

## Reviews and Meta-Analysis

# School-based diabetes interventions and their outcomes: a systematic literature review

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### Significance for public health

Diabetes is one of the most common chronic childhood diseases; both type 1 and type 2 diabetes are increasing in children globally. Against this backdrop, the school is a critical environment for children with diabetes. This systematic literature review on school-based diabetes interventions and their outcomes demonstrates that increasing efforts are being made to improve diabetes care and create a safe school environment. Studies reported gains in knowledge and confidence of school staff, as well as improved health and quality of life of students. Given the disparity of the assessment tools used, it was not possible to determine optimal ways to improve the health, quality of life and academic performance of children with diabetes. Future evaluations should include experimental designs, longer follow-up studies, and larger sample sizes. School-based diabetes interventions and solid evaluations will contribute to improving diabetes school policies and ensuring children with diabetes have the same educational opportunities as other children.

### Abstract

Type 1 diabetes is one of the most common chronic childhood diseases, while type 2 diabetes in children is increasing at alarming rates globally. Against this backdrop, the school is a critical environment for children with diabetes. They continue to face barriers to education that may lead to depression, poor academic performance, and poor quality of life. To address these challenges, diabetes interventions have been implemented in school and the goal was to systematically review these interventions and their outcomes between 2000 and 2013. Fifteen studies were included in the narrative synthesis. Education of school personnel was the main focus before 2006. Studies reported gains in knowledge and perceived confidence of school staff. Since 2006, more comprehensive interventions have been developed to promote better care coordination and create a safe school environment. These studies reported improved diabetes management and quality of life of students. Assessment tools varied and study design included randomized controlled trials, quantitative and qualitative methods. Although many of the studies reported a significant difference in the parameters measured, it was not possible to determine optimal ways to improve the health, quality of life and academic performance of children with diabetes, given the disparity in scope, assessment tools and measured outcomes. Experimental designs, longer follow-up studies, larger sample sizes, and a higher number of participating schools are critical issues to consider in future studies. Most of the research was conducted in North America and further research is needed in other parts of the world.

### Introduction

Type 1 diabetes is one of the most common chronic childhood diseases, affecting an estimated 497,100 children under 15 years globally.<sup>1</sup> The incidence of type 1 diabetes among children is increasing in many countries, and more than 79,000 children under 15 years are estimated to develop type 1 diabetes annually worldwide.<sup>1-3</sup> Young people today also face another danger that threatens their ability to attain a healthy and successful future as evidence shows that type 2 diabetes is increasing in children and adolescents around the world at alarming rates.<sup>1,4-10</sup> With rising levels of childhood obesity and physical inactivity in many countries, type 2 diabetes in childhood has the potential to become a global public health issue leading to serious health outcomes and a significant burden on the family and society.

Children with diabetes spend between 6 and 10 hours a day in school and doing school-related activities. Diabetes management requires intensive resources; blood glucose monitoring, insulin administration and the treatment of low blood glucose are essential for children with diabetes during the school day, and the need for assistance varies across age groups. As a result, the school system is a critical environment for children with diabetes.<sup>11-18</sup>

Position statements and guidelines for diabetes in children and adolescents issued by diabetes organizations call for all children with diabetes to have the right to manage their diabetes without being excluded or discriminated against in school, and the right to participate fully and safely in all school activities.<sup>19-21</sup> Resources have been made available to improve the management of diabetes at school.<sup>22-27</sup> However, many school children with diabetes continue to face barriers to education and the effective management of their disease in school. The main obstacles include a lack of informed and trained staff, poor or limited knowledge of, and misconceptions about diabetes, a lack of equipment and communication, the absence of a school nurse on site daily, and a lack of diabetes management policies.<sup>15,17,28-45</sup>

The literature has shown that children with diabetes are still confronted with many challenges and issues in school: they may have a limited ability to monitor and treat blood glucose levels and be at risk of diabetes complications; they may be denied access to school and extracurricular activities; they may face a lack of support or stigma and discrimination; they may hide their condition and feel that they are treated differently in school because of their diabetes. All of these factors are leading to absenteeism, depression, stress, poor academic performance and poor quality of life.<sup>13,15,18,28,35,38,40,41,44-46</sup> School-based diabetes interventions become critical to improve support, increase knowledge and confidence, protect against discrimination, and ensure a safe environment for children with diabetes.

