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DIABETIC Medicine

REVIEW

Developments in the design and delivery of self-management support for children and young people with diabetes: A narrative synthesis of systematic reviews

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Abstract

Aims: Facilitated self-management support programmes have become central to the treatment of chronic diseases including diabetes. For many children and young people with diabetes (CYPD), the impact on glycated haemoglobin (HbA_{1c}) and a range of self-management behaviours promised by these programmes remain unrealised. This warrants an appraisal of current thinking and the existing evidence to guide the development of programmes better targeted at this age group.

Methods: Create a narrative review of systematic reviews produced in the last 3 years that have explored the impact on CYPD of the four key elements of self-management support programmes: education, instruction and advice including peer support; psychological counselling via a range of therapies; self-monitoring, including diaries and telemetric devices; and telecare, the technology-enabled follow-up and support by healthcare providers.

Results: Games and gamification appear to offer a promising means of engaging and educating CYPD. Psychological interventions when delivered by trained practitioners, appear to improve HbA_{1c} and quality of life although effect sizes

were small. Technology-enabled interactive diaries can increase the frequency of self-monitoring and reduce levels of HbA_{1c}. Telecare provided synchronously via telephone produced significant improvements in HbA_{1c}.

Conclusions: The cost-effective flexibility of increasing the reliance on technology is an attractive proposition; however, there are resource implications for digital connectivity in underserved populations. The need remains to improve the understanding of which elements of each component are most effective in a particular context, and how to optimise the influence and input of families, caregivers and peers.

KEYWORDS

children and young people, glycaemic control, self-management behaviours, self-management support, type 1 diabetes, type 2 diabetes

1 | INTRODUCTION

Supported self-management has become central to the treatment of chronic disease with evidence of improved treatment adherence, healthcare utilisation and clinical outcomes in a range of conditions.[1,2] Commonly defined as the ability to manage symptoms, treatments, lifestyle changes and psychosocial consequences of health conditions,[3] individuals are equipped to fulfil the various processes and tasks these entail through a range of facilitated self-management support programmes (SSP).[4] Enabled by combinations of healthcare providers (HCPs), educators and peers, they are designed to increase disease knowledge, improve self-efficacy and develop the technical skills necessary to respond to symptoms and the progression of their condition by treatment adjustment. In meeting these objectives, programmes of self-management support share four key components: (1) Education, instruction and advice that includes the use of peer support; (2) Psychological counselling involving the delivery of a range of therapies; (3) Self-monitoring, which can include diaries and telemetric devices and (4) Telecare, the technology-enabled follow-up and support by HCPs that is increasingly delivered by digital communication platforms.[1] The most successful of these programmes tend to incorporate a combination of these components, tailored to the needs and circumstances of specific patient groups.[5]

The deployment of SSPs has been shown to elicit a range of favourable outcomes in patients with diabetes including more frequent and accurate monitoring of blood glucose and reductions in glycated haemoglobin (HbA_{1c}).[6] Perhaps surprisingly given recent consensus statements,[7] the evidence of a reduction in hypoglycaemia with SSPs, at least in children living with type 1 diabetes, is sparse and also non-confirmatory.[8,9] However, for children and young people with diabetes (CYPD), particularly those in disadvantaged or underserved populations, these have failed to yield the same benefits as in the rest of the population.[10–12] There are multiple barriers that can account for this which are exacerbated by age, including limited diabetes knowledge and technical skill, less functional health literacy and/or numeracy, dependence on often inadequate community support systems and susceptibility to the influences of family and wider socio-cultural

What is already known?

- There is a need to understand how the four elements central to facilitated self-management i.e., Education, instruction and advice; Psychological counselling; Self-monitoring; and Telecare, can most effectively support children and young people with diabetes.

What this study has found?

- Gaming techniques and family focussed interventions offer a promising means of improving self-management.
- Technology has a growing role to play in supporting personalised programmes, but face-to-face contact with appropriately trained care providers is of continued importance.

What are the implications of the review?

- Longer, more consistently designed studies are needed to understand which elements are most effective in a particular context, and how to optimise the influence and input of families, caregivers and peers.

factors.[13,14] It is therefore important that any SSP directed towards CYPD recognises and accommodates these intrinsic and extrinsic influences on their ability to self-manage in its design and delivery.[15]

The 'Diversity in Diabetes' study is for the first time attempting to address this issue by co-designing a self-management intervention programme with, and for CYPD from ethnic minorities or economically disadvantaged communities.[16] To successfully facilitate the co-design process, it is important to first understand the latest developments and opportunities available to support self-management, with a focus on CYPD, a process complicated by the huge increase in the literature on self-management in diabetes witnessed over the past decade.[5] Therefore, to gain some clarity regarding the latest evidence of what is working in the delivery of SSP in CYPD we have identified and collated the evidence described by the most recent systematic reviews on the subject within each of the four key components. We then discuss their findings within the context of our wider understanding of self-management support for people living with diabetes of all ages and reflect on the implications for the development and delivery of future programmes.

