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Review Article

Distal technology interventions in people with diabetes: an umbrella review of multiple health outcomes

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What's new?

- Our umbrella review showed that in a large number of systematic review and meta-analyses, distal technology leads to improvement only in HbA_{1c} levels.
- The evidence to support distal technology use for other outcomes, such as blood pressure, lipids and patient-reported outcomes, was weak.
- Most distal technologies for diabetes care are used *in silo* and not in synchronization with healthcare systems.
- There is a need to connect up these distal technologies (e.g. glucometers, activity counters, apps) to fully realise their clinical potential.

Abstract

Aim To summarize and evaluate the existing evidence on the effectiveness of distal technology with regard to multiple health outcomes in people with diabetes.

Methods We searched PubMed, EMBASE and the Cochrane Database of Systematic Reviews from database inception to 31 August 2018 for systematic reviews and/or meta-analyses of studies that examined the impact of distal technology and reported any clinical or patient-related outcomes among people with type 1 or type 2 diabetes.

Results The umbrella review identified 95 reviews, including 162 meta-analyses with 46 unique outcomes. Evidence from meta-analyses of randomized controlled studies supports the use of distal technology, especially telehealth and mHealth (healthcare delivered by

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mobile technology), in people with diabetes for improving HbA_{1c} values by 2–4 mmol/mol (0.2–0.4%). For other health outcomes, such as changes in fasting plasma glucose levels, risk of diabetic ketoacidosis or frequency of severe hypoglycaemia, the evidence was weaker. No evidence was reported for most patient-reported outcomes including quality of life, self-efficacy and medication-taking. The evidence base was poor, with most studies rated as low to very low quality.

Conclusion Distal technologies were associated with a modest improvement in glycaemic control, but it was unclear if they improved major clinical outcomes or were cost-effective in people with diabetes. More robust research to improve wider outcomes in people with diabetes is needed before such technologies can be recommended as part of routine care for any patient group.

(PROSPERO study registration number: CRD42018084577)

Introduction

Almost 415 million people worldwide have diabetes, 85–90% of whom have type 2 diabetes [1]. This figure is projected to increase further in the coming decade, resulting in an increased cost of treatment attributable to long-term complications (including cardiovascular disease, kidney disease, retinopathy and amputations). Despite many pharmacological and technological advances, the majority of people with diabetes do not achieve or maintain glucose levels that prevent complications [2]. Barriers that have been reported include poor treatment adherence [3,4] (both to medication as well as to self-management programmes), lack of coordinated care in health systems [5], poor patient–provider communication [6], and lack of financial support [7].

Distal technologies are electronic systems designed to provide services remotely and include heterogeneous systems such as telehealth, social platforms, web-based platforms and mHealth [8,9]. Numerous studies and reviews estimating the impact of distal technologies have been conducted so far, and suggest that they have the potential for improving HbA_{1c} in people living with diabetes, but the magnitude varies. Umbrella reviews are a relatively new study design that aim to examine, compare and contrast the findings of relevant reviews on a specific research topic using a comprehensive and systematic approach [10]. By conducting an umbrella review, the possibility is offered for us to further understand the strength of evidence and extent of potential biases of studies that have examined the effects of distal

technology use in people with diabetes on different health outcomes. In the present study, we performed an umbrella review and meta-analysis on the effectiveness of digital technologies on multiple health outcomes in the management of diabetes, as well as provide an overview of the validity of these associations.

Methods

Literature search

We searched the following three databases: PubMed, EMBASE and the Cochrane database of systematic reviews from database inception to 31 August 2018 for systematic reviews and/or meta-analyses that examined the efficacy of distal technologies in people with diabetes, using the following search algorithm: '(diabetes) AND (telemedicine OR telehealth OR mHealth OR game-based OR social platform OR patient portal) AND (meta-analysis OR systematic review) (Appendix)'. These search terms were peer-reviewed by a librarian, and also cross-referenced to established Cochrane-based systematic reviews and amended where necessary. To identify grey literature, we performed a manual review of potentially eligible systematic reviews from identified studies. The titles, abstracts and full texts of the studies were subsequently examined in detail, and any discrepancies were resolved by consensus.

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Eligibility criteria and data extraction

There was considerable variation in the definition of distal technology among studies as well as among reviews. In the present study, we followed the approach taken by Duke *et al.* [9] to include telehealth, mobile health (mHealth), game-based support, social platforms and patient portals (Table 1).

Articles were included if the authors had performed a systematic search of databases to identify studies examining distal technology in people with diabetes and reporting a health outcome or patient-reported outcome. A full description of the inclusion/exclusion criteria and search strings can be found in Appendix S1. Studies were excluded if they were not published in English or did not include distal technologies. For each article, two investigators independently reviewed abstracts for information on the article characteristics, outcomes examined, intervention outcome data and reported summary effects. If the article included a meta-analysis, we recorded the number of participants, the mean difference and 95% CIs, but we did not review the primary study articles included.

Assessment of summary effects and heterogeneity

For each meta-analysis, we re-analysed the summary effects using both fixed- and random-effects methods and corresponding 95% CIs. We also calculated the 95% prediction intervals for the summary random-effects estimates, which can be used to account for heterogeneity among studies and indicate the range of effect estimates that would be expected in future studies. When we could not reanalyse data from a meta-analysis, we reported the estimates and measures of heterogeneity or publication bias.

In addition, we assessed if smaller studies gave higher risk estimates than larger studies, an indication of publication bias, genuine heterogeneity or other reasons, using Egger's regression test for any reanalyses that included >10 studies. A *P* value <0.1 was considered significant for Egger's test. We applied the test for excess significance to evaluate whether the observed number of statistically significant results in a body of evidence was too large compared to their expected number [11]. We calculated the expected number of studies with significant results from each meta-analysis according to the sum of the statistical power estimates for each component study. An excess significance was considered if *P* values were <0.10.

We subsequently reconstructed the forest plots from reanalysed/extracted data to display the summary estimates for the outcome examined, representing the most recent study available. When two or more meta-analyses reported on the same outcome or question within the last 24-month period, the meta-analysis with the largest number of studies was selected, but we also conducted sensitivity analyses to assess the concordance between summary estimates (direction, magnitude and significance) in these meta-analyses.