In response to the rising obesity trends in children and adolescents, innovative multi-faceted school-based diabetes prevention programs have been implemented, such as the HEALTHY study,<sup>47</sup> Bienestar school-based diabetes mellitus prevention programmes,<sup>48</sup> the Jump

into Action school-based diabetes prevention programme,<sup>49</sup> the medical education for children/adolescents for realistic prevention of obesity and diabetes intervention study,<sup>50</sup> and the NDKK-funded NEEMA school-based diabetes risk prevention programme.<sup>51</sup> In the past few years, several literature reviews have been conducted to review existing school-based prevention interventions focusing on type 2 diabetes risk factors and promoting healthy lifestyles.<sup>52-58</sup>

Focusing on the impact of school-based diabetes interventions, a systematic literature review, which was conducted in 2002, assessed the effectiveness of diabetes education for school personnel and concluded that the literature was very scant, the methodology was inadequate and results were mixed.<sup>38</sup> The review concluded that further research was needed to define effective diabetes interventions for school personnel. Two additional integrative reviews focused only on type 1 diabetes management in the school setting.<sup>17,45</sup> They identified gaps for effective diabetes management and areas for improvement in communication, education of staff and peers, and school nurse availability.

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## Objectives

It is time again to review the literature about school-based diabetes interventions and their outcomes over the past decade (2000-2013). In the early 2000s, the management of diabetes considerably changed, and ever since, technological advances have grown: children have started to use improved blood glucose meters, insulin pumps that deliver rapid-acting insulin and pen devices.<sup>42,45</sup> In addition, both the UN Resolution on World Diabetes Day in December 2006 and the UN Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases in September 2011 have put diabetes on the global health agenda.<sup>59,60</sup> On the basis of the findings of earlier studies as well as recent policy developments, we have formulated two research questions. The first one is: what school-based diabetes interventions have been implemented since 2000?

According to the literature, the evaluation of health interventions is essential for two main reasons: i) improving programmes; and ii) improving policy.<sup>61,62</sup> Evaluation may help improve programmes and their outcomes by adjusting programme content, identifying the best strategies for increasing participation and adherence, addressing problems and identifying the most effective methods. Evaluation may also help advocate for the programme and mobilize health authorities' support to implement policies and trigger action. This leads to the formulation of the second research question: what were the outcomes of these school-based diabetes interventions?

The present systematic literature review aims to provide a comprehensive overview of school-based diabetes interventions and their outcomes between 2000 and 2013. The ultimate goal is to determine effective school-based interventions to enhance the health, quality of life and academic results of children with diabetes.

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## Search strategy and information sources

Using multiple electronic databases including PubMed, CINAHL, PsychInfo and the Psychology and Behavioral Sciences Collection, we conducted a systematic literature review of articles written in English and published in peer-reviewed journals between 2000 and 2013. The databases were searched using the following key words in titles or abstracts: *diabetes* and *school* and *intervention*, *campaign*, *program*, *project* or *promotion*, as well as the following Medical Subject Headings

(Mesh) terms: *diabetes mellitus* combined with *schools* and *health campaign* or *health education*.

Titles and abstracts of articles extracted by this search were reviewed for relevance and, if potentially relevant, the full-text article was retrieved and reviewed. Only full articles of original studies were considered for final inclusion. We also conducted a manual search by reviewing the reference lists of relevant articles. However, this did not result in additional studies eligible for inclusion.

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## Inclusion criteria

The inclusion criteria for the articles reviewed were the following: i) primary studies; ii) published in English; iii) between 2000 and 2013; iv) a school-based intervention included; and v) intervention focusing on diabetes.

Descriptive studies focusing on the needs of school children with diabetes or identifying the gaps in diabetes care in school were excluded if there had not been an intervention. They were, however, used to provide baseline information in the introduction. Studies focusing on children with diabetes outside the school, such as summer camps or paediatric centres, were also excluded. Studies focusing on type 2 diabetes prevention, with interventions comprised of nutrition and exercise components and evaluation measured by food choices, physical activity or anthropometric characteristics were beyond the scope of this review.

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## Study selection

We followed the PRISMA Statement to conduct the study selection (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).<sup>63</sup> All references were downloaded to RefWorks and duplicates were automatically removed. The first investigator checked all titles and abstracts of references generated by the extensive search for relevance. A second screening was undertaken based on the full text analysis to select eligible studies. Two independent coders reviewed the full articles to ensure the validity of the review. Ten articles were subject to discussion and were thereby resolved.