2 | METHODS

2.1 | Study design

The work consists of a narrative review of systematic reviews.[17] This involves a comprehensive search of current literature with the aim of determining what knowledge and ideas have been established in the design and implementation of interventions intended to support self-management in CYPD, reporting their impact on key diabetes-related outcomes, and the implications for the design of the next generation of self-management programmes. We chose a three-year timeframe based on the assumption that some 50% of systematic reviews are considered out of date once older than 5 years.[18] Study eligibility criteria were established using the Population, Intervention, Comparison, Outcome and Study design (PICO) framework[17] (see Table 1), we followed best practice in conducting reviews of reviews[19] and reported our findings in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[20]

2.2 | Search methods

The literature was searched from 2019 onwards using the following electronic medical databases: The Cochrane Library, MEDLINE, PubMed, CINAHL and EPPI. The

TABLE 1 Summary of study eligibility

Type of study	Population or problem	Intervention or exposure	Comparison	Outcome
Systematic reviews including systematic reviews of reviews and systematic scoping reviews. Primary research can draw on a range of methodologies including but not limited to RCTs, qualitative studies and mixed methods	Children and young people with diabetes (aged between 2 and 24)	Programmes designed to support self-management explicitly relating to Diabetes education, instruction or advice including peer support; psychological counselling; self-monitoring; telecare	Routine care (including unsupported self-management)	Glycaemic control measured by HbA_{1c}, and a range of self-management behaviours, and psychological outcomes

inclusion criteria for our review comprised; systematic reviews, systematic reviews of reviews or systematic scoping reviews peer-reviewed and published in English between January 2019 and January 2022. The search terms were self-management interventions explicitly described within four areas: Diabetes education, instruction or advice including peer support; Psychological counselling; Self-monitoring; and Telecare (as defined in Table 2). Exclusion criteria include a lack of stipulation or description of the age range, not being published in English or prior to 2019. See File S1 for the full search terms.

2.3 | Quality appraisal

Quality of included systematic reviews was assessed using A Measurement Tool to Assess systematic Reviews (AMSTAR2) that assesses the quality of the review within 10 domains, described by 16 items (S1).

2.4 | Data extraction and synthesis

IL and SG reviewed the text of the identified reviews and categorised them within the four intervention typologies. The following data items were extracted (i) Intervention type (ii) author and publication date (iii) number of studies included in review and the date range of the search (iv) target population (age range/condition), i.e., type 1 or type 2 diabetes (v) quality score (vi) summary of effect. A primarily narrative approach consistent with the recommended analytical method for narrative synthesis[21] was used to summarise the nature of the interventions included in each review, the results of any meta-analyses and/or more broadly the direction of effect of the interventions within the four types of self-management support. The criteria for selecting the data we reported were based on their relevance to the design and delivery of future programmes for CYPD.

3 | RESULTS

A total of 125 studies were identified and of these, 13 were included in the review. The PRISMA Flow Diagram is shown in Figure 1. The reasons for reviews being excluded were the lack of a precise description of age range (for example the use of mean age with no upper or lower limit), if the reviews identified were not systematic, or they were not available in English. The characteristics of the reviews included are summarised in Table 3. The references for the identified reviews and the individual studies cited can be found in File S2 (S1-S58).

TABLE 2 Definition of self-management component and modes of delivery

Type of intervention	Definition	Mode of delivery
Diabetes Self-management Education, advice and/or instruction (DSME) (including peer support)	Structured, sequenced educational information and behavioural counselling designed to facilitate the knowledge, skills and ability necessary for diabetes self-care	Led by trained educators, counsellors, HCPs or peers and delivered in person to groups or one-to-one in person or via a range of digital platforms. Includes articles, videos, taught components and the application of gaming mechanisms
Psychological counselling	Activities used to modify the behaviour, emotional state or feelings of an individual can include counselling, cognitive behavioural therapy, interpersonal therapy or neuro-emotional techniques	
Self-monitoring	The routine recording of relevant and/or pre-defined information by an individual including a range of physiological variables such as levels of activity, heart rate and blood glucose. These data are used often to set goals and targets and are analysed and adjusted over time	Data can be recorded manually often close to the event and for various lengths of time or via a range of wearable electronic technologies often in conjunction with hand-held devices such as smartphones
Telecare	Health-specific and responsive feedback and support often delivered by HCPS and involving technology-enabled, remote communication and remote monitoring of patients	Can be delivered synchronously or asynchronously via telephone or a range of digital platforms, using elements such as tailored SMS. The remote-monitoring component uses a range of information technology to gather data at a distance

3.1 | Education, advice and/or instruction

We found a total of five reviews that explored the impacts of DSME delivered by a range of methods and educators with a variety of outcomes that included glycaemic control, treatment adherence, physiological measures of disease, risk behaviours and disease knowledge.

3.1.1 | HbA_{1c} control

Nkhoma et al., explored DSME delivered via a range of digitally enabled technologies and pooled results from adults and children (S5). They reported positive impacts on HbA_{1c} though these were smaller in type 1 diabetes than in type 2 diabetes populations. They also noted that as the mean study age increased, the reduction in HbA_{1c} grew smaller (S5). It was also noted that though mobile applications and patient portals had a better impact on glycaemic control than any other single approach, those interventions that used a combination of tools were most effective (S5).

