Behavioral Interventions for Adolescents With Type 1 Diabetes

How effective are they?

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OBJECTIVE — To evaluate the effectiveness of behavioral interventions for adolescents with type 1 diabetes based on a systematic review of the literature.

RESEARCH DESIGN AND METHODS — The literature was identified by searching 11 electronic databases, hand-searching 3 journals from their start dates, and contacting individual researchers. Only articles that reported evaluations of behavioral (including educational and psychosocial) interventions for adolescents (age range 9–21 years) with type 1 diabetes that included a control group were included in the present review. Data summarizing the key features of the interventions and their effects were extracted from each article. Where possible, effect sizes for the randomized control trials (RCTs) were calculated.

RESULTS — The search process identified 64 reports of empirical studies. Of these, 35 studies included a control group, and 24 were RCTs. Effect sizes could be calculated for 18 interventions. The overall mean effect size calculated across all outcomes was 0.33 (median 0.21), indicating that these interventions have a small- to medium-sized beneficial effect on diabetes management. Interventions that were theoretically based were significantly more effective than those that were not ($P < 0.05$, 1-tailed).

CONCLUSIONS — Research to date indicates that these interventions are moderately effective. Several methodological weaknesses to be avoided in future studies are noted. It is also recommended that investigators use the reach, efficacy, adoption, implementation, and maintenance (RE-AIM) framework to guide the design of future studies, which should result in more disseminable interventions. RE-AIM assesses the intervention's reach, or percent or representativeness of patients willing to participate; efficacy across a range of outcomes; adoption, or the percent and representativeness of settings willing to implement the intervention; implementation, or the consistency of the delivery of the intervention as intended; and maintenance, or the extent to which delivery of the intervention becomes a routine part of health care in the medical setting.

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Abbreviations: RCT, randomized control trial; RE-AIM, reach, efficacy, adoption, implementation, and maintenance.

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

During adolescence, young people learn to take responsibility for and manage their own diabetes (1–4). Research consistently demonstrates that there is a marked worsening of metabolic control at this time (5–7) and that poor control is associated with the onset and progression of complications in this age-group (8–10). Although this deterioration is partly attributable to physiological changes, the decline in self-care behavior is of at least equal importance (2,5,11–13).

Behavioral interventions are designed to improve levels of self-care by applying psychological principles to assist people with diabetes in making desired changes to their behavior patterns and lifestyle. These interventions are wide ranging. They may address knowledge and skills, psychological factors (e.g., self-efficacy), and behaviors (e.g., eating and exercise patterns). A recent review of evaluations of psychosocial and educational interventions for adults with diabetes concluded that these interventions are beneficial, but that this optimism must be tempered by the methodological weaknesses of many studies, including small sample sizes, poor measurement of outcomes, and inadequate reporting of the interventions (14). That review included all of the published meta-analyses on interventions for adults with diabetes (15–22). No previous review or meta-analysis has been devoted exclusively to evaluating the effects of behavioral interventions on adolescents.

The aim of the present review was to appraise the research to date on the effectiveness of behavioral interventions for adolescents with type 1 diabetes and to identify what is known from past research and where future research efforts should be directed. This aim was accomplished by providing a descriptive account of the studies to characterize past research and to identify strengths and weaknesses. Next, meta-analysis of effect sizes was used to provide an estimate of the general beneficial impact of behavioral interventions for diabetes by examining their overall effectiveness (averaging across types of interventions and outcomes). In addition, the effectiveness of these interventions for more specific categories of outcomes