Assessment of methodological quality

We assessed the methodological quality of included meta-analyses using the AMSTAR2 tool, a measurement tool to assess the quality of systematic reviews [12]. We subsequently used the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) working group classification to assess the quality of evidence for each outcome included in the umbrella review [13]. The GRADE approach categorizes evidence from systematic reviews and meta-analyses into 'high', 'moderate', 'low' or 'very low' quality. This rating was not an assessment of the methodological quality of a review, but of the overall quality of

evidence presented in that review. Reviews were not excluded based on methodological quality.

Strength of evidence

Finally, we categorized the reported outcomes from each review article as convincing or otherwise, based on the following four criteria: reported significance of outcome ($P < 0.001$); inclusion of more than 500 or 1000 participants; absence of considerable heterogeneity ($I^2 < 75\%$); and the absence of small study effects. A detailed description can be found in Appendix S1. All statistical analysis and power calculations were performed with STATA version 13 (StataCorp, College Station, TX, USA).

Data availability statement

All data generated and analysed in this study are available from the corresponding author on reasonable request.

Results

The search identified 1490 articles, of which 1271 were excluded after screening of titles and abstracts. In the 131 remaining articles, 95 reviews assessing the impact of distal technologies on people with diabetes were included (Fig. 1) [14–108]. Of these, 46 reviews included a meta-analysis. The reviews had been published between 2001 and 2018 and originated from 25 countries, with most of the reviews originating from North America ($n=31$), Europe ($n=30$) and Asia ($n=25$). They included eight reviews that examined only people with type 1 diabetes, 30 reviews that involved people with type 2 diabetes and 57 reviews that involved both type 1 diabetes and type 2 diabetes. The most common examined distal technology was telehealth and mHealth.

The median (range) number of studies included in the systematic reviews was 16 (11–34; Table S1) and in the meta-analysis it was 13 (3–111). These reviews had used the Cochrane risk of bias tool ($n=36$), Jadad score ($n=8$) or their own tool ($n=21$) to assess the risk of bias

of the included studies. Other tools used to appraise the quality of studies included the Drummond item checklist [22], as well as the mixed-method appraisal tool [23]. Only 11 meta-analyses had reported the quality of evidence in the outcome assessed using the GRADE classification [14,19,35,38,39,44,54,76,92,95,97].

A total of 162 meta-analyses, which examined 46 unique outcomes in people with type 1 diabetes ($n=5$ studies), type 2 diabetes (16 studies) or both type 1 diabetes and type 2 diabetes ($n=25$ studies), were reported. Outcomes reported were mostly related to glycaemic control: HbA_{1c} ($n=44$), fasting plasma glucose ($n=7$) and 2-h postprandial glucose ($n=2$; Table S1). Other outcomes examined were related to clinical measures such as systolic and diastolic blood pressure, total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides and weight changes. Patient-reported outcomes examined were empowerment, diabetes distress, depression, adherence, quality of life, and level of physical activity. Several studies also examined adverse events such as frequency of severe hypoglycaemia and frequency of diabetic ketoacidosis (Table S2). All eligible meta-analyses had used summary-level data from published literature and none had access to individual participant data. In 43 meta-analyses presented in five articles, data on effect sizes for individual studies were not presented [37,38,40,55,71].

Strength of evidence

The strength of evidence from each of the reported outcomes is shown in Fig. 2. We found that 65% of the 162 meta-analyses reported no statistical differences in the outcomes assessed ($P>0.05$ for the summary random effects). Only 17% of meta-analyses ($n=27$) were supported by conclusive to highly suggestive evidence and summarized data on HbA_{1c} ($n=18$), systolic ($n=3$) and diastolic blood pressure ($n=1$), BMI ($n=1$), LDL cholesterol ($n=2$), HDL cholesterol ($n=1$) and diabetes self-efficacy ($n=1$). For all other health outcomes, the evidence reported from meta-analyses was only suggestive or weak. No association was noted for most of the patient-reported outcomes, except for patient empowerment and effectiveness of remote feedback, which were rated as suggestive or weak.

Telehealth and mHealth

The terms telehealth and mHealth were used interchangeably with telemedicine, mHealth, teleconsultation in many of the reviews. Several studies also categorized telehealth into the care activities involved, such as monitoring, education, consultation, as well as care coordination [31]. Among people with type 1 diabetes, there was conflicting evidence to suggest that telehealth and/or mHealth was effective in improving HbA_{1c}, with two studies reporting no improvement while another two reported otherwise. In comparison, telehealth and/or mHealth was reported to be effective in improving HbA_{1c} in all seven meta-analyses that had examined people with type 2 diabetes. Similarly, most meta-analyses ($n=14$) that examined both type 1 diabetes and type 2 diabetes had reported that telehealth and/or mHealth was effective in improving HbA_{1c} levels. Summary effects from the most recent meta-analyses suggest that telehealth and mHealth led to improvements of between 2 mmol/mol (0.2%) and 4 mmol/mol (0.4%) in HbA_{1c} [31,39,40] (Fig. 3); however, there was limited evidence to support the use of telehealth and/or mHealth in all other outcomes such as blood pressure, lipid levels, BMI, triglycerides and other patient-related outcomes such as severe hypoglycaemia and diabetic ketoacidosis [34,38] (Fig. 2).

mHealth

There was agreement that mHealth was effective in improving HbA_{1c} in people with type 2 diabetes [45], but evidence was weak when used in people with type 1 diabetes. No significant improvements were noted when mHealth was used for reducing the risk of severe hypoglycaemia, body weight, blood pressure, or cholesterol levels.

Game-based support

Three reviews examined how game-based interventions were used in diabetes care [44,61,98]. These studies found that game-based interventions were a useful tool to enhance patient education, but had minimal impact on HbA_{1c} (-1 mmol/mol [95% CI -3 to 1] or -0.1% [95% CI -0.3 to 0.1]) [44].