Rohilla et al.'s systematic review of reviews concluded that it was difficult to determine the benefits of DSME on HbA_{1c} due to the broad heterogeneity of interventions and study designs (S6). Two reviews included meta-analyses of RCTs to determine the effects of games and gaming mechanisms on HbA_{1c} with mixed results (S3, S4). Martos and Cabrera found no significant mean effect, the Standardised Mean Difference (SMD) in the percentage of HbA_{1c} was −0.12 (95% confidence interval −0.57, 0.33) (S3). However, Shiau et al did find a small but significant impact on HbA_{1c} control (SMD HbA_{1c} = 0.18, $p = 0.02$) (S4).

3.1.2 | Other outcomes

Nkhoma et al suggested that digital DSME emphasis on lifestyle modifications favoured type 2 diabetes which tended to be diagnosed later in life (S5). Rohilla et al were unable to draw more certain conclusions about the impact of digital technologies on behavioural outcomes and called for more structured long-term assessment of both clinical and behavioural outcomes, using qualitative and quantitative methods to develop and refine DSME for children with type 1 diabetes (S6).

Shiau et al's review noted the potential effectiveness of "exergames" that used mobile devices among individuals with type 2 diabetes. These exergames require the user to move their body in order to progress through a game or programme, creating a physically interactive platform (S15) that resulted in a significant increase in physical activity ($g = 0.59$, $p < 0.001$) (S4).

Lau's review explored the growing use of humanoid robot-assisted interventions although the studies identified were predominantly related to the development, usability, feasibility and acceptability of interventions (S2). Two small-scale randomized controlled trials (RCTs) were found in the existing evidence (S16, S17), indicating benefits to self-management behaviours in children with type 1 diabetes (S2). The two reviews that explored DSME delivered using gaming mechanisms described benefits for children in the accrual of diabetes-based knowledge (S3, S4).

3.2 | Psychological counselling

We found five reviews that collated evidence of the impact of psychological counselling on CYPD. The therapies utilised included; cognitive behavioural therapy (CBT), which seeks to break negative patterns of thoughts and feelings by regularly utilising practical methods of improving mood (S18); family therapy, which seeks to nurture positive behaviours in families by considering them a product of the interactions between members (S19); Multi-systemic therapy (MST), an intensive family and community-based intervention designed predominantly to address anti-social behaviours (S20), and coping skills training (CST) providing education on the utilisation of coping mechanisms (S21).

3.2.1 | HbA_{1c}

Winkley et al's review explored a range of psychological interventions in pre-teens including CBT, and family therapy, concluding there was no significant effects on HbA_{1c} in children with type 1 diabetes or type 2 diabetes (SMD −0.09, 95% CI −0.22 to 0.04) (S13). There were limitations: only 2 of the 11 interventions assessed were conducted outside of the United States, and despite the known effect of socioeconomic status on diabetes morbidity (S22, S23), it was only measured in one study (which showed no significant impact on HbA_{1c}) (S24). Treatment fidelity (i.e. the reliability/consistency of the delivery of a particular therapy) was not reported in any of the included studies despite its influence on the 'dose' of psychological treatment received (S25). Interestingly, despite clinical guidelines suggesting time of diagnosis as a critical period in offering psychological support (S26), only one (feasibility) study specifically targeted children/adolescents at this point and found they could be engaged (S27).

The review Aljawarneh et al exploring psychological interventions in adolescents with type 1 diabetes (S7),