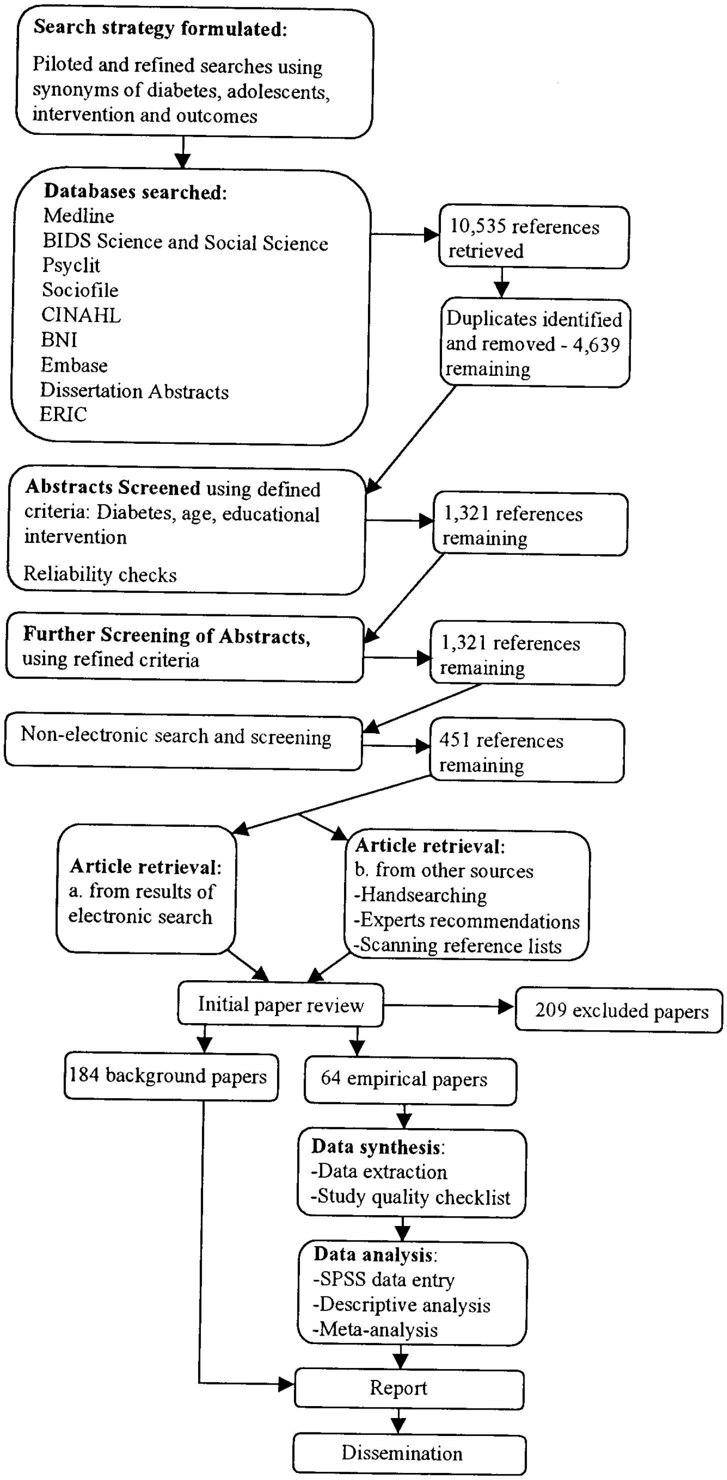

Figure 1—*Flow chart of review methodology.*

(e.g., psychosocial, metabolic, self-management, and knowledge) was examined. Behavioral interventions aim primarily to change psychosocial and self-management outcomes, which are seen as intervening variables that contribute to metabolic outcomes (23,24). Therefore, we examined whether effects were larger for intervening (psychosocial, self-management, and knowledge) variables than for metabolic outcomes. We also used meta-analysis to test whether interventions based on theoretical principles were more effective than those that were not theoretically based (25).

Finally, those interventions that yielded the largest effect sizes were evaluated in terms of the reach, efficacy, adoption, implementation, and maintenance (RE-AIM) framework (26). RE-AIM assesses the intervention's reach, or percent or representativeness of patients willing to participate; efficacy across a range of outcomes; adoption, or the percent and representativeness of settings willing to implement the intervention; implementation, or the consistency of the delivery of the intervention as intended; and maintenance, or the extent to which delivery of the intervention becomes a routine part of health care in the medical setting. This framework extends the evaluation of interventions to encompass their applicability to real-world health care settings.

