ISSN: 2754-477X

Journal of Food Technology & Nutrition Sciences

SCIENTIFIC Research and Community

Research Article

Open Access

School Personnel and Student Knowledge of Diabetes and Obesity: A Systematic Review and Meta-Analysis of School-Based Interventions

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ABSTRACT

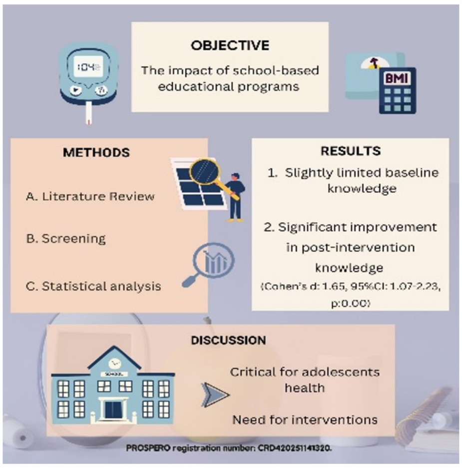
Introduction: Schools are key environments for preventing and managing adolescent diabetes, yet the knowledge and preparedness of school personnel and students remain variable. This systematic review examined the effectiveness of professional development and school-based educational programs in improving knowledge, attitudes, and self-efficacy related to type 1 and type 2 diabetes.

Methods: A PRISMA-guided search of major databases identified peer-reviewed studies published between 2000 and 2025. Eligible studies evaluated training or educational interventions delivered in school settings and reported outcomes on diabetes knowledge or preparedness. Data extraction and quality appraisal were performed independently by two reviewers. When possible, a random-effects meta-analysis was conducted using pre- and post-intervention mean knowledge scores with 95% confidence intervals (CI). Heterogeneity was assessed using the I^2 statistic, and certainty of evidence was evaluated using GRADE.

Results: Sixteen studies met inclusion criteria. Overall, baseline knowledge of diabetes and obesity among school personnel was limited. Professional development programs consistently improved educator knowledge, self-efficacy, and readiness to support students with chronic conditions. Student-focused educational interventions also led to increased knowledge. Meta-analysis of four studies showed a significant improvement in post-intervention knowledge (Cohen's d = 1.65, 95% CI: 1.07–2.23, $p < 0.001$), although heterogeneity was high ($I^2 = 92\%$).

Discussion: School-based training and educational initiatives effectively enhance diabetes-related knowledge among both educators and students. However, variability in intervention design and outcome measures contributes to heterogeneity, and few studies evaluate long-term retention of knowledge.

Implications for Research and Practice: Standardised, evidence-based training for school personnel and comprehensive student education are needed to strengthen school capacity for diabetes prevention and management. Future research should employ rigorous designs, common outcome metrics, and follow-up assessments to determine sustained impact.



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Received: May 23, 2026; **Accepted:** May 27, 2026; **Published:** June 05, 2026

Keywords: Nutrition Education, Teachers, Adolescents, Obesity, Diabetes, School-Based Interventions, Health Literacy, Prevention

Introduction

The escalating prevalence of diabetes and obesity represents a major public health challenge globally, with significant implications for individual well-being and societal health systems. These conditions, often co-occurring and influenced by lifestyle factors, are associated with reduced quality of life, increased morbidity, and higher healthcare costs. Alarmingly, both obesity and type 2 diabetes are now increasingly observed among adolescents -a population traditionally considered at lower risk. The International Diabetes Federation (IDF) estimates that approximately 1 in 6 adolescents worldwide is overweight or obese, and the incidence of type 2 diabetes in this age group is rising at an unprecedented rate [1]. These trends highlight the urgent need for early intervention strategies within adolescent populations [1-3].

Schools are uniquely positioned to support both the prevention and management of chronic conditions like diabetes and obesity. As structured environments with broad reach, schools offer a cost-effective platform to deliver health education, foster positive behaviors, and implement health-promoting policies. In particular, school personnel-including teachers, nurses, and administrators-play a central role in shaping adolescents' knowledge, attitudes, and practices related to nutrition and chronic disease prevention. However, despite their critical influence, educators often lack adequate training or confidence to support students living with or at risk for these conditions [2,3].