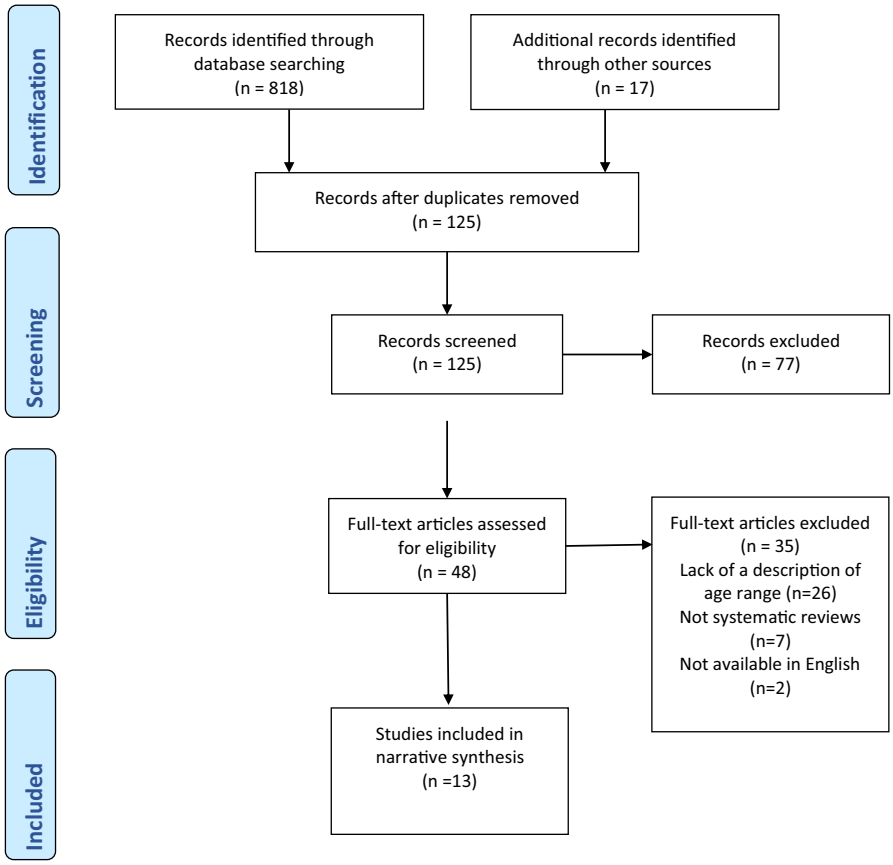

FIGURE 1 PRISMA diagram

found those that used coping skills training (CST, providing education on the utilisation of coping mechanisms [S21]) and CBT appeared to be the most beneficial for improving metabolic control (S28–S30).

Resureccion et al. conducted a review of psychological interventions, delivered by a psychology professional to children, adolescents and adults with type 1 diabetes (S9). They identified three studies conducted with adolescents, one of which showed significant benefits in improving HbA_{1c} (S31).

3.2.2 | Other outcomes

Aljawarneh et al's review (S7) found that the studies that had used the principles of CBT (S27-S30) or MST (S32-S35) had most effect on adherence. Resureccion et al found that MST proved useful in reducing diabetes distress (S34) and that those interventions with a focus on emotional components were most effective in improving psychological adjustment in adolescents with type 1 diabetes (S9). A meta-analysis exploring the impact of psychoeducational interventions on quality of life (QoL) (S8) for children with a range of chronic conditions, included seven studies that focussed on diabetes, though there was a non-significant effect (SMD = 0.00, 95% CI: −0.12 to 0.13). (S36-S42). The authors noted that these interventions were more effective in younger children with diabetes than adolescents (S8).

3.3 | Self-monitoring

The support for self-monitoring delivered as usual care was supplemented with a variety of technology-based media such as mobile phone apps, text messages from care providers or otherwise automated, websites and activity monitors.

3.3.1 | HbA_{1c}

The review by Knox et al. exploring the effects of technological interventions on self-monitoring behaviours in children and adults, which identified 15 studies conducted with children and adolescents (with type 1 diabetes and type 2 diabetes aged between 2 and 18 [S12]). Of these were nine RCT's only two of which reported a significant effect (9.2 ±2.2%, 95% CI −1.9, −0.5, $p < 0.001$) (S43), HbA_{1c} (%), median (range) 9.2 (7.4–12.6) (at 6 months) ($p < 0.05$) (S46).

A meta-analysis of standalone smartphone applications (i.e., those not involving feedback from any third parties) in self-monitoring for type 1 diabetes conducted by Sun et al. (S13) found three studies based in youth and

adolescent populations (S45–S47). Two studies reported significant reductions in HbA_{1c} (8.63 ± 1.07%) (S48) had a decrease of 0.6 percentage points in mean HbA_{1c} ($p < 0.001$) (S49). The authors of the review suggested that these mobile apps were effective because they logged parameters relevant to diabetes management, provided graphic analysis and set reminders (S13).

3.3.2 | Other outcomes

The Knox et al review (S12) found that overall technology-based health interventions exerted a positive if minor influence on self-monitoring of blood glucose (as a behavioural outcome). They concluded that although technology-based interventions appeared to have some merit for promoting self-monitoring behaviours (in-line with the guideline objectives for the management of type 1 diabetes in children and young people), the need to ascertain which elements of interventions are most effective remains (S12). The review by Sun et al (S13) also identified two papers that significantly improved self-monitoring behaviours (S47, S48).

3.4 | Telecare

The telecare described in the original research includes communication facilitated by a range of digital platforms and smart-phone apps that connected the patient to a HCP.

3.4.1 | HbA_{1c}

Sun et al's review of telecare interventions (S13) found one study which reported that using mobile apps with SMS feedback (as part of interactive diaries) found a non-significant improvement in HbA_{1c} (SMD = −0.13; 95% CI [−0.33, 0.06]) (S50). This work by Ryan et al. studied the use of the Intelligent Diabetes Management app, in which participants recorded their glucose readings, their anticipated carbohydrate intakes and their planned physical activities (S50). The app used individualized insulin dosing parameters to suggest an insulin dose for the proposed food intake. HCPs then monitored blood glucose records and sent feedback to the participants (S50).

Froisland et al.'s study conducted amongst adolescents in Norway used the Diamob app, which involved patients taking pictures of meals and then entering the carbohydrate contents and insulin boluses. This reported no differences in HbA_{1c} but patients preferred the increased access to their healthcare team via the text messaging element, feeling more secure as a result (S51).