RESEARCH DESIGN AND METHODS

Searching and screening

Procedural details of the review methodology are shown in Fig. 1. Eleven databases were searched from their start date through June 1999, and the journals *Diabetes Care*, *Diabetic Medicine*, and *Practical Diabetes International* were hand-searched from their start date through June 1999. Researchers were contacted by personal letters, notices in journals, web sites, and flyers distributed at conferences to solicit reports of completed or ongoing work, published or unpublished. Reference lists were scanned for further articles. Reports were included in the review if *1)* participants had type 1 diabetes, *2)* the age range was 9–21 years, and *3)* the article reported an evaluation of a behavioral intervention (i.e., including 1 or more of the following: education, skills training, or any other form of behavioral or psychosocial intervention designed to improve adolescents' diabetes management). The screening process resulted in the identification of 64 empirical articles. Of these, 35 reports described interventions that included a randomized, nonrandomized, or waiting-list control group. These 35 studies (27–63) are the focus of the present review. The results of the more inclusive review, in which studies without control groups were also appraised, are reported elsewhere (64). Each report was read by 1 or 2 reviewers who extracted descriptive features of the intervention (e.g., study design, number of participants, nature of the interventions, and effects on outcomes). A third reviewer repeated this process for 10% of the reports, and the average inter-reviewer reliability was 0.85 (Cohen's κ).

Calculation of effect sizes

Effect sizes provide a common metric with which to combine and compare results from different studies. Effect sizes were calculated for interventions evaluated in randomized control trials using the following formula: (difference between group means at follow-up) − (difference between means at baseline) ÷ pooled SD at baseline.

It is conventional in the behavioral sciences to interpret effect sizes of ~0.20 to be "small" in magnitude, those of ~0.50 to be "medium," and those >0.80 to be "large" (65).

For effect-size analyses, outcomes were categorized as psychosocial, GHb, other metabolic measures, self-management behaviors, or knowledge. The psychosocial category included outcomes that were self-reports or parent reports of changes on psychological or interpersonal constructs (e.g., self-efficacy, and communication skills). The GHb category included all measures of GHb. The category of other metabolic measures included measurements such as fructosamine, fasting blood glucose, or urinary blood glucose. The self-management category included outcomes that assessed behaviors (e.g., eating patterns and frequency of blood glucose testing). The range of outcomes included in these categories, with the exception of GHb, was broad because there were very few outcomes that were identical across studies. The aim was to maximize the number of effect sizes in each category without producing incoherent categories. Accordingly, the effect sizes within each category were tested for heterogeneity (66). Significant heterogeneity is an indication that the category includes effect sizes that are markedly dissimilar from the others, which may be because the category combines too diverse a range of outcomes. For studies that had >1 measure within a particular category, the mean effect size was calculated across all of the measures within that category so that each study only contributed 1 effect size per category (15). In 2 reports (34,58), there were 2 intervention groups compared against a single control group. For these studies, separate effect sizes were calculated for each intervention. Unless otherwise stated, the follow-up mean effect size was calculated across all of the postintervention assessment points (i.e., immediately after intervention and during any subsequent follow-ups).

RESULTS

Descriptive results

The earliest of the 35 studies was published in 1980. The cutoff date for published studies was June 1999, although 1 study currently in press (63) and 1 study currently under review (39) were included. More than one-third of the studies (40%) did not provide a statement (including a reference) of the theoretical principles underlying the design of the intervention. For those that did specify theoretical principles, most were based on family therapy (20%), followed by social learning theory (14%), and behavioral principles (8.6%). The "other" category was also sizeable (17.1%) and included any studies with theoretical principles, such as anchored instruction (54–56) or social support (48).

The majority (74.3%) of the 35 studies was randomized control trials (RCTs). Most were conducted in the U.S. (71.4%); the U.K. was the second most likely location (2.9%). The mean number of participants was 55. The ethnic status of participants was reported in detail in only 26% of these studies. The mean age was 12.4 years, and the mean duration of diabetes was 4.7 years (range 0 months to 8.8 years).

The studies illustrate a wide variety of interventions. The most common was some form of skills training (45.7%), followed by family-related interventions (25.7%), dietary interventions (20%), and problem-solving interventions (20%). Most commonly (42.4%), only 1 interventionist was involved in delivering the intervention. Where specified, the interventionists were most likely to be psychologists (30.3%), nurses (27.3%), or doctors (15.2%). Interventions were most commonly group-based (45.7%), as opposed to individual (22.9%) or family-based (14.3%).

Reports were frequently unclear about where the intervention had been conducted (20%). Given the information provided, it appears that hospital outpatient programs (34.3%) and other community settings (22.9%) were the most likely locations for interventions. The most typical community setting was diabetes summer camps. In a small number of studies, the location differed for different aspects of the intervention.