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Social platforms

Two reviews examined the potential of social platforms such as Facebook and Twitter for improving diabetes care among people with type 1 diabetes and type 2 diabetes [71,93]. These were mainly used for providing diabetes education, promoting self-efficacy and support. The evidence supports the role of social platforms in improving HbA_{1c}, blood pressure, triglycerides, total cholesterol and HDL cholesterol levels in people with type 2 diabetes [71] (Fig. 3).

Patient portals

Four reviews examined the impact of online disease management as a means of providing people with support and the necessary tools to monitor and manage their diabetes [28,76,78,96]. Patient portals were found to improve HbA_{1c} control among people with diabetes by 2 mmol/mol (0.2%) [76]; however, no significant improvements were noted in patient-reported outcomes.

Small study effects and heterogeneity

We were able to reanalyse 82 (51%) of the 162 reported outcomes, as data were insufficiently detailed in the remaining studies. Fifteen (18%) of the meta-analyses had a high level of heterogeneity ($I^2 > 50\%$) and 26 meta-analyses (32%) had a very high level of heterogeneity ($I^2 > 75\%$). A possible explanation for the high level of heterogeneity observed could be the variation in terms of geography of study, definition of distal technology, type of technology used, duration of follow-up, the definition of control/usual care, intensity of intervention as well as activities involved in the intervention. For the remaining 80 meta-analyses that we could not reanalyse, 9% ($n=7$) did not publish any measure of heterogeneity, 26 studies (33%) reported low heterogeneity, 10 studies (13%) reported moderate heterogeneity, while 37 studies (46%) had evidence of a high or very high level of heterogeneity (Table S3).

We also repeated the Egger test in 31% ($n=25$) of the meta-analysis as the remaining reviews had insufficient sample sizes (<10 studies). The presence of small study effects was observed in 36% of meta-analyses ($n=9$, Egger's test $P < 0.10$). This included the review that examined the effects on fasting plasma glucose ($P < 0.001$) [31], triglycerides ($P = 0.02$) [31] and

physical activity ($P=0.005$) [38]. Another six reviews had examined the effects of distal technology on HbA_{1c} (P values between 0.001 and 0.029; Table S3) [14,46,54,58,64,71].

Excess significance bias

We further assessed the presence of excess significance bias to determine if the observed number of studies with nominally significant results was different from the expected number. This test was only performed for the 40 meta-analyses reported since data were not sufficiently detailed in the other studies. Only three studies (8%) had a nominal significant summary association as per random-effects calculation, for the outcome of HbA_{1c} [39,76] and fasting plasma glucose [92].

Quality of systematic reviews included

Using the AMSTAR2 tool, results from 13 studies were rated as having a high level of confidence, one as moderate, 34 studies as low and 47 as critically low. The majority of the reviews did not meet the AMSTAR2 critical domains relating to the following: review protocol registration ($n=70$; 74%), risk of bias from individual studies ($n=38$; 40%), justification for study exclusion ($n=18$; 19%), consideration of risk of bias when interpreting results as well as presence ($n=33$; 35%; Table S4). Table S5 shows the breakdown of GRADE scores for studies representing each outcome.

Discussion

This is the first comprehensive attempt to map and appraise systematic reviews of randomized controlled trials that examined the effectiveness of distal technologies and associated clinical outcomes in people with diabetes. Overall, we found 95 reviews that examined five different distal technologies: telehealth, mHealth, game-based support, social platforms and patient portals for diabetes care. Our overview found some evidence to support the use of telehealth and mHealth to improve glycaemic control.

The present review found that the scope of technologies used to improve the management of diabetes was very broad. For example, the type of technologies ranged from using SMS, mobile apps or internet portals, and included simple devices such as glucometers to more

advanced devices such as web-enabled glucometers which had the ability to deliver reminders and track glycaemic patterns. While meta-analyses looking at telehealth and mHealth have shown highly significant summary effects in improving glycaemic control, the results are highly heterogeneous. We also found that the methodological quality of studies in this area is suboptimal. Half of the reviews ($n=42$; 50%) are characterized by important methodological limitations and risks of bias that impair their internal validity and limit their usefulness for clinical and policy decision-making purposes. Our assessment also showed that a large proportion of meta-analyses had a high degree of heterogeneity and evidence of small study effects. In addition to the methodological quality, another key issue relates to the grouping of type 1 diabetes or type 2 diabetes studies in the analysis and synthesis of results.

In view of the increasing prevalence of diabetes, there is much interest and investment in distal technologies offering the possibility of a hybrid system of care between humans (multidisciplinary professional teams and people with diabetes) and machines (medical devices and consumer products) [109,110]. While major therapy changes will probably still be made during human-to-human interactions, in-between visits and routine care may be delivered by distal technologies. Some potential tasks that are being delegated to technologies include adherence promotion, peer-to-peer support, either through social media or smart-watches, apps and widgets, and health education promotion [110]. Google, IBM and other major companies are investing in artificial intelligence technologies that can use data from connected devices.

Several reviews have suggested that patient factors such as socio-demographic, age, sleep amount and health literacy can affect these self-management skills [111–114]. The use of telehealth and mHealth is thought to be able to overcome some of these patient factors to improve outcomes, through improving access to care, patient engagement and medication-taking. For example, the use of mobile apps, online module can help deliver reinforcement of diabetes education. Technology can also play a major role in bridging some of the resource gaps between high and low resource settings, either through training or even remote delivery of diabetes care directly to the patient [115].

The present overview has some limitations. Firstly, we did not appraise the quality of all individual primary studies that were included in the meta-analyses as this was beyond the scope of the review. As such, some studies may include cohort and non-randomized studies. In addition, several reported meta-analyses in this study may include duplicate studies, leading to overestimation of effect sizes. Some meta-analyses were excluded from heterogeneity and bias testing as they did not provide sufficient data for the respective analyses. In addition, the excess statistical significance test only offers suggestion of bias, not definitive proof. Most of the primary studies included in the review did not report on the theories relating to behaviour change or models used, or provide sufficiently detailed description of the components of intervention and usual care. As such, misclassifications of the type of distal technology are likely and could be an avenue for future studies to improve the rigour of their systematic reviews. The studies included represent a heterogeneous group of studies from a diverse population group of different socio-economic backgrounds (e.g. age, sex, ethnicity) and therefore results should be interpreted with caution as they are not specific to any socio-demographic group. We also limited our search to include only studies published in English. This could have affected the number of studies included in our analysis, but we believe that will have minimal impact on our results, given our broad inclusion criteria.

