, Physician | Videoconference | – | Weekly | Yes | – | Yes | Yes | – | – |
| Waki,146 2014 | CDSS, Physician, Dietitian | Email, Telephone, Smart devices | Daily | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Leichter,120 2013 | Physician | Email, Telephone, Computer software | Twice | Yes | – | – | – | Yes | – |
| Quinn,115 2008 | CDSS, Diabetes educator, Physician, Nutritionist, Research team | Email, Smartphone application | – | Yes | Yes | Yes | Yes | – | – | Yes |
| Kim,103 2006 | Nurse | Patient Web page, Telephone | Weekly | Yes | – | – | Yes | – | Yes |
| Farmer,104 2005 | CDSS, Nurse | Patient Web page, Telephone, Smartphone application | Every 2 wk | Yes | Yes | – | – | – | – |
| Bell,122 2012 | Nurse | Smartphone, video message | – | NA | – | – | – | – | Yes |
| Glasgow,126 1997 | CDSS, Research team | Video message, Telephone | 5 times | Yes | – | Yes | – | – | Yes |
| Heisler,93 2014 | CDSS, Community health care worker | Smartphone application, Telephone | – | Every 3 wk | Yes | – | – | – | – | Yes |
| Kaur,110 2015 | Physician | Telephone | Telephone | Weekly | Yes | – | Yes | Yes | – | – |
| Shahid,112 2015 | Research team | Telephone | – | ~ every 2 wk† | Yes | – | Yes | Yes | – | Yes |
| Chan,113 2014 | Trained peer | Telephone | Telephone | Every 2 wk then monthly then every 2 mo | Yes | – | Yes | Yes | – | Yes |
| Esmatjes,118 2014 | Diabetes team | Telephone | Smart device | Monthly | Yes | Yes | Yes | Yes | – | – |
| Lynch,119 2014 | Trained peer | Telephone | – | Weekly | Yes | – | Yes | Yes | – | Yes |
| O’Conner,116 2014 | Care manager, Diabetes educator, Pharmacist | Telephone | – | Once | Yes | – | – | – | – | – |
| Suh,121 2014 | CDSS, Trained peer | Telephone | Smart device | Twice monthly | Yes | Yes | Yes | Yes | – | Yes |
| Varney,124 2014 | Dietitian | Telephone | – | Monthly | Yes | – | Yes | Yes | – | Yes |
| Aliha,125 2013 | Nurse | Telephone | – | Twice weekly then weekly | Yes | – | – | – | – | Yes |
| Blackberry,18 2013 | Nurse | Telephone | – | ~ monthly† then 3 sessions | Yes | Yes | – | – | Yes | Yes |
| Crowley,128 2013 | Nurse | Telephone | – | Monthly | Yes | Yes | Yes | Yes | Yes | Yes |

*Study (subgroup) refers to the specific study or subgroup within a study.
Table 2 (part 5 of 6): Telemedicine interventions

| Study* (subgroup) | Provider | Form of communication | Provider to patient | Patient to provider | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Exercise | Blood pressure management | General education |
|-------------------|----------|-----------------------|---------------------|---------------------|----------------------|-----------------------|-----------------------|----------------------|----------|---------------------------|------------------|
|                  |          |                       |                     |                     |                      |                       |                       |                      |          |                           |                  |
| Eakin,*67 2013   | Counsellor | Telephone              | –                   | –                   | ~ every 2 wk†       | Yes                   | –                     | Yes                  | Yes      | –                         | Yes              |
| Gagliardino,*66 2013 | Trained peer | Telephone             | –                   | –                   | Weekly then every 2 wk then monthly | Yes                  | –                     | –                    | –        | –                         | Yes              |
| Mons,*111 2013   | Nurse     | Telephone              | –                   | Monthly             | Yes                  | Yes                   | –                     | –                    | –        | –                         | –                |
| Munshi,*112 2013 | Care manager Diabetes educator | Telephone          | –                   | –                   | ~ every 2 wk†       | Yes                   | Yes                  | Yes                  | Yes      | –                         | Yes              |
| Plotnikoff,*122 2013 | Telephone counsellor | Telephone        | –                   | –                   | Yes                  | –                     | –                    | Yes                  | –        | –                         | Yes              |
| Van Dyck,*140 2013 | Psychologist | Telephone            | –                   | –                   | Every 2 wk then monthly | Yes                  | –                     | –                    | –        | –                         | Yes              |
| Bogner,*4 2012   | Research team | Telephone            | –                   | Twice               | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
| Del Prato,*4 2012 | Physician  | Telephone              | –                   | –                   | –                    | Yes                   | Yes                  | –                    | –        | –                         | –                |
| Jarab,*7 2012     | Pharmacist | Telephone              | –                   | Weekly              | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | Yes                       | Yes              |
| Marois,*107 2012  | Exercisephysiologist | Telephone       | –                   | Weekly              | Yes                  | –                     | –                    | Yes                  | –        | –                         | –                |
| Patja,*1 2012     | Nurse     | Telephone              | –                   | Monthly             | Yes                  | –                     | –                    | –                    | –        | –                         | Yes              |
| Williams,*15 2012 | Nurse     | Telephone              | –                   | Every 2 wk          | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
| Williams,*1 2012  | CDSS Research team | Telephone          | Automated interactive voice (Telephone to CDSS) | Weekly              | Yes                  | –                     | Yes                  | Yes                  | –        | –                         | –                |
| Farsaei,*7 2011   | Pharmacist | Telephone              | –                   | –                   | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
| Franciosi,*7 2011 | Nurse Physicin | Telephone        | –                   | Monthly             | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | –                         | –                |
| Frosch,*7 2011    | Nurse     | Telephone              | –                   | ~ monthly†          | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
| Keogh,*6 2011     | Psychologist | Telephone            | –                   | Once                | Yes                  | –                     | Yes                  | –                    | Yes      | –                         | –                |
| Kim,*4 2011       | Research team | Telephone           | Telephone           | Weekly              | Yes                  | –                     | Yes                  | Yes                  | –        | –                         | –                |
| Walker,*4 2011    | Diabetes educator | Telephone        | –                   | ~ monthly†          | Yes                  | –                     | Yes                  | Yes                  | –        | –                         | –                |
| Anderson,*9 2010  | Nurse     | Telephone              | –                   | Weekly              | Yes                  | –                     | Yes                  | Yes                  | Yes      | –                         | –                |
| Farsaei,*7 2010   | Pharmacist | Telephone              | –                   | Weekly              | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | –                         | –                |
| Heisler,*9 2010   | Care manager Trained peer Research team | Telephone | –             | Yes                  | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
| Nesari,*14 2010   | Nurse     | Telephone              | –                   | Twice weekly then weekly | Yes                  | Yes                  | Yes                  | Yes                  | Yes      | –                         | –                |
| Dale,*9 2009      | Trained peer | Telephone           | –                   | 6 times (frequency decreased over follow-up) | Yes                  | Yes                  | –                     | –                    | –        | –                         | –                |
| Istepanian,*6 2009 | Physician | Telephone              | –                   | Smart device        | –                    | Yes                  | –                     | –                    | –        | –                         | Yes              |
| Rodriguez-Idigoras,*10 2009 | CDSS Nurse Physician | Telephone | Smart device Telephone | –             | Yes                  | –                     | –                    | –                    | –        | –                         | –                |
Table 2 (part 6 of 6): Telemedicine interventions