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## Data collection process and data items

The following data for each study has been taken into consideration: date and country of study, intervention (objectives, design, duration, theory-grounded) and evaluation (study population, study design, measurement tools, scales, indicators, results), implications and limitations. The results are summarized below using narrative synthesis.<sup>64</sup>

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## Results

### Study selection

As can be seen in the PRISMA 2009 Flow Diagram in Figure 1,<sup>63</sup> the database search resulted in 1473 records; 246 duplicates were removed by the RefWorks automatic duplicates tool; 1227 titles and abstracts were reviewed and 1107 records were removed as they did not meet the inclusion criteria. Out of the 120 full-text articles reviewed, a total of 15 full papers that met all criteria were included in the final study selection. The breakdown of the full-text article screening (n=120) is the following: i) 15 articles were eligible studies; ii) 15 were baseline studies with no intervention focusing on diabetes knowledge and the needs

of children with diabetes in school; iii) 34 were focusing on diabetes prevention programmes (risk factors/lifestyle interventions); iv) 17 were focusing on children with diabetes outside the school environment; v) 13 were non-scientific articles or communication statements; and vi) 26 were duplicates or irrelevant (not focusing on school children with diabetes).

### Study characteristics

Fifteen studies were included into this systematic literature review (Table 1 and Supplementary Table S1).<sup>42,46,65-77</sup> The majority of studies were conducted after 2006 (n=9), and six were conducted before 2005. All studies were undertaken in North America (n=14 in the USA and n=1 in Canada). Most of the studies lasted one year (n=7); four studies lasted between 3-5 years, while four studies lasted three months or less. The majority of studies focused on type 1 diabetes but four studies conducted after 2005 addressed both type 1 and type 2 diabetes in school.

## Synthesis of results

### Interventions

The first research question was: what school-based diabetes interventions have been implemented since 2000? In order to answer this, we have considered the objectives, the target audience and the components of the interventions, as well as the theory used (Supplementary Table S1).

Two main types of intervention can be distinguished: i) studies targeting school personnel focusing on diabetes education; and ii) comprehensive studies focusing on children with diabetes aiming to improve their health, academic performance, and well-being.

Seven studies focused on diabetes education targeting school personnel, mainly school nurses or school teachers.<sup>42,65,67,71,74,76,77</sup> Their main objective was to increase knowledge about diabetes and confidence in caring for school children with diabetes. Interventions included diabetes education programmes, continuing education, creation of a resource for school personnel, on-line education and CD-ROM, and