By definition, the included studies were carried out over the past 10 years, and as such are rearward facing, while technology, and the way we use it is advancing rapidly in a forward direction. What we can see in the present umbrella review is where the gaps are in our knowledge. Most of the technological solutions are based on promoting better adherence or facilitating interaction between patients and healthcare professionals. It is possible that we need to optimize the technology further and improve the interaction. It is also possible that healthcare systems may stymie the individual potential of distal technologies. The review surprisingly also found that telehealth seems to be more efficacious in people with type 2 diabetes rather than type 1 diabetes. This is slightly counter-intuitive, as given the frequent adjustments required in type 1 diabetes, we may have expected better outcomes. This may be attributable to the results of the meta-analyses which rely on the size and quality of the individual studies, many of which are small and heterogeneous.

In summary, the present umbrella review that focused on using systematic reviews and/or meta-analysis demonstrated that distal technology can be a useful intervention to improve glycaemic control at least in the short term in people with diabetes. Nonetheless, there has not been any clear and consistent evidence to show any clinical other relevant improvement in other long-term outcomes. Further robust clinical studies are needed to further understand how we can optimize distal technologies to improve other health outcomes among people with diabetes.

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Competing interests

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References

1. Ogurtsova K, da Rocha Fernandes JD, Huang Y, Linnenkamp U, Guariguata L, Cho NH *et al.* IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Pract* 2017; **128**:40–50.
2. Gregg EW, Li Y, Wang J, Rios Burrows N, Ali MK, Rolka D *et al.* Changes in Diabetes-Related Complications in the United States, 1990–2010. *N Engl J Med* 2014; **370**:1514–1523.
3. Kirkman MS, Rowan-Martin MT, Levin R, Fonseca VA, Schmittiel JA, Herman WH *et al.* Determinants of Adherence to Diabetes Medications: Findings From a Large Pharmacy Claims Database. *Diabetes Care* 2015; **38**:604.

4. Schechter CB, Walker EA. Improving Adherence to Diabetes Self-Management Recommendations. *Diabetes Spectrum* 2002; **15**:170.
5. Kahn R, Anderson JE. Improving Diabetes Care: The Model for Health Care Reform. *Diabetes Care* 2009; **32**:1115.
6. Gregg EW. The Changing Tides of the Type 2 Diabetes Epidemic—Smooth Sailing or Troubled Waters Ahead? Kelly West Award Lecture 2016. *Diabetes Care* 2017; **40**:1289.
7. Nanditha A, Ma RCW, Ramachandran A, Snehalatha C, Chan JCN, Chia KS *et al.* Diabetes in Asia and the Pacific: Implications for the Global Epidemic. *Diabetes Care* 2016; **39**:472.
8. Lee JY, Wong CP, Tan CSS, Nasir NH, Lee SWH. Telemonitoring in fasting individuals with Type 2 Diabetes Mellitus during Ramadan: A prospective, randomised controlled study. *Scientific Reports* 2017; **7**:10119.
9. Duke DC, Barry S, Wagner DV, Speight J, Choudhary P, Harris MA. Distal technologies and type 1 diabetes management. *Lancet Diabetes Endocrinol* 2018; **6**:143–156.
10. Aromataris E, Fernandez R, Godfrey CM, Holly C, Khalil H, Tungpunkom P. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *Int J Evid Based Healthc* 2015; **13**:132–140.
11. Ioannidis JP, Trikalinos TA. An exploratory test for an excess of significant findings. *Clin Trials* 2007; **4**:245–253.
12. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J *et al.* AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017; **358**.
13. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J *et al.* GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011; **64**:383–394.
14. Hou C, Xu Q, Diao S, Hewitt J, Li J, Carter B. Mobile phone applications and self-management of diabetes: A systematic review with meta-analysis, meta-regression of 21 randomized trials and GRADE. *Diabetes Obes Metabol* 2018; **20**:2009–2013.
15. Tchero H, Kangambega P, Briatte C, Brunet-Houdard S, Retali GR, Rusch E. Clinical Effectiveness of Telemedicine in Diabetes Mellitus: A Meta-Analysis of 42 Randomized Controlled Trials. *Telemed J E Health* 2019; **25**:569–583.
16. Wu IXY, Kee JCY, Threapleton DE, Ma RCW, Lam VCK, Lee EKP *et al.* Effectiveness of smartphone technologies on glycaemic control in patients with type 2 diabetes: systematic review with meta-analysis of 17 trials. *Obes Rev* 2018; **19**:825–838.
17. Kim Y, Park JE, Lee BW, Jung CH, Park DA. Comparative effectiveness of telemonitoring versus usual care for type 2 diabetes: A systematic review and meta-analysis. *J Telemed Telecare* 2018:1357633x18782599. doi: 10.1177/1357633x18782599