A large variety of outcomes was assessed. The most common (71.4%) was GHb. Psychosocial measures for either individual or family functioning were the next most commonly assessed outcomes (57.1%). These included such constructs as self-efficacy for diabetes management (31,32), measures of family climate (42,61) or family conflict (28,63), diabetes-specific stress (31,37–39), and quality of life (33,37–39,63). Knowledge was assessed in 25.7% of the studies. Diabetes self-management behaviors, such as adherence to diet (11.4%), were less commonly assessed. Outcomes with cost implications, such as service use (14.3%), were also relatively rare. Most studies did not have a follow-up assessment subsequent to the immediate postintervention assessment (62.9%). Of those that did, follow-ups were most likely to occur more than 1 year after the intervention (14.3%). A minority had follow-up assessments <6 months after the postintervention assessment (11.4%).

Effect-size analyses

There were 18 interventions evaluated in randomized control trials for which sufficient details were provided so that effect sizes could be calculated. To determine the representativeness of these studies, a series of χ^2 and *t* tests were performed on the study characteristics coded from the data extraction process, comparing those studies for which effect sizes could be calculated with those for which they could not. The only significant difference was that the effect-size studies were likely to have been published more recently (mean year 1993) than the non–effect-size studies (mean year 1989).

The quality of the studies was evaluated with respect to randomization, attrition, and concealment allocation. Only 1 study reported how randomization was performed, attrition was low in all studies, and blinding of both participants and interventionists was not possible in this type of intervention. Therefore, no weighing of effect sizes was made on the basis of quality.

The mean and median effect size for each category (psychosocial, GHb, other metabolic variables, self-management behavior, and knowledge) within each study is shown in Table 1. The mean of all effect sizes across all studies was 0.33 (median 0.21), which is indicative of a small- to medium-sized beneficial effect of these interventions on adolescent diabetes management. The mean effects sizes for each study (Table 1) were not significantly heterogenous (χ^2 = 24.52, NS, df = 17).

The largest mean effect size was for psychosocial outcomes (mean 0.37, SD 0.24). This category was not significantly

Table 1—*Mean effect size for each category of outcome variable for each intervention*

Study	Psychosocial	GHb	Other metabolic	Self-management	Knowledge	Mean
Anderson et al. (27)	—	0.47	—	—	—	0.47
Anderson et al. (28)	0.72	−0.48	—	—	—	0.12
Boardway et al. (31)	0.11	—	−0.21	−0.44	—	−0.18
Brown et al. (32)	0.36	−0.11	—	—	−0.09	0.05
Daley (33)	0.28	—	—	—	—	0.28
Delamater et al. (34)						
Intervention 1	—	0.18	—	—	—	0.18
Intervention 2	—	0.18	—	—	—	0.18
Grey et al. (37–39)	0.48	0.34	—	—	0.09	0.30
Hansson et al. (42)	0.62	—	—	—	—	0.62
Huttunen et al. (45)	—	—	−0.05	−0.14	—	−0.10
Marrero et al. (49)	—	−0.17	—	—	—	−0.17
McNabb et al. (51)	—	0.15	—	—	—	0.15
Pichert et al. (54)	—	—	—	—	0.47	0.47
Satin et al. (58)						
Intervention 1	—	1.18	—	—	—	1.18
Intervention 2	—	2.03	—	—	—	2.03
Simell et al. (59)	—	0.23	—	—	—	0.23
Sundelin et al. (61)	0.00	—	—	—	—	0.00
Wysocki et al. (63)	0.37	−0.03	—	0.13	—	0.16
All studies						
Mean	0.37	0.33	−0.13	−0.15	0.16	0.33
Median	0.36	0.18	−0.13	−0.01	0.09	0.21

Effect sizes were averaged across different outcomes within each category within each study. For Anderson et al.'s study (28), effect sizes were calculated for the teamwork intervention versus standard care. For Wysocki et al.'s study (63), effect sizes were calculated for behavioral family systems therapy versus standard therapy. Based on different analytic approaches, the effect sizes reported here may therefore differ from the results reported by the authors.