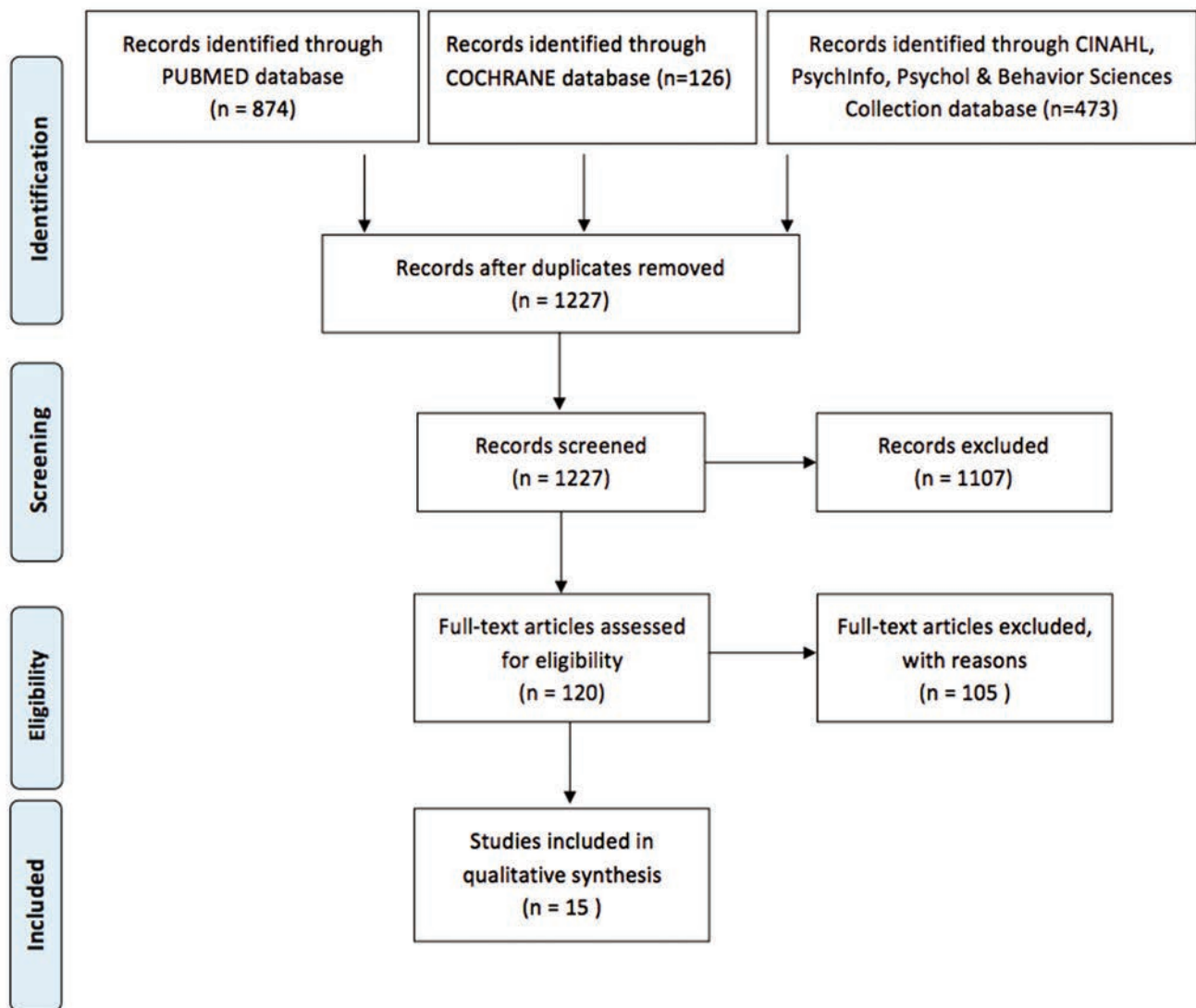


Figure 1. PRISMA 2009 flow diagram.<sup>63</sup>

computer-based education. They were mainly conducted between 2000 and 2005; only two were conducted after, respectively in 2008 and 2012.<sup>65,77</sup> After 2005, eight studies proposed a more comprehensive approach to improve diabetes management in school and create a safe environment for children with diabetes.<sup>46,66,68-70,72,73,75</sup> The interventions consisted of the application of the Healthy Learner Model, a collaborative approach to diabetes care and prevention, School Nurse Case Management programmes, paediatric nurses' school visits, school nurse supervision of diabetes management and school-centered telemedicine. They included components such as direct care, education/counselling, and care coordination, in order to improve diabetes management in school.

Nine studies were theory-based. Case Management (n=3),<sup>68,69,75</sup> the Healthy Learner Model (n=2)<sup>46,66</sup> and the Social Cognitive Theory (n=2)<sup>70,77</sup> served as main theoretical frameworks for the development of the study interventions. Two other theories (Roger's theory of diffusion of innovation and Mantel and Teorey's usability framework)<sup>65,76</sup> were also used to support interventions. None of the studies focusing on school personnel's training before 2005 were theory-based, while the two education interventions after 2006 were theory-grounded.<sup>65,77</sup> All the comprehensive studies focusing on diabetes care in school after 2005 were theory-based, apart from two.<sup>71,73</sup>

Among all interventions, the study populations can be classified into three groups: i) school personnel (n=10), comprising school nurses (n=7), teachers (n=3) or other school staff (n=2); ii) school children with diabetes (n=6); and iii) parents of children with diabetes (n=6).

## Evaluation

The second research question was: what were the outcomes of these school-based diabetes interventions? To answer this, we have considered the study design, measurement tools used, and reported results in the studies (Supplementary Table S1). The outcomes of the interventions have been reported using multiple and diverse tools, and a combination of study designs. Six studies were assessed by randomized controlled trials (RCTs) measuring diabetes knowledge, perceived competence/confidence, Quality of Life (QoL), Haemoglobin A1c (HbA1c) levels or satisfaction. Ten studies used quantitative and qualitative methods to assess the satisfaction with the intervention, the diabetes knowledge or confidence, perceived improvement in diabetes

care, health outcomes/QoL, student self-efficacy or follow-up impact. In five studies, other complementary tools such as individual goal attainment, activity logs and student academic outcomes were also used.