| Study* (subgroup) | Provider                  | Form of communication | Frequency of feedback | Interactive follow-up | Medication adjustment | Nutrition counselling | Exercise | Blood pressure management | General education |
|-------------------|---------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|---------------------------|-------------------|
| Glasgow,77 2005   | Care manager              | Telephone             | Telephone             | Twice yearly          | Yes                   | –                     | Yes      | Yes                       | –                 |
| Maljanian,106 2005| Nurse Nutritionist        | Telephone             | –                     | Weekly                | Yes                   | –                     | Yes      | –                         | –                 |
| Young,103 2005    | Nurse Telecarer           | Telephone             | –                     | 3 groups: Every 3 mo  | Yes                   | Yes                   | –        | –                         | Yes               |
| Montori,2 2004    | Nurse                     | Telephone             | Smart device          | Every 2 wk            | Yes                   | Yes                   | –        | –                         | –                 |
| Wolf,104 2004     | Care manager              | Telephone             | –                     | Monthly               | Yes                   | –                     | Yes      | Yes                       | –                 |
| Kim,105 2003      | Nurse Dietitian           | Telephone             | –                     | Twice weekly then weekly | Yes                   | Yes                   | Yes      | Yes                       | Yes               |
| Biermann,104 2002 | Physician                 | Telephone             | Smart device          | –                     | Yes                   | Yes                   | –        | –                         | –                 |
| Thompson,107 1999 | Nurse                     | Telephone             | Telephone             | 3 times weekly        | Yes                   | Yes                   | –        | –                         | –                 |
| Weinberger,108 1995| Nurse                    | Telephone             | –                     | Monthly               | Yes                   | Yes                   | Yes      | Yes                       | Yes               |
| Ahring,109 1992   | Research team             | Telephone             | Smart device          | Weekly                | Yes                   | Yes                   | Yes      | –                         | Yes               |
| Luley,110 2014    | CDSS Research team        | Letter                | Smart device          | Weekly                | –                     | Yes                   | Yes      | Yes                       | Yes               |

Note: CDSS = clinical decision support system, NA = not applicable, PCP = primary care provider, PDA = personal digital assistant, SMS = short message service (text messaging), “–” = not reported.

*Studies are ordered by provider-to-patient communication; they are ordered by any use of Web portals, SMS text messaging, automated communication, smart device, computer software, videoconference, email, customized patient Web pages, video messaging, smartphone application, telephone and letter. A smart device is any computerized device specifically developed to collect and transmit patient data to health care providers. Web portals are websites where patients upload blood glucose or other clinical data and share these with their health care providers; many times providers also use Web portals to provide feedback to patients. CDSS systems receive data from patients and automatically respond using computer algorithms in a variety of ways, such as precomposed messages sent as SMS text messages to patients (Kim 2010), alerts sent to the providers when abnormal data are received (Gomez), analyzed data reports sent to providers (Quinn) and voice feedback over the telephone to patients (Schillinger). Other components not mentioned in this table include psychological support, such as support for depression, smoking cessation and behavioural therapy.

†Indicates an approximate frequency of feedback. For example, we used “~ daily” rather than 3 times per week for Lim; “~ every 2 wk” replaced 14 times per 6 months for Eakin; and 11 times per 6 months for Munshi; “~ monthly” replaced 5 times per 6 months for Blackberry and Frosch; and 10 times per year for Walker; and “~ every 2 mo” replaced every 7 weeks for Young.