heterogenous ($\chi^2 = 4.42$, NS, df = 7). The mean effect size for GHb was 0.33 (SD 0.67). This category was significantly heterogeneous ($\chi^2 = 28.45$, $P < 0.05$, df = 11) because of the 2 large effects from the study by Satin et al. (58). The median effect size (0.18) or the mean without the outliers (0.08) may be more reliable indicators of the typical effect on GHb. To give an indication of the clinical relevance of the mean effect size for GHb, it was converted into change in percent HbA_{1c} using the SD for HbA_{1c} reported by Mortensen and Hougaard (67) in their study of 2,873 children and adolescents from 18 different countries (8.6 ± 1.7%). Using these data, an effect size of 0.33 is equivalent to a change of just over one-half of a percentage point in HbA_{1c} (0.60%), and an effect size of 0.18 is equivalent to a change of just less than one-third of a percentage point (0.31%).

Contrary to our hypothesis, the mean effect size for intervening variables (psychosocial and self-management categories: 0.23 ± 0.34) was smaller than the mean effect size for metabolic outcomes (GHb and other metabolic outcomes: 0.26 ± 0.64). However, when the 2 GHb outliers were removed, the mean was considerably reduced (0.04 ± 0.26), and the difference between the means was in the hypothesized direction but did not reach statistical significance ($t = 1.58$, df = 21, NS). Moreover, consistent with our hypothesis, for each of the 4 studies where both psychosocial outcomes and GHb were measured (28,32,37–39,63), the effects for psychosocial variables were larger than the effects for GHb.

The mean effect size for interventions with an explicit theoretical basis provided in the introduction to the report (27,28,31,33, 37,42,51,54,58,61,63) was compared with the mean effect size for interventions with no explicit theoretical basis (32,34a,34b, 45,49,59). As predicted, the mean effect size for theoretically based interventions (0.47 ± 0.60) was significantly larger than the mean effect size for atheoretical interventions (mean 0.06, SD 0.16, $t = 2.05$, df = 17, $P < 0.05$ by 1-tailed Student's t test).

RE-AIM evaluation of selected studies

The studies that produced the largest effect size in each of the psychosocial, GHb, and knowledge categories, and any study that produced an effect of at least 0.30 in more than 1 category, were selected for RE-AIM evaluation. For the psychosocial category, the intervention by Anderson et al. (28) produced the largest effect size (0.72). This effect size was the mean of 2 parental ratings of unsupportive behavior and family conflict. The intervention encouraged parent-teen responsibility for sharing diabetes tasks and avoiding conflict. It was conducted with individual families for 4 sessions at routine clinic appointments over 1 year. Reach was good for this intervention; 76% of eligible families who attended a specialist clinic participated. Adoption has the potential to be high because this nurse-led intervention can be conducted as part of routine medical care. Implementation should also be high because a written intervention protocol is available. Maintenance of the intervention by the setting was not reported.

The largest effect sizes for GHb were obtained in the study by Satin et al. (58). Both interventions involved 6 weekly multifamily group therapy sessions with a professional group leader to address issues of living with diabetes and improving adherence. GHb was assessed at 3-month and 6-month follow-ups. The largest effect was obtained by the intervention that included 1 week of parental simulation of diabetes. Participation rates were not reported, so reach is unknown. This intervention requires a professional group leader trained in group therapy and depends on families being willing to attend numerous sessions. Moreover, parental simulation (including injecting saline solution and blood testing) is demanding. Therefore, widespread adoption of this intervention is unlikely. Consistency of implementation of the intervention was not assessed, and subsequent maintenance of this intervention in this setting is unknown.

The largest effect on knowledge was produced in the study by Pichert et al. (54). In this intervention, adolescents at summer camp attended 4 nurse-led group sessions. They were taught using the theoretical principles of anchored instruction, which is based on a problem-focused discussion. They discussed a video depicting a person with diabetes taking a daylong boat trip that included numerous problems for diabetes management. Beneficial effects of this more active approach to learning have yet to be demonstrated on behavioral or metabolic outcomes.

The intervention evaluated by Grey et al. (37–39) was the only one to report effect sizes of at least 0.30 for both psychosocial outcomes (measures of coping and self-efficacy) and GHb. However, the effects on GHb cannot be attributed exclusively to the behavioral intervention because participants were receiving intensive therapy. The intervention consisted of training coping skills in groups attended by adolescents and led by nurse practitioners, and it was provided as an adjunct to intensive insulin therapy. Reach was good, with 71% of eligible adolescents from a specialized diabetes clinic agreeing to participate. Wider adoption of this intervention is made possible by the provision of a detailed manual, which should also ensure consistent implementation. Maintenance of the use of this intervention by the setting was not reported.