Eight studies used a pre/post- evaluation design and three studies were longitudinal with measurements at different points in time during the intervention. As can be seen in Supplementary Table S1, nine studies reported statistically significant improvements. Significantly higher knowledge of diabetes in school personnel has been shown by Radjenovic and Layne Wallace (P<0.033),<sup>76</sup> Siminerio and Koerbel (P<0.004),<sup>42</sup> and Smith and colleagues (P<0.001),<sup>77</sup> in diabetes education programmes focusing on school personnel (face-to-face or computer-based training). There is also evidence of higher self-perceived competence in school nurses who have completed continuing education (P=.0001),<sup>67</sup> CD-ROM based training (P=0.016),<sup>71</sup> or advanced training programmes (P<0.001).<sup>77</sup> Only in the study of the effectiveness of a CD-ROM training, the increase in knowledge, measured by a RCT, was not statistically significant.<sup>71</sup> In two studies focusing on children with diabetes, Engelke and colleagues reported a significant increase in QoL of children with diabetes as a result of Case Management interventions in the school setting.<sup>68,69</sup> Similarly, significant improvements in QoL were reported by Izquierdo and colleagues as outcomes of a combination of usual care and telemedicine.<sup>72</sup> Nguyen and colleagues showed a significant decrease in HbA1c in children with poorly controlled type 1 diabetes who were supervised by school nurses for glucose checks and insulin injection (P<0.0001).<sup>73</sup> Peery and colleagues also showed the perceived positive outcome by parents and teachers of school nurse interventions on children's self-management.<sup>75</sup> Even though some positive trends were observed, no statistically significant differences in student with diabetes self-efficacy were seen by Faro and colleagues as a result of monthly school visits by a paediatric nurse in schools.<sup>70</sup> All authors who conducted satisfaction surveys reported high satisfaction rates with the programmes.<sup>46,65,66,70,72,74,76</sup>

## Discussion

An increasing number of school-based diabetes interventions have been implemented in developed countries over the past 14 years (2000-

**Table 1. List of papers included in our literature review.**

First author	Title	Date	Country
Bachman <sup>65</sup>	Evaluation of online education about diabetes management in the school setting	2008	US
Bobo <sup>66</sup>	Diabetes management at school: application of the Healthy Learner Model	2011	US
Bobo <sup>46</sup>	A collaborative approach to diabetes management: the choice made for Colorado schools	2011	US
Bullock <sup>67</sup>	Continuing education: improving perceived competence in school nurses	2002	US
Engelke <sup>68</sup>	School nurse case management for children with chronic illness: health, academic, and quality of life outcomes	2008	US
Engelke <sup>69</sup>	School nurses and children with diabetes: a descriptive study	2011	US
Faro <sup>70</sup>	Improving students' diabetes management through school-based diabetes care	2005	US
Husband <sup>71</sup>	The effectiveness of a CD-rom in educating teachers who have a student with diabetes	2000	Canada
Izquierdo <sup>72</sup>	School-centered telemedicine for children with type 1 diabetes mellitus	2009	US
Nguyen <sup>73</sup>	Targeting blood glucose management in school improves glycemic control in children with poorly controlled type 1 diabetes mellitus	2008	US
Nimsgren <sup>74</sup>	Implementing a new diabetes resource for Wisconsin schools and families	2005	US
Peery <sup>75</sup>	Parent and teacher perceptions of the impact of school nurse interventions on children's self management of diabetes	2012	US
Radjenovic <sup>76</sup>	Computer-based remote diabetes education for school personnel	2001	US
Siminerio <sup>42</sup>	A diabetes education program for school personnel	2000	US
Smith <sup>77</sup>	Evaluation of the impact of a diabetes education curriculum for school personnel on disease knowledge and confidence in caring for students	2012	US

2013). These interventions are varied in terms of scope, duration and measured outcomes.

All studies in this review were conducted in North America which can be explained by US federal legislation, the central role of the school nurse in diabetes management and the provision of school diabetes policies and diabetes management plans in the US. Some studies examined the outcomes of interventions on teachers', school nurses' and other school personnel's diabetes knowledge and confidence in delivering care. Interventions consisted of diabetes training and education of school personnel about diabetes, including face-to-face training, continuing education, resource guides and also online education, CD-ROM or computer-based training. Most of these studies were conducted before 2006 (five out of seven studies). All studies reported overall satisfaction with the training provided. In addition, some studies used knowledge and confidence questionnaires and demonstrated gains in knowledge and perceived competence (although in one instance, the gain in knowledge was not significant). Four RCTs were conducted and showed a significant increase in nurses' confidence. None of these studies measured the effects on practices and behaviour change. These interventions, however, showed the importance of on-going education of school personnel to stay aware of developing knowledge and new technological advances in diabetes management, and gain confidence in managing children with diabetes.<sup>42,65,67,71,74,76,77</sup>