Zhao et al's review that explored the impact of Internet and phone-based diabetes self-management support in children and adolescents with type 1 diabetes (S14) found that those interventions that included phone calls significantly improved HbA_{1c} (MD = −0.17; 95% CI [−0.33, −0.01]). However, this was not the case for those interventions using group messaging (MD = −0.07; 95% CI [0.45, 0.31]; three studies pooled), mobile apps (MD = −0.21; 95% CI [−0.68, 0.27]; three studies pooled) or webpages group (MD = 0.02; 95% CI [−0.42, 0.46]; five studies pooled).

3.4.2 | Other outcomes

Sun's review identified two studies that showed improvements in fasting and postprandial glucose levels, and decreased incidence of severe hypoglycaemia in children (S52, S53). These two studies used the Diabetes Interactive Diary app which can transmit data to healthcare teams and communicate between patients and their healthcare teams via text messaging (S52, S53).

Zhao et al. (S14) reported that those interventions that relied on modern technologies such as smart apps showed a significant improvement in self-efficacy (SMD = 0.37; 95% CI [0.07, 0.67]; $I^2 = 0\%$) (S45, S54, S55). However, there was a lack of consistency in the interventions targeted at children and adolescents with modes of delivery including text messaging (S56), mobile phone applications (S46), teleconferencing (S57), mobile apps (S47) and websites (S58).

4 | DISCUSSION

4.1 | Summary of findings

Structuring the findings within the four key components of SSP has provided a useful overview of the developments within each and offers insight for the development of more holistic, multi-component support programmes. The successful delivery of DSME is considered central to many SSP programmes for adults and there is promising evidence of its effectiveness for CYPD, although the persistent heterogeneity in design and delivery of the DSME interventions reviewed precludes a more precise understanding of which particular elements prove most effective. Nevertheless, games and gamification appear to offer a promising means of engaging and educating CYPD.

Psychological interventions when delivered by trained practitioners, in particular CBT and MST, seems

TABLE 3 Summary of included systematic reviews

Domain	Authors	Intervention	Date of search (Number of studies and study design)	Target Population (age range) Condition (Number of participants)
Education, advice and/or instruction (DSME) including behaviour change and peer support	Lau et al. 2020 (S2)	Humanoid robot-assisted interventions	May 1989 to February 2020 ($n = 22$; 2 experimental, 9 nonexperimental, 3 qualitative, 1 mixed method, 7 developmental and acceptability studies)	Children (5–14) Type 1 and type 2 (not reported)
	Martos-cabrera 2020 (S3)	Games and Health Education	Up to July 2020 ($n = 10$; 7 RCTs, 1 cohort, 1 case–control, 1 qualitative study)	Children and adults (8–65) Type 1 and type 2 (1406)
	Shiau et al. (S4)	Game-based self-management interventions	Up to January 2020 ($n = 13$ RCTs)	Children and adults (>8) Type 1 and type 2 (1195)
	Nkhoma et al. 2021 (S5)	Digitally enabled DSME	January 2010 to August 2019 ($n = 35$ RCTs)	Children and adults (13–70) Type 1 and type 2 (6861)
	Rohilla et al 2021 (S6)	DSME for children and young adults	January 2010 to May 2020 ($n = 8$ reviews; original research consisted of 140 RCTs, 13 pre-post design and 6 non-RCTs)	Children and adults (<25) Type 1 (not reported)
Psychological counselling	Aljawarneh et al (2020) (S7)	Psychological interventions for adherence, metabolic control and stress	January 1990 March 2019 ($n = 24$; 20 RCTs, 2 quasi-experimental, 2 multiple baseline design)	Children and young adults (9–21) Type 1 (2559)
	Day et al. 2020 (S8)	Psychoeducation	January 1980 August 2018 ($n = 7$ RCTs)	Children and adolescents (7–18) Type 1 and type 2 (not reported)
	Resurrecion et al 2021 (S9)	Psychotherapeutic interventions on adjustment in T1DM	Up to December 2020 ($n = 8$; 7 RCTs, 1 Non-RCT)	Adolescents (10–19) T1DM (935)
	Velasco et al. 2020 (S10)	Psychosocial interventions	January 1995 to December 2019 ($n = 12$; 11 RCTs, 1 Cluster trial)	Children (7–13) Type 1 (1659)
	Winkley et al 2020 (S11)	Psychological interventions	January 2003 to June 2018 ($n = 23$ RCTs)	Children and adolescents (5–19) Type 1 (2567)
Self-monitoring	Knox et al 2019 (S12)	Intervention is primarily delivered through a technology-based medium (e.g. mobile phone, website, activity monitor)	Up to April 2017 ($n = 30$; 21 RCTs, 3 non-RCT, 6 cohort)	Children and adolescents (2–18) Type 1 (2459)
	Sun et al (2020) (S13)	Standalone apps used in self-monitoring	Up to February 2018 ($n = 9$; 5 pre/post, 2 RCTS, 1 cohort)	Children and adolescents (10–18) Type 1 (553)