Emerging evidence suggests that structured nutrition education within the school setting can positively impact adolescent dietary behaviors and metabolic health outcomes. Interventions targeting school personnel have demonstrated improvements in educators' knowledge, perceptions, and self-efficacy, which in turn influence students' lifestyle choices and disease risk. Yet, findings remain inconsistent, and considerable variability exists in how such programs are designed, implemented, and evaluated across educational contexts [2,3].

Research also indicates that untreated or poorly managed nutrition-related conditions during adolescence can result in long-term consequences, including adult obesity and early-onset type 2 diabetes [2,3]. Studies have shown that severe obesity in adolescence significantly increases the likelihood of developing type 2 diabetes in early adulthood, with estimates suggesting that 57–61% of adult-onset type 2 diabetes may be attributable to elevated BMI during adolescence [3].

In light of the escalating prevalence of adolescent obesity and type 2 diabetes, schools represent a uniquely positioned -but often underutilized -platform for early prevention. Equipping high school staff with accurate, evidence-based knowledge on nutrition-related chronic diseases, as well as practical strategies for effective health communication, is no longer optional -it is essential. Educators are frequently the first line of support for students at risk, yet many lack the training, confidence, and institutional support needed to intervene meaningfully [3].

This systematic review addresses a critical gap in the literature by synthesizing the available evidence on school-based nutrition education interventions targeting high school personnel. It examines their effectiveness in enhancing educators' knowledge, attitudes, and self-efficacy related to diabetes and obesity, and explores the downstream impact on student health literacy and outcomes. By consolidating findings across diverse educational settings and delivery models, this review aims to inform the development of scalable, policy-relevant, and sustainable school health promotion frameworks.

Methods

This systematic review and meta-analysis were conducted by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines and the methodology outlined in the Cochrane Handbook for Systematic Reviews of Interventions [4]. The primary aim was to assess the effectiveness of nutrition education programs targeting school personnel on improving diabetes and obesity knowledge, perceptions, and student-related health outcomes.

Data Sources and Search Strategy

A comprehensive literature search was performed across four electronic databases: PubMed, ScienceDirect, Wiley Online Library, and the Cochrane Library. To ensure inclusion of the most recent studies, the search was extended to cover publications from January 2000 through February 2025. Keywords and Boolean operators used in the search strategy included:

- "High School Personnel" OR "teachers" OR "educators"
- AND "nutrition" AND "diabetes" AND "obesity"
- AND "adolescents" OR "teenagers"
- AND "school-based interventions" OR "secondary school" OR "BMI" OR "type 1 diabetes" OR "type 2 diabetes"

The reference lists of all included studies and relevant reviews were also manually screened to identify additional studies. All identified records were imported into a reference manager for deduplication and screening. A completed PRISMA 2020 checklist is provided as supplementary material to ensure transparent reporting of the review process (Supplementary Figure 1).

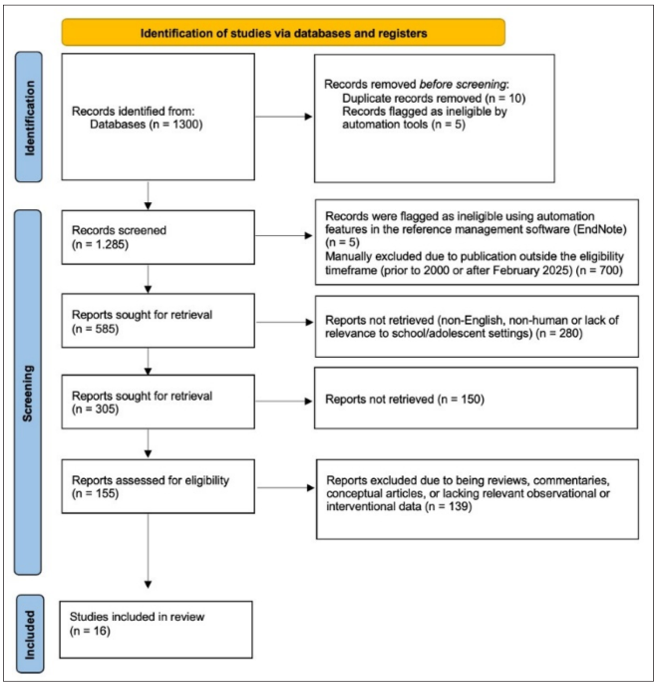


Figure 1: PRISMA 2020 flow Diagram. Regenerated from: (33)