New comprehensive approaches focusing on the care of children with diabetes have been implemented in the school setting since 2005. Compared to the interventions described previously, these campaigns lasted longer (usually one school year, but lasting up to five years). These theory-based programmes offered an integrative and collaborative approach of care to meet the needs of the child with diabetes in school. The main goal was to offer a standardized approach to care in order to improve diabetes management and promote a safe and healthy school environment for children with diabetes. Interventions based on Case Management, telemedicine and collaborative approaches to diabetes management included a full set of services such as education, direct care, counselling, meetings, coordination and communication with the families. Most of these interventions were theory-grounded and, apart from one,<sup>76</sup> all theory-based interventions have been conducted since 2005.<sup>46,65,66,68-70,75,77</sup> They illustrate a positive trend in theory-based interventions, in line with the literature that has shown the benefits of theory-grounded interventions in health education and communication.<sup>78</sup> Evaluations involved multiple tools and indicators. In addition to satisfaction surveys about the programme, indicators such as HbA1c levels and QoL were used as these studies aimed to improve the diabetes management and well-being of students with diabetes at school. Activity/intervention logs, individualized goals, as well as students' academic measures, were also complementary assessment tools. These studies all included a pre and post evaluation design and, in three studies,<sup>46,66,72</sup> a longitudinal evaluation was conducted at several points in time. RCTs were used to assess the effectiveness of two interventions and showed significant improvements in HbA1c levels as a result of school nurse supervision in diabetes care<sup>73</sup> or school-centered telemedicine.<sup>72</sup> School-centered diabetes management interventions provided evidence of the critical role of a supportive school environment to improve the health and quality of life of children with diabetes.

## Limitations

Some limitations could be observed regarding the evaluation of the studies. Although many of the studies reported a significant difference in the parameters measured, it was not possible to determine optimal ways to improve the health, quality of life and academic performance of children with diabetes given the disparity in scope, assessment tools

and measured outcomes. Only six studies used RCTs, and both quantitative and qualitative methods have been used. In several cases, the evaluation was limited to satisfaction surveys or perceived improved knowledge, and confidence levels. Behaviour change and practice were not assessed. Scales were not always validated. The samples and the number of schools were rather limited in most cases, making impossible to generalize results. Only one study reported a follow-up study and the long-term impact after one year was never assessed.

The large heterogeneity of school-based diabetes interventions, measurement tools and measured outcomes among the reviewed studies did not allow a statistical pooling of results. Therefore no single value can be presented to demonstrate the effectiveness of school-based diabetes interventions. Small samples, the use of non-validated scales and qualitative studies do not provide adequate data for supporting evidence on the effectiveness of school-based diabetes interventions and replicability. All studies were conducted in North America, making difficult to generalize findings to other parts of the world. Lastly, the cost-effectiveness of the interventions was never assessed and should be integrated in future evaluation.

## Conclusions

This systematic literature review has shown an increase in school-based diabetes interventions since 2005 in response to the rising prevalence of diabetes in children (both type 1 and type 2 diabetes) and the higher global attention given to the diabetes burden. The education of school personnel was the main focus before 2006. Interventions aimed to address the lack of informed and trained staff, limited knowledge and misconception about diabetes, and to increase knowledge and confidence of school personnel. Interventions such as diabetes training and continuing education of school nurses and teachers have reported school personnel's gained knowledge and improved self-perceived competence. More comprehensive approaches focusing on children with diabetes have been developed since 2005. These integrative interventions have aimed to promote better care coordination, collaboration between all care givers and the provision of a safe school environment. These studies have measured HbA1c levels and quality of life of students and, in pre/post tests, have shown significant improvements.

This review highlights the importance of conducting thorough evaluations of school-based diabetes interventions. Additional thinking about long-term outcomes that reflect the nature of the interventions, and how they can be measured best, is needed. Comprehensive evaluation of school-based diabetes projects will contribute to adjusting and improving the interventions. It will also serve as a powerful advocacy tool for improving school policies on diabetes.

This systematic literature review does not provide definitive guidance toward the optimal school-based diabetes interventions, given the large heterogeneity of the assessment tools used and limited evaluation in some cases. It does, however, demonstrate that increasing efforts are being made, and it does provide evidence that can be used for developing future school-based interventions. Experimental designs, longer follow-up studies, larger sample sizes, and higher numbers of participating schools are critical issues that should be taken account of before work is begun. Further research is needed and studies should be conducted in other parts of the world than North America in order to promote a safe school environment and ensure children with diabetes have the same educational opportunities as other children everywhere in the world.

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