AMSTAR quality assessment (S1) (Risk of Bias)	Primary outcomes	Effect size	Direction of effect/comments
Low (N/A)	Multiple self-management-related outcomes	N/A	Positive effects were observed but many of the identified studies had methodological issues
Low (Not reported)	Control of HbA_{1c}	SMD in the percentage of HbA_{1c} was −0.12 (95% confidence interval −0.57, 0.33)	Beneficial for diabetes education and promote adherence to healthy lifestyle habits. However only a limited effect on HbA_{1c}
High (Low risk of bias)	HbA_{1c}, Physical activity	SMD HbA_{1c} = 0.18, $p = 0.02$), Adherence to physical activities ($g = 0.59$, $p < 0.001$)	Despite significant benefits to HbA_{1c} and physical activity there needs to be more consistent study design and larger scale studies
Moderate (RoB via multiple tools)	HbA_{1c}	HbA_{1c} 6 months of follow-up (T1 T2 all interventions) 0.480 (0.09) (−0.66, −0.29) $p = 0.00$	Digital DSME can improve HbA1c and disease knowledge, particularly in T2DM
Low (N/A)	Clinical outcomes, self-management behaviours, psychosocial outcomes	N/A	The heterogeneity of the interventions and results meant that no patterns emerged as to the benefits of any particular element
Low (No RoB)	HbA_{1c}, Medication adherence, diabetes stress	N/A	Medication adherence benefitted from CBT, and CST appeared to improve HbA_{1c}
High (RoB multiple tools)	Quality of life	SMD = 0.00, 95% CI: −0.12 to 0.13)	The small but significant effect in QoL was more prominent in children under 12
Moderate (RoB multiple tools)	HbA_{1c} and quality of life	N/A	Quality of life improved where interventions were delivered by trained psychologists, evidence of benefit to HbA1c unclear
Low (RoB-Cochrane tool)	HbA_{1c} and self-management behaviours	N/A	Effect sizes small and non-significant
High (RoB-multiple methods)	HbA^{1c}	HbA_{1c} (SMD −0.09, 95% CI −0.22 to 0.04)	Interventions included counselling, CBT and family therapies. There was no significant effect on HbA_{1c}
Low (RoB Cochrane collaboration tool)	Self-monitoring of blood glucose, HbA_{1c} and/or psychological or cognitive outcomes	N/A	There appeared positive effects on self-monitoring, which in some cases led to improvements in HbA_{1c} and/or psychological diabetes self-management outcomes
Moderate (RoB two Cochrane tools)	Impact on HbA1c levels Self-management behaviours	N/A	Frequency of daily blood glucose checks increased and HbA_{1c} decreased

TABLE 3 (Continued)

Domain	Authors	Intervention	Date of search (Number of studies and study design)	Target Population (age range) Condition (Number of participants)
Telecare	Sun et al (2020) (S13)	Smartphone apps plus SMS feedback	Up to February 2018 ($n = 1$; pre/post)	Children and adolescents (13–19) Type 1 (270)
	Zhao et al 2021 (S14)	Internet and Phone-Based	1989 to March 2020 ($n = 23$ RCTs)	Children and adolescents (<20) Type 1 (1824)

to improve HbA_{1c} and quality of life in CYPD although effect sizes were small. With regards to self-monitoring, technology-enabled "interactive diaries" appear to both improve self-monitoring behaviours, (i.e., increase the frequency of monitoring) alongside reducing levels of HbA_{1c}. Linking this independently recorded data either automatically or manually to HCPs thus enabling feedback (defined within this review as Telecare) also seemed to produce a positive effect in self-management outcomes. In particular, when this feedback was provided synchronously by telephone, significant improvements in HbA_{1c} were described, although such a resource-intensive initiative would have significant implications for health service organisations.

The cost-effective flexibility of technology-enabled SSPs is an attractive proposition and a greater reliance on technology in the long-term is almost inevitable. However, few original studies have so far considered the change in work practices and the resources that would be required for these interventions to become sustainably embedded in care pathways. Perhaps more pertinent in the near future is addressing the discrepancies that persist across geographies and between communities in the ability to access and utilise digital technologies; until this has happened for many CYPD their viability remains in question.[22]

4.2 | Strengths and limitations

This work has highlighted current thinking on self-management interventions for CYPD, described within the key components of a comprehensive SSP. We acknowledge it shares limitations common to any 'cross-sectional' method of surveying a field by being time bound and we have taken care to place these reviews in the context of existing knowledge to avoid distorting any conclusions. Although the reviews were published in the last 3 years the research they cite extends as far back as 2010. Similarly, we have used a narrative description of the 'direction of effect' in line with recommended practice for describing the results of reviews with a combination of methods and provenance.[23]

There is a degree of overlap in how self-management support is studied and reported. Recently, the focus is on mode of delivery and selecting four of the most common and important components of SSP has led to instances where single reviews have contributed evidence to more than one of these components (S12, S13). Aligning the data as we have done is far closer to the reality of the multicomponential design of SSP, and has offered the opportunity for comparing learning in terms of each component, whilst also informing more comprehensive designs of SSP.