18. Huang JW, Lin YY, Wu NY. The effectiveness of telemedicine on body mass index: A systematic review and meta-analysis. *J Telemed Telecare* 2018;1357633x18775564. doi: 10.1177/1357633x18775564.
19. Lunde P, Nilsson BB, Bergland A, Kvaerner KJ, Bye A. The Effectiveness of Smartphone Apps for Lifestyle Improvement in Noncommunicable Diseases: Systematic Review and Meta-Analyses. *J Med Internet Res* 2018; **20**:e162.
20. Shen Y, Wang F, Zhang X, Zhu X, Sun Q, Fisher E et al. Effectiveness of Internet-Based Interventions on Glycemic Control in Patients With Type 2 Diabetes: Meta-Analysis of Randomized Controlled Trials. *J Med Internet Res* 2018;**20**:e172.
21. Bellei EA, Biduski D, Cechetti NP, De Marchi ACB. Diabetes Mellitus m-Health Applications: A Systematic Review of Features and Fundamentals. *Telemed J E Health* 2018; **24**:839–852.
22. Lee JY, Lee SWH. Telemedicine Cost-Effectiveness for Diabetes Management: A Systematic Review. *Diabetes Technol Ther* 2018; **20**:492–500.
23. Mold F, Raleigh M, Alharbi NS, de Lusignan S. The Impact of Patient Online Access to Computerized Medical Records and Services on Type 2 Diabetes: Systematic Review. *J Med Internet Res* 2018; **20**:e235.
28. Coughlin SS, Williams LB, Hatzigeorgiou C. A systematic review of studies of web portals for patients with diabetes mellitus. *mHealth* 2017; **3**:23.
29. de Ridder M, Kim J, Jing Y, et al. A systematic review on incentive-driven mobile health technology: As used in diabetes management. *J Telemed Telecare* 2017;**23**:26–35.
30. Alvarado MM, Kum H-C, Gonzalez Coronado K, Foster MJ, Ortega P, Lawley MA. Barriers to Remote Health Interventions for Type 2 Diabetes: A Systematic Review and Proposed Classification Scheme. *J Med Internet Res* 2017;**19**:e28.
31. Lee SWH, Chan CKY, Chua SS, Chaiyakunapruk N. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis. *Sci Rep* 2017; **7**:12680.
32. Heitkemper EM, Mamykina L, Travers J, Smaldone A. Do health information technology self-management interventions improve glycemic control in medically underserved adults with diabetes? A systematic review and meta-analysis. *J Am Med Inform Assoc* 2017;**24**:1024–1025.
33. Fu H, McMahon SK, Gross CR, Adam TJ, Wyman JF. Usability and clinical efficacy of diabetes mobile applications for adults with type 2 diabetes: A systematic review. *Diabetes Res Clin Pract* 2017;**131**:70–81.
34. So CF, Chung JWY. Telehealth for diabetes self-management in primary healthcare: A systematic review and meta-analysis. *J Telemed Telecare* 2017; **24**:356–364.
35. Wu Y, Yao X, Vespasiani G, Nicolucci A, Dong Y, Kwong J et al. Mobile App-Based Interventions to Support Diabetes Self-Management: A Systematic Review of Randomized Controlled

- Trials to Identify Functions Associated with Glycemic Efficacy. *JMIR mHealth and uHealth* 2017; **5**:e35.
36. Joiner KL, Nam S, Whittemore R. Lifestyle interventions based on the diabetes prevention program delivered via eHealth: A systematic review and meta-analysis. *Prev Med* 2017; **100**:194–207.
 37. Bonoto BC, de Araujo VE, Godoi IP, de Lemos LL, Godman B, Bennie M *et al*. Efficacy of Mobile Apps to Support the Care of Patients With Diabetes Mellitus: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *JMIR mHealth and uHealth* 2017; **5**:e4.
 38. Kongstad MB, Valentiner LS, Ried-Larsen M, Walker KC, Juhl CB, Langberg H. Effectiveness of remote feedback on physical activity in persons with type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials. *J Telemed Telecare* 2017;1357633x17733772.
 39. Lee SWH, Ooi L, Lai YK. Telemedicine for the management of glycemic control and clinical outcomes of type 1 diabetes mellitus: A systematic review and meta-analysis of randomized controlled studies. *Front Pharmacology* 2017; **8**:330.
 40. Faruque LI, Wiebe N, Ehteshami-Afshar A, Liu Y, Dianati-Maleki N, Hemmelgarn BR *et al*. Effect of telemedicine on glycated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials. *CMAJ* 2017; **189**:E341–E364.
 41. Holmen H, Wahl AK, Cvancarova Småstuen M, Ribu L. Tailored communication within mobile apps for diabetes self-management: A systematic review. *J Med Internet Res* 2017; **19**:e227.
 42. Ershad Sarabi R, Sadoughi F, Jamshidi Orak R, *et al*. The effectiveness of mobile phone text messaging in improving medication adherence for patients with chronic diseases: A systematic review. *Iran Red Crescent Med J* 2016; **18**:e25183.
 43. Porter J, Huggins CE, Truby H, Collins J. The effect of using mobile technology-based methods that record food or nutrient intake on diabetes control and nutrition outcomes: A systematic review. *Nutrients* 2016; **8**: pii: E815.
 44. Christensen J, Valentiner LS, Petersen RJ, Langberg H. The Effect of Game-Based Interventions in Rehabilitation of Diabetics: A Systematic Review and Meta-Analysis. *Telemed J E Health* 2016; **22**:789–797.
 45. Cui M, Wu X, Mao J, Wang X, Nie M. T2DM self-management via smartphone applications: A systematic review and meta-analysis. *PloS One* 2016; **11**:e0166718.
 46. Su D, Zhou J, Kelley MS, Michaud TL, Siahpush M, Kim J *et al*. Does telemedicine improve treatment outcomes for diabetes? A meta-analysis of results from 55 randomized controlled trials. *Diabetes Res Clin Pract* 2016; **116**:136–148.
 47. Kuo A, Dang S. Secure messaging in electronic health records and its impact on diabetes clinical outcomes: A systematic review. *Telemed J E Health* 2016; **22**:769–777.
 48. Viana LV, Gomes MB, Zajdenverg L, Pavin EJ, Azevedo MJ, Brazilian Type 1 Diabetes Study Group. Interventions to improve patients' compliance with therapies aimed at lowering glycated