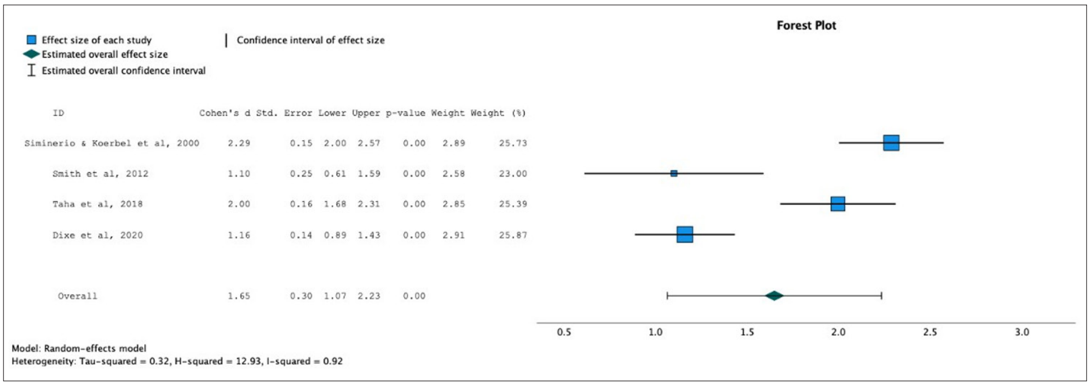
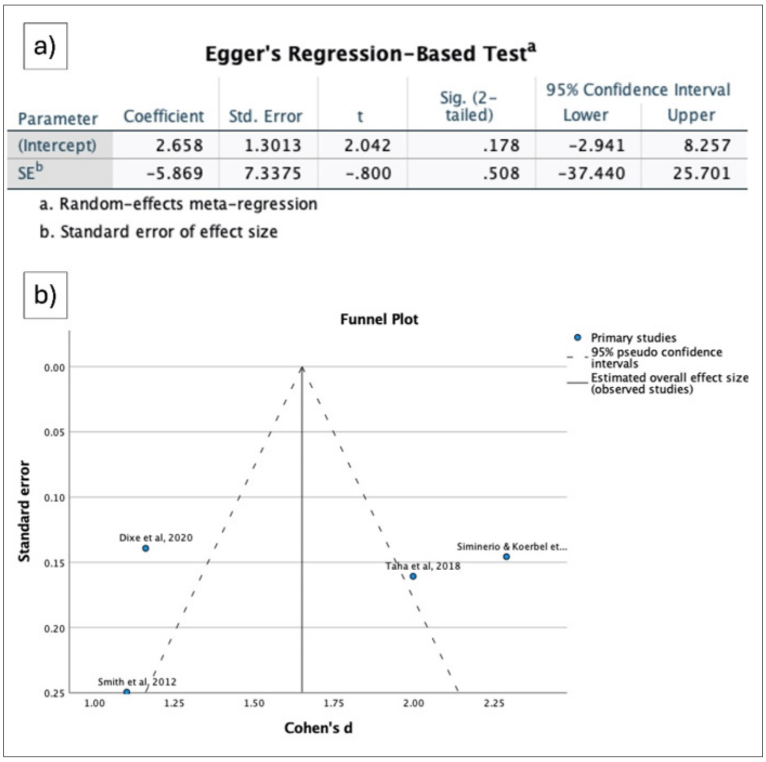


Figure 2: Forest Plot. Evaluation of the Impact School-Based educational interventions had on school's personnel knowledge

8 Supplementary Figures

Supplementary Figure 1. (a) Funnel Plot. Publication bias assessment. (b) Egger's Regression. Publication bias assessment.



a)

Egger's Regression-Based Test[a]

Parameter	Coefficient	Std. Error	t	Sig. (2-tailed)	95% Confidence Interval Lower	Upper
(Intercept)	2.658	1.3013	2.042	.178	-2.941	8.257
SE[b]	-5.869	7.3375	-.800	.508	-37.440	25.701

a. Random-effects meta-regression
b. Standard error of effect size

Eligibility Criteria

Studies were included if they met the following criteria:

- Focused on high school populations
- Targeted school personnel knowledge, perceptions, or behaviors related to nutrition, diabetes, or obesity
- Described school-based nutrition education interventions
- Were primary research studies (interventional or observational)
- Included human participants and were published in English between January 2000 and February 2025 were eligible for inclusion.