4.3 | Specific findings

Below the findings are placed in the context of existing evidence of their impact on self-management in the broader population alongside considerations of the implications for future self-management programmes.

4.4 | Diabetes self-management education and advice

Although the capability of DSME to improve a range of self-management outcomes for patients of all ages is widely recognised,[24] previous systematic reviews exploring the impact of DSME on glycaemic management amongst CYPD have described inconsistent effects.[25,26] However, we found encouraging signs of more consistent benefits, and particularly promising appears to be the use of gaming mechanisms and methodologies (S5, S6).

Playing has been recognised as one of the most effective means of communicating knowledge for young people with chronic disease, particularly for those with lower levels of health literacy.[27] The use of games and gaming mechanisms in CYPD resulted in improvement in HbA_{1c} and disease knowledge of varying degree (S3, S4). This corresponds to previous findings that games offer a risk-free environment for CYPD, in which to explore food consumption and insulin

AMSTAR quality assessment (S1) (Risk of Bias)	Primary outcomes	Effect size	Direction of effect/comments
Moderate (RoB two Cochrane tools)	Impact on HbA1c levels Self-management behaviours	SMD = −0.13; 95% CI (−0.33, 0.06)	There was a high variability in the number of text messages exchanged during the various studies. The reasons for which were not fully explored
Moderate (RoB-multiple tools)	HbA1c, self-management behaviour changes, and psychological effects	HbA1c, SMD = −0.17; 95% CI (−0.33, −0.01); Self-efficacy (SMD = 0.37; 95% CI (0.07, 0.67); I^2 = 0%)	No significant benefits for behaviour change or quality of life were observed and additional RCTS of longer duration were recommended by the authors

production, and to engage recently diagnosed CYPD with new routines, and diabetes-related education.[28,29] These game-based interventions appear particularly effective when children are involved in their co-design.[30] Another technology-enabled if esoteric attempt to engage CYPD in DSME, is the use of humanoid robots, successfully used in teaching and social care[31] they have been co-opted to support DSME and overall diabetes management, again with some success (S2). It is widely understood that combining traditional educational elements with tailored digital tools can be more effective at reaching underserved populations.[32] In this context, technology-enabled DSME offers a promising means of reaching and engaging CYPD and although acceptance levels are high and they appear effective, barriers to access, cost and maintenance persist (S1, S3, S6).

The heterogeneity of the interventions meant that the recognised difficulty in identifying key components or recommendations for future DSMEs are set to continue for CYPD.[7] Other gaps in our knowledge and evidence base remain: there is the need for a better understanding of how DSME for CYPD can incorporate peer-led interventions that have benefitted adult populations,[33] particularly now that peers can be more effectively linked by digital tools.[34] Methods successfully used to reach adult populations with lower literacy such as teach-back (a way of monitoring understanding by asking patients to describe what they have been taught in their own words), or group discussion are yet to be properly explored in CYPD[35] and the need remains for a better understanding of how the widely acknowledged contextual influence of families, caregivers and social and cultural circumstance affected outcomes.[13,14] The extent to which information on new diabetes technologies such as insulin pumps, or continuous glucose monitoring was contained or presented within existing DSME interventions was also not clear.[36]

4.5 | Psychological

The pronounced psychological impact of diabetes across all age groups means that addressing factors such as depression, anxiety or diabetes distress are recognised as an integral element of successful self-management.[37] Despite its distribution across all age groups, the sources of diabetes distress and other common psychological concerns vary considerably between adults and CYPD.[38] However, the development of the most common psychological interventions such as CBT or motivational interviewing have been conducted largely in adult populations.[39]

Despite this focus on adults, evidence is now emerging of improvements in self-management behaviours and quality of life in CYPD resulting from interventions that included CBT, CST and MST (S7, S8, S9, S10, S11). The apparent efficacy of motivational interviewing in improving treatment adherence and glycaemic control in CYPD has led to its inclusion in recent consensus guidelines from the American Diabetes Association for diabetes education in children and adolescents.[7]

Because psychological interventions are often complex and form part of a broader self-management intervention programme, more work is needed to fully understand which concepts and modes of delivery work best with CYPD.[40] Consideration needs to be given to whether the integration of psychotherapeutic techniques such as motivational interviewing, cognitive behavioural elements or coaching into DSME might be helpful in increasing the programme's efficacy. It must also be noted that interventions delivered by trained psychologists appear to have the greatest effect in CYPD.[41]

It has been recommended previously that psychological interventions for CYPD are implemented during adolescence,[14] though they must be sensitive to the different coping styles of adolescents with diabetes and their fluctuation over time.[42] Of interest for any future psychological interventions is that those delivered to younger children appeared to be more effective in terms of improving quality of life (QoL), though this might be because QoL is often more impaired in adolescents than younger children, as witnessed in other chronic conditions (S8).