CONCLUSIONS — Despite the numerous obstacles to conducting appropriate clinical trials of interventions for the management of diabetes (68), this review identified 64 reports evaluating interventions for adolescents. A control group design was used in 35 of these trials. The meta-analysis of 18 of these interventions indicated that a small-to-medium beneficial effect was observed across a variety of outcomes.

The descriptive data indicated that there were numerous methodological shortcomings in the past literature that future studies should avoid. Less than one-half of the interventions were theoretically guided (25). However, the meta-analysis demonstrated that theoretically guided studies generated larger effect sizes than atheoretical ones. Over one-half of the studies used GHb as an outcome. However, it is more appropriate to evaluate the effectiveness of a behavioral intervention in terms of the behaviors it is designed to impact. Follow-up assessments were relatively rare but, to examine maintenance, the long-term effectiveness of these interventions needs to be evaluated. However, if interventions do not include components to address maintenance issues, then improvements in self-management are likely to decline over the follow-up period. Sample sizes were typically small and rarely based on power analyses, effects of ethnicity and socioeconomic status were not examined, and cost-effectiveness issues were not addressed.

The meta-analysis indicated that, overall, these interventions were effective and, consistent with our hypothesis, theoretically based interventions were more effective than atheoretical interventions. Theoretical principles provide a rationale for determining the contents of the intervention and what outcomes to assess, which results in more powerful interventions than those with no underlying theoretical basis. The effects for intervening variables were larger than the effects on metabolic outcomes but not significantly so, which did not support our hypothesis. However, the meta-analysis had several limitations. Only a relatively small number of interventions were reported in sufficient detail to permit the calculation of effect sizes. The wide variety of outcomes, with few common outcomes across studies, made it difficult to form coherent categories and weakened the power of between-category comparisons. These limitations made it impossible to draw conclusions about which interventions are most effective for which outcomes.

The interventions that generated substantial effect sizes on psychosocial outcomes or GHb were all conducted in specialized diabetes clinics and required considerable commitment on the part of the participants. In terms of both the meta-analysis and the RE-AIM framework, the interventions by Anderson et al. (28) and Grey et al. (37–39) probably emerge as the best. These interventions changed targeted behaviors and have the potential to be incorporated as part of routine medical care. However, their ability to be more widely disseminated remains to be demonstrated.

In evaluating the relatively modest effects of these interventions, it should be remembered that they occur in addition to the diabetes education and skills training that patients received at diagnosis. Moreover, such interventions are rarely closely integrated with medical care (the study by Grey et al. [37–39]) being a notable exception) so that GHb is subject to numerous influences in addition to the behavioral intervention. The modest positive effect on GHb should be viewed in light of the results of the Diabetes Control and Complication Trial, which demonstrated a dose-response relationship between reductions in GHb and microvascular complications (8). From a public health perspective, effects of this magnitude have potential for substantial improvements in the health of the type 1 diabetic population and, hence, cost savings, if they can be maintained in the long term.

On the basis of this review, the following recommendations about future research can be made. The methodological shortcomings identified in the descriptive analysis should be avoided (e.g., small sample sizes and lack of a theoretical basis). To facilitate future meta-analysis, outcomes need to be assessed by a common set of reliable and valid measurements (23). There is a tendency, perhaps a preference, for researchers to develop their own interventions independently. If more definitive conclusions are to be reached about which interventions are most effective for different aspects of diabetes management, there needs to be a more coordinated approach. Finally, as the RE-AIM framework highlights, there are criteria in addition to effectiveness that determine whether an intervention will be able to be disseminated and thereby have a wide impact on the health of adolescents with diabetes. Interventions may produce large effect sizes but not score well on other dimensions associated with disseminability. Conversely, an intervention that can be widely disseminated in RE-AIM terms may only produce small effect sizes. However, the latter would have the potential to make a larger impact than the former on the health of the adolescent diabetic population. Consequently, more attention to the additional RE-AIM criteria is needed in the design and evaluation of these interventions.

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