Studies were excluded if they:

- Focused exclusively on university students, pre-primary children, or parents
- Included participants with non-related chronic conditions (e.g., cardiovascular disease)
- Were reviews, commentaries, or protocols
- Did not disaggregate adolescent-specific data within broader populations

Study Selection

The collected documents underwent screening with the use of both manual and automation tools. Duplicates will also be removed. Full text screening will also be performed in order to collect the final articles for the systematic review and the meta-analysis.

Data Extraction and Management
Data were extracted independently by three reviewers using a standardized data extraction form developed a priori. Extracted variables included study design, sample size, country, target population, intervention type, duration, outcomes assessed, and key findings. Discrepancies between reviewers were resolved through discussion, and where consensus could not be reached, a third reviewer was consulted. Where necessary, authors of primary studies were contacted for clarification or missing data.

Quality Assessment and Risk of Bias
Randomized trials were assessed with ROB 2; non-randomized studies were appraised with ROBINS-I. Five domains were assessed for the evaluation of risk of bias in randomized controlled trials: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of outcomes, and bias in the selection of the reported results [5]. Seven specific domains of potential bias in non-randomised studies were assessed: bias due to confounding, bias in selection of participants, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes, and bias in selection of the reported result [6]. Disagreements regarding the quality assessment were addressed thoroughly by the reviewers and were resolved. Domains mapped to Tables 4 and 5 for comparability.

Meta-Analysis
Continuous data was reported in the form of Cohen's d, standard errors, upper and lower confidence intervals, p-value and weights. These variables were calculated from the extracted mean values, standard deviations and sample sizes of the included studies. Knowledge pre and post intervention was quantified through the application of a continuous meta-analysis applying a random effects model, and it was visually presented as a forest plot. The heterogeneity test employed I2; I2 of 0-40% indicates insignificant heterogeneity, 30-60% moderate, 50-90% substantial, and 75–100% considerable heterogeneity [7]. Publication bias was also assessed by applying Egger's test, and it was visually presented as a funnel plot [8-10]. Statistical significance was defined as $p<0.05$, with all analyses conducted in SPSS 28.0.

GRADE Approach
Certainty of evidence for meta-analytic outcomes was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) approach, focusing on risk of bias, inconsistency, indirectness, imprecision, and publication bias [11].

Protocol and Registration
The review protocol is registered in PROSPERO under registration number CRD420251141320. The methodology was also pre-specified and approved through the University of Nicosia's doctoral research process, including review and oversight by an academic committee. The review followed the PRISMA 2020 reporting guidelines, and the protocol is available upon request from the corresponding author.

Results
Literature Screening Process
A total of 1,300 records were identified. After removing 10 duplicates and 5 records flagged as ineligible by automation tools, 1,285 records remained for screening. Five records were flagged as ineligible using automation features in the reference management software (e.g., keyword-based exclusion rules within EndNote). These records were subsequently verified manually before exclusion to ensure accuracy. Of these, 700 records were excluded due to publication outside the eligibility timeframe (prior to 2000 or after February 2025). The remaining 585 articles were screened, resulting in the exclusion of 280 studies for reasons such as language (non-English), population (non-human), or lack of relevance to school/adolescent settings. Full texts were sought for 305 records, of which 150 could not be retrieved. The remaining 155 full-text articles were assessed for eligibility, and 139 were excluded due to being reviews, commentaries, conceptual articles, or lacking relevant observational or interventional data. A total of 16 studies were included in the qualitative synthesis. Of the 5 studies eligible for quantitative synthesis, only 2 provided sufficient continuous data on knowledge outcomes to be included in the meta-analysis [3,12-25] The PRISMA follow chart of the screening process is visually depicted in Figure 1.

Outcomes of Included Studies
The 16 included studies encompassed diverse designs and were conducted across Europe (Portugal, Greece, Spain, etc.), USA, and Asia (India, Kuwait, etc.) [3,12,14-20,22-28]. Six out of the 16 studies applied and evaluated the effectiveness of different diabetes educational programs, delivered either in person or online [12,18,23,26-28]. The remaining studies conducted surveys to examine if any programs are already applied and how effective are they; baseline knowledge, and the willingness of teachers and students to be trained and learn more about diabetes management [14-17,19,20,22,24,25,27]. The study conducted by Twig et al. (2020) is the largest study included in the systematic review with 1,462,362 participants in total, that examined the rate of diabetes cases in accordance with BMI [3]. Only three of the included studies were conducted with student participants [14,15,23,27], the rest were based on school personnel, mostly teachers [12,16-20,22,24-26,28]. All the described characteristics are summarized in Table 1.