- hemoglobin (HbA1c) in type 1 diabetes: systematic review and meta-analyses of randomized controlled clinical trials of psychological, telecare, and educational interventions. *Trials* 2016;**17**:94.
49. Isaacs T, Hunt D, Ward D, Rooshenas L, Edwards L. The Inclusion of Ethnic Minority Patients and the Role of Language in Telehealth Trials for Type 2 Diabetes: A Systematic Review. *J Med Internet Res* 2016;**18**:e256.
 50. Wickramasinghe SI, Caffery LJ, Bradford NK, Smith AC. Enablers and barriers in providing teledabetes services for Indigenous communities: A systematic review. *J Telemed Telecare* 2016;**22**:465–471.
 51. Joo JY. Effectiveness of web-based interventions for managing diabetes in Korea. *Comput Inform Nurs* 2016;**34**:587–600.
 52. Farmer AJ, McSharry J, Rowbotham S, McGowan L, Ricci-Cabello I, French DP. Effects of interventions promoting monitoring of medication use and brief messaging on medication adherence for people with type 2 diabetes: A systematic review of randomized trials. *Diabet Med* 2016;**33**:565–579.
 53. Su D, McBride C, Zhou J, Kelley MS. Does nutritional counseling in telemedicine improve treatment outcomes for diabetes? A systematic review and meta-analysis of results from 92 studies. *J Telemed Telecare* 2016; **22**:333–347.
 54. Hou C, Carter B, Hewitt J, Francisa T, Mayor S. Do Mobile Phone Applications Improve Glycemic Control (HbA1c) in the Self-management of Diabetes? A Systematic Review, Meta-analysis, and GRADE of 14 Randomized Trials. *Diabetes Care* 2016; **39**:2089–2095.
 55. Hadjiconstantinou M, Byrne J, Bodicoat DH, Robertson N, Eborall H, Khunti K *et al*. Do web-based interventions improve well-being in type 2 diabetes? A systematic review and meta-analysis. *J Med Internet Res* 2016; **18**:e270.
 56. Alharbi NS, Alsubki N, Jones S, Khunti K, Munro N, de Lusignan S. Impact of information technology-based interventions for type 2 diabetes mellitus on glycemic control: A systematic review and meta-analysis. *J Med Internet Res* 2016;**18**(11):e310.
 57. Arambepola C, Ricci-Cabello I, Manikavasagam P, Roberts N, French DP, Farmer A. The impact of automated brief messages promoting lifestyle changes delivered via mobile devices to people with type 2 diabetes: A systematic literature review and meta-analysis of controlled trials. *J Med Internet Res* 2016;**18**:e86.
 58. Huang Z, Tao H, Meng Q, Jing L. Effects of telecare intervention on glycemic control in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. *European journal of endocrinology* 2015; **172**:R93–101.
 59. Mushcab H, Kernohan WG, Wallace J, Martin S. Web-based remote monitoring Systems for self-managing type 2 diabetes: A systematic review. *Diabetes Technol Ther* 2015;**17**:498–509.

60. Deacon AJ, Edirippulige S. Using mobile technology to motivate adolescents with type 1 diabetes mellitus: A systematic review of recent literature. *J Telemed Telecare* 2015;**21**:431–438.
61. Theng YL, Lee JWY, Patinadan PV, Foo SSB. The Use of Videogames, Gamification, and Virtual Environments in the Self-Management of Diabetes: A Systematic Review of Evidence. *Games Health J* 2015; **4**:352–361.
62. Nuti L, Turkcan A, Lawley MA, Zhang L, Sands L, McComb S. The impact of interventions on appointment and clinical outcomes for individuals with diabetes: a systematic review. *BMC Health Serv Res* 2015;**15**:355.
63. Tildesley HD, Po MD, Ross SA. Internet blood glucose monitoring systems provide lasting glycemic benefit in type 1 and 2 diabetes: a systematic review. *Med Clin* 2015;**99**:17–33.
64. Flodgren G, Rachas A, Farmer AJ, Inzitari M, Shepperd S. Interactive telemedicine: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev* 2015:Cd002098.
65. Hamine S, Gerth-Guyette E, Faulx D, Green BB, Ginsburg AS. Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. *J Med Internet Res* 2015;**17**:e52.
66. Lepard MG, Joseph AL, Agne AA, Cherrington AL. Diabetes self-management interventions for adults with type 2 diabetes living in rural areas: a systematic literature review. *Curr Diab Rep* 2015;**15**:608.
67. Majeed-Ariss R, Baildam E, Campbell M, Chieng A, Fallon D, Hall A *et al*. Apps and adolescents: A systematic review of adolescents' use of mobile phone and tablet Apps that support personal management of their chronic or long-term physical conditions. *J Med Internet Res* 2015;**17**:e287.
68. Shi L, Wu H, Dong J, Jiang K, Lu X, Shi J. Telemedicine for detecting diabetic retinopathy: A systematic review and meta-analysis. *Br J Ophthalmol* 2015;**99**:823–831.
69. Mignerat M, Lapointe L, Vedel I. Using telecare for diabetic patients: A mixed systematic review. *Health Pol Technol* 2014;**3**(2):90–112.
70. Greenwood DA, Young HM, Quinn CC. Telehealth remote monitoring systematic review: Structured self-monitoring of blood glucose and impact on A1C. *J Diabetes Sci Technol* 2014;**8**:378–389.
71. Toma T, Athanasiou T, Harling L, Darzi A, Ashrafian H. Online social networking services in the management of patients with diabetes mellitus: systematic review and meta-analysis of randomised controlled trials. *Diabetes Res Clin Pract* 2014; **106**:200–211.
72. Cotter AP, Durant N, Agne AA, Cherrington AL. Internet interventions to support lifestyle modification for diabetes management: a systematic review of the evidence. *J Diabetes Complications* 2014;**28**:243–251.
73. Peterson A. Improving type 1 diabetes management with mobile tools: A systematic review. *J Diabetes Sci Technol* 2014;**8**:859–864.