Evidence suggests that using trained psychologists (as opposed to peers, educators or HCPs without similar qualifications) to deliver psychological or psychosocial

interventions improves a range of self-management behaviours and outcomes (S11). Previous studies exploring various psychological interventions in a range of chronic diseases found that physicians, nurses and other health professionals lack the training and skills to deliver behavioural-based treatments and produce no demonstrable improvements in patient-based outcomes.[43]

The growing understanding of the psychological impact on parents and caregivers of diabetes (S14) and the success of a range of psychological interventions such as CBT and MST, for parents of children and adolescents with chronic illness, including diabetes, has led to an improvement in parenting behaviour.[44] There is growing evidence that future psychological counselling needs to include and be tailored to the families of carers of CYPD and include a greater focus on approaches which provide the coping skills and motivation necessary to improve diabetes knowledge and self-management-related behaviours for the whole family.[45]

4.6 | Self-monitoring

The consensus of the reviews we identified was that technology-enabled self-monitoring improved self-management outcomes in CYPD (S12, S13). Similar benefits have been observed in adult populations both in terms of self-monitoring behaviours, where it increased the frequency of daily blood glucose checks (S49) and clinically where it has led to significantly improved HbA_{1c} levels.[46]

Despite the apparent benefits of continuous glucose monitoring, barriers to its use remain, particularly amongst young children where the pressure created by the quantity and independent interpretation of the data can reduce engagement of the patient and their families or carers.[47] Support is needed if these issues are to be overcome and one of the individual studies identified by Sun's review (S13) reflected on the benefits of using visualisation within the monitoring interface (S52). It has been recognised previously that images can improve comprehension and recall of health information and improve treatment adherence, particularly where the pictures and visual cues were culturally relevant and designed by the patients themselves.[48]

Again, there were issues with the consistency of the findings and gaps in the evidence remain. For example, it was notable that the interventions described in the original studies were pursuing a variety of monitoring regimes in terms of timing, frequency and duration, reflective of variation in much of current practice.[49] No studies compared stand-alone mobile apps against mobile apps with text-messaging systems (what this review would class as Telecare). Comparing these different types of mobile apps would help to determine whether the extra resources associated with the text-messaging component improve outcomes (S13). It is also worth noting that none of the studies explicitly explored wearable devices, though a recent systematic review suggests they offer a promising opportunity to support self-management in diabetes.[50]

4.7 | Telecare

Recent figures suggest that more than 80% of adolescents and young adults are online worldwide and the variety of telecommunication and digital platforms offer multiple opportunities to link those providing, supporting and receiving, care with CYPD.[7] Previous systematic reviews have described the effectiveness of short message service (SMS), and computer and web-based interventions for adults.[51] However, the reviews we identified failed to describe similar benefits of telecare for CYPD unless used alongside follow-up telephone calls (S14). The lack of demonstrable evidence echoes previous systematic reviews that found no significant effects of telemedicine on HbA_{1c}, or severe hypoglycaemia in children and adolescents (S57).[52]

There is growing interest in using smartphone technology for self-management of diabetes via apps that are abundant, cheap, capable of monitoring a range of health-related parameters and facilitating feedback from any location. Not only do they offer a promising way of decreasing HbA_{1c}, but also improving lifestyle factors.[53] Though their use has tended to focus on type 2 diabetes which is mostly an adult disease, this is now shifting to exploring their use with CYPD.[54] It is worth noting that their multiple and varied interacting components that include their content, display and degree of interactivity, are vulnerable to a range of contextual influences such as digital connectivity and that previous systematic reviews have described uncertainty in the clinical effectiveness of smartphone apps across all age groups.[55]

In attempts to improve adherence and achieve a more consistent effect on reducing HbA_{1c}, there have been calls for app design to incorporate behaviour change theories and gaming mechanisms alongside feedback from HCPs or automated systems.[46] Whatever the specifics of the design and context, there is a clear need for a more systematic approach to introducing and exploring the efficacy of smartphone apps to optimize outcomes in specific populations and determine the resources necessary for the systems that provide the feedback essential for their success (S13).

5 | CONCLUSIONS

It is understood that CYPD incorporate individuals with a broad range of cognitive abilities, requirements and

preferences, with needs that change over time and more rapidly than other age groups. The evidence collated here within the four key components of SSP provides a holistic understanding of the current evidence of various self-management interventions. In doing so it makes a valuable contribution to the design of more comprehensive SSP that targets CYPD. Despite a growing evidence base, the need remains for larger, longer and more consistently designed studies to facilitate understanding of which elements of each component are most effective in a particular context, and how to optimise the influence and input of families, caregivers and peers. The importance of being able to tailor various components of self-management support to the preferences and requirements of individuals is increasingly recognised. Technology undoubtedly has a clear role to play in supporting such personalised programmes, but it is not a panacea, and the continuing importance of face-to-face contact with appropriately trained care providers should not be underestimated. One way in which future self-management support programmes can retain the appropriate level of flexibility and maintain the balance of in-person and digital support is through co-design. To this end the next phase of the "Diversity in Diabetes" study will be developing self-management support directly with CYPD and their families from underserved communities where they will be implemented, accommodating the preferences and needs of these populations, and addressing the barriers that have previously prevented their successful implementation.

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CONFLICT OF INTEREST

None reported.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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