74. Saffari M, Ghanizadeh G, Koenig HG. Health education via mobile text messaging for glycemic control in adults with type 2 diabetes: A systematic review and meta-analysis. *Prim Care Diabetes* 2014;**8**:275–285.
75. Suksomboon N, Poolsup N, Nge YL. Impact of phone call intervention on glycemic control in diabetes patients: a systematic review and meta-analysis of randomized, controlled trials. *PloS One* 2014;**9**:e89207.
76. Pal K, Eastwood SV, Michie S, Farmer A, Barnard ML, Peacock R *et al*. Computer-based interventions to improve self-management in adults with type 2 diabetes: A systematic review and meta-analysis. *Diabetes Care* 2014; **37**:1759–1766.
77. Zhai YK, Zhu WJ, Cai YL, Sun DX, Zhao J. Clinical- and cost-effectiveness of telemedicine in type 2 diabetes mellitus: a systematic review and meta-analysis. *Medicine* 2014;**93**:e312.
78. Amante DJ, Hogan TP, Pagoto SL, English TM. A systematic review of electronic portal usage among patients with diabetes. *Diabetes Technol Ther* 2014; **16**:784–793.
79. Marcolino MS, Maia JX, Alkmim MB, Boersma E, Ribeiro AL. Telemedicine application in the care of diabetes patients: systematic review and meta-analysis. *PloS One* 2013;**8**:e79246.
80. van Vugt M, de Wit M, Cleijne WH, Snoek FJ. Use of behavioral change techniques in web-based self-management programs for type 2 diabetes patients: systematic review. *J Med Internet Res* 2013;**15**:e279.
81. Connelly J, Kirk A, Masthoff J, MacRury S. The use of technology to promote physical activity in Type 2 diabetes management: a systematic review. *Diabet Med* 2013;**30**:1420–1432.
82. Herbert L, Owen V, Pascarella L, Streisand R. Text message interventions for children and adolescents with type 1 diabetes: A systematic review. *Diabetes Technol Ther* 2013;**15**:362–370.
83. Tao D, Or CK. Effects of self-management health information technology on glycaemic control for patients with diabetes: A meta-analysis of randomized controlled trials. *J Telemed Telecare* 2013;**19**:133–143.
84. Pal K, Eastwood SV, Michie S, Farmer AJ, Barnard ML, Peacock R *et al*. Computer-based diabetes self-management interventions for adults with type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2013;(3):CD008776.
85. El-Gayar O, Timsina P, Nawar N, Eid W. A systematic review of IT for diabetes self-management: Are we there yet? *Int J Med Inform* 2013;**82**:637–652.
86. Baron J, McBain H, Newman S. The impact of mobile monitoring technologies on glycosylated hemoglobin in diabetes: A systematic review. *J Diabetes Sci Technol* 2012;**6**:1185–1196.
87. van den Berg N, Schumann M, Kraft K, Hoffmann W. Telemedicine and telecare for older patients—a systematic review. *Maturitas* 2012;**73**:94–114.
88. Yu CH, Bahniwal R, Laupacis A, Leung E, Orr MS, Straus SE. Systematic review and evaluation of web-accessible tools for management of diabetes and related cardiovascular risk factors by patients and healthcare providers. *J Am Med Inform Assoc* 2012;**19**:514–522.

89. Cassimatis M, Kavanagh DJ. Effects of type 2 diabetes behavioural telehealth interventions on glycaemic control and adherence: a systematic review. *J Telemed Telecare* 2012;**18**:447–450.
90. Holtz B, Lauckner C. Diabetes management via mobile phones: A systematic review. *Telemed J E Health* 2012;**18**:175–184.
91. Ramadas A, Quek KF, Chan CKY, Oldenburg B. Web-based interventions for the management of type 2 diabetes mellitus: A systematic review of recent evidence. *Int J Med Inform* 2011;**80**:389–405.
92. Angeles RN, Howard MI, Dolovich L. The effectiveness of web-based tools for improving blood glucose control in patients with diabetes mellitus: A meta-analysis. *Can J Diabetes* 2011;**35**:344–352.
93. Sutcliffe P, Martin S, Sturt J, Powell J, Griffiths F, Adams A *et al*. Systematic review of communication technologies to promote access and engagement of young people with diabetes into healthcare. *BMC Endocr Disord* 2011; **11**:1.
94. Liang X, Wang Q, Yang X, Cao J, Chen J, Mo X *et al*. Effect of mobile phone intervention for diabetes on glycaemic control: A meta-analysis. *Diabet Med* 2011;**28**:455–463.
95. Shulman RM, O'Gorman CS, Palmert MR. The impact of telemedicine interventions involving routine transmission of blood glucose data with clinician feedback on metabolic control in youth with type 1 diabetes: a systematic review and meta-analysis. *Int J Med Pediatr Endocrinol* 2010; **2010**: pii: 536957.
96. Osborn CY, Mayberry LS, Mulvaney SA, Hess R. Patient web portals to improve diabetes outcomes: A systematic review. *Curr Diab Rep* 2010; **10**:422–435.
97. Samoocha D, Bruinvels DJ, Elbers NA, Anema JR, van der Beek AJ. Effectiveness of web-based interventions on patient empowerment: A systematic review and meta-analysis. *J Med Internet Res* 2010; **12**:e23.
98. DeShazo J, Harris L, Pratt W. Effective intervention or child's play? A review of video games for diabetes education. *Diabetes Technol Ther* 2010; **12**:815–822.
99. Verhoeven F, Tanja-Dijkstra K, Nijland N, Eysenbach G, van Gemert-Pijnen L. Asynchronous and synchronous teleconsultation for diabetes care: a systematic literature review. *J Diabetes Sci Technol* 2010;**4**:666–684.
100. Polisen J, Tran K, Cimon K, Hutton B, McGill S, Palmer K. Home telehealth for diabetes management: A systematic review and meta-analysis. *Diabetes Obes Metab* 2009;**11**:913–930.
101. Verhoeven F, van Gemert-Pijnen L, Dijkstra K, Nijland N, Seydel E, Stehouder M. The contribution of teleconsultation and videoconferencing to diabetes care: a systematic literature review. *J Med Internet Res* 2007;**9**:e37.
102. Pare G, Jaana M, Sicotte C. Systematic review of home telemonitoring for chronic diseases: The evidence base. *J Am Med Inform Assoc* 2007;**14**:269–277.
103. Garcia-Lizana F, Sarria-Santamera A. New technologies for chronic disease management and control: a systematic review. *J Telemed Telecare* 2007;**13**:62–68.

104. Jaana M, Pare G. Home telemonitoring of patients with diabetes: A systematic assessment of observed effects. *J Eval Clin Pract* 2007; **13**:242–253.
105. Farmer A, Gibson OJ, Tarassenko L, Neil A. A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes. *Diabet Med* 2005; **22**:1372–1378.
106. Montori VM, Helgemoe PK, Guyatt GH, Dean DS, Leung TW, Smith SA *et al*. Telecare for patients with type 1 diabetes and inadequate glycemic control: a randomized controlled trial and meta-analysis. *Diabetes Care* 2004; **27**:1088–1094.
107. Montani S, Bellazzi R, Quaglini S, d'Annunzio G. Meta-analysis of the effect of the use of computer-based systems on the metabolic control of patients with diabetes mellitus. *Diabetes Technol Ther* 2001; **3**:347–356.
108. Hersh WR, Helfand M, Wallace J, Kraemer D, Patterson P, Shapiro S *et al*. Clinical outcomes resulting from telemedicine interventions: a systematic review. *BMC Med Inform Decis Mak* 2001; **1**:5.
109. American Diabetes Association. Lifestyle Management: Standards of Medical Care in Diabetes—2018. *Diabetes Care* 2018; **41**:S38–S50.
110. Chatterjee S, Davies MJ, Heller S, Speight J, Snoek FJ, Khunti K. Diabetes structured self-management education programmes: a narrative review and current innovations. *Lancet Diabetes Endocrinol* 2018; **6**:130–142.
111. Norris SL, Engelgau MM, Venkat Narayan KM. Effectiveness of Self-Management Training in Type 2 Diabetes: a systematic review of randomized controlled trials. *Diabetes Care* 2001; **24**:561–587.
112. Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: a systematic review and meta-analysis. *Sleep Med Rev* 2017; **31**:91–101.
113. Lorig KR, Holman HR. Self-management education: History, definition, outcomes, and mechanisms. *Ann Behav Med* 2003; **26**:1–7.
114. Rothman RL, DeWalt DA, Malone R, Bryant B, Shintani A, Crigler B *et al*. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. *JAMA* 2004; **292**:1711–1716.
115. Peiris D, Praveen D, Johnson C, Mogulluru K. Use of mHealth systems and tools for non-communicable diseases in low- and middle-income countries: a systematic review. *J Cardiovasc Transl Res* 2014; **7**:677–691.

Table 1 Definition of distal technologies used in the included studies

<p>Telehealth</p> <p>Telehealth refers to the use of electronic medium (e.g. videoconferencing, telephone calls) which facilitates synchronous (real-time) communication between a patient and healthcare provider. The aim of such technology is to reduce the geographical barrier between both individual, without sacrificing access to tailored treatment and live interaction.</p>
<p>mHealth</p> <p>mHealth can be subdivided into two distinct technologies: messaging systems and mobile applications.</p> <p><i>Messaging systems</i></p> <p>Messaging systems technologies include short message service (SMS), text messaging, and email. These are asynchronous communications, do not include an auditory component, and typically are unlikely to be personalized to the individual's need.</p> <p><i>Mobile applications</i></p> <p>Applications (apps) or software downloaded from a website or an app store and accessible via smartphones and tablet devices. The software is designed to fulfil a particular purpose, which can include self-management education, psychoeducation, reference sources (e.g. database of nutritional content of foods), data tracking (e.g. physical activity, diet, blood glucose levels) and behavioural interventions.</p>
<p>Game-based support</p> <p>Computer and video games have been developed to facilitate diabetes education and promote self-management. Typically, they include situational problem-solving and interactive activities and reinforce health behaviours to improve diabetes outcomes.</p> <p>They are largely targeted at children, adolescents and young adults with type 1 diabetes.</p>

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<p>Social platforms</p> <p>Web-based social platforms enable people with diabetes to access social support without geographic boundaries, forming online health communities. These platforms include widely used social media sites (e.g. Facebook, Twitter), and various other discussion forums. Web-based social platforms create unique opportunities for online peer support as well as diabetes education and intervention.</p>
<p>Patient portals</p> <p>Online interactive treatment environments are systems that facilitate sharing of personal health records between the individual with type 1 or 2 diabetes and their health professionals and provide multiple methods for self-managing health information. Portal functions can include online appointment scheduling, appointment reminders, prescription refill requests, journaling and tracking tools, opportunities for health professional support, psychoeducational tools, and the ability to upload, view and manage health information.</p>

FIGURE 1 Study flow.

FIGURE 2 Summary of the strength of evidence reported by studies for evaluated outcomes. The numbers indicated in the bar are the number of meta-analyses with convincing, highly suggestive, suggestive, weak or no evidence for each of the reported outcome. (a) Health outcomes. (b) Patient-reported outcomes. MCS, xxx; PCS, xxx.

Commented [MD4]: TYPESETTER: FIGURE 2
CORRECTIONS: Please change:
'HbA1c' to 'HbA_{1c}'
'2hr post prandial' to '2-h postprandial'
'Body mass index' to 'BMI'
'High-density lipoprotein' to 'HDL cholesterol'
'Low-density lipoprotein' to 'LDL cholesterol'

FIGURE 3 Forest plot of meta-analyses of randomized controlled studies reporting different outcomes, stratified by type of distal technology, in people with diabetes. All summary effect sizes are presented as originally reported from published meta-analysis. (a) People with type 1 diabetes only. (b) People with type 2 diabetes only. (c) People with type 1 and type 2 diabetes.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Search strategies, inclusion criteria and grading of evidence.

Table S1. Detailed characteristics of studies that are included in the current review

Table S2. Characteristics and quantitative synthesis of meta-analyses for diabetes using distal technology. All data presented have been recalculated.

Table S3. Evaluation of small study effects and excess significance bias.

Table S4. AMSTAR2 ratings for studies included in the current review.

Table S5. Details of GRADE classification.

Commented [MD5]: TYPESETTER: FIGURE 3

CORRECTIONS: Please change:

'HbA1c' to 'HbA_{1c}'

'Body mass index' to 'BMI'

'High-density lipoprotein' to 'HDL cholesterol'

'Low-density lipoprotein' to 'LDL cholesterol'

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