A consistent theme across studies was the limited baseline knowledge of school personnel regarding diabetes and obesity management [3,12,14-20,22-28]. More specifically, in the study conducted by Gökçe et al. (2020), the baseline knowledge was lower than the baseline score (17.7 score out of 39; baseline score 19,5) [19], whereas in the study of Metos et al. it was slightly above the average (62%) [16]. Only in Stefanowicz-Bielska et al. the baseline knowledge was great at 20 out of 29; and 31.8% stated that they had received training for T1DM [25].

Knowledge improvements following the initiation of diabetes educational programs have been noted across all the studies initiating an educational program (Table 1. & Supplementary Table 1.). In the study conducted by Siminerio & Koerbel (2000), mean values increased from 75 ± 11.0 (mean ± SD) in the pre-test to 94 ± 4.1 in the post-test [12]. Similarly, Dixe et al. reported an increase in overall knowledge from 10.8 ± 2.8 (pre-test) to 13.7 ± 2.1 (post-test) [18]. Smith et al. also reported a statistically significant improvement of 2.89 ± 2.48 ($p < 0.0001$) [26]. Furthermore, Taha et al. demonstrated that knowledge improvement was not only significant but also sustained over time (Pre-test: 57.16 ± 1.64; Post-test 1: 86.32 ± 0.94; 6-month follow-up: 84.64 ± 1.31; 12-month follow-up: 87.69 ± 1.40) [28].

Table 1: Study Characteristics

Study Title	Year	Country	Sample Size	Population	Method	Quantification Details	Results
Siminerio & Koerbel	2000	USA	156	School personnel (school nurses and teachers from elementary middle and high school)	Diabetes Education Program (5Cs Program)	Pre/post testing (100% considered perfect score)	1. pretest scores were 75±11.0; post-test scores were 94±4.1 (mean±SD) (n= 156) 2. (p<0.004) improvement in overall knowledge scores 3. understanding the symptoms and management of hypoglycemia were high (88–95%) 4. Glucagon knowledge (64%) 5. Understanding hyperglycemia symptoms (53%)
Davis et al.	2007	USA	23	Latina Female adolescents	Dietary intervention (≤10% of total daily calorie intake from added sugar & ≥14 g/1000 kcal of dietary fiber a day)	Oral glucose tolerance test & Motivational Interviews (home-based)	1. Dietary fiber increased by 44% (8.6 g/1000 kcals to 12.4 g/1000 kcals; β=0.20; p < 0.01) 2. Time effect for BMI z-scores (p<0.05) 3. Refined carbohydrates decreased (4.1± /2.8 to 2.7 ±/1.4 serving/day (β= /0.16; p </0.01) 5. Energy intake decreased from 1878 ± /737 kcal/day to 1456± /469 kcal/day (β= 0.35; p < 0.001) 6. No other significant changes in physiological or metabolic variables
Smith et al.	2012	USA	81	School Personnel (9 elementary schools, 3 middle schools, 2 high schools, and 1 vocational school)	Educational Session 60 minutes	Knowledge assessment (Pre-&Post-Test)	↑ Diabetes extended knowledge by 2.89 ± 2.48 (mean ± SD) (p<0.0001) (n=37)
Venditti et al.	2014	USA	4,603	Students (6th to 8th grade; 52.7% girls)	Multicomponent intervention program	Evaluating interviews using a Likert-type scale (1 = low to 5 = high)	1. 3.5 out of 5 average effectiveness 2. Teacher acceptance to training was 4 out of 5 3. Students interest was 3.4-3.7 out of 5
Salameh et al.	2017	Jordan	401	Students	Single-Blinded Randomized Control trial 12-week educational program	Weight & FBG alternations	Weight: mean difference -2.26 for intervention group and 1.04 for control group; F = 146.55, P < .0000 FBG ↑ by 1.67 mg/dL ; means difference of −0.96 for intervention group and 0.46 for control group; F = 140.64, P < .000)
Taha et al.	2018	Kuwait	124 (34 male & 90 female)	Public School's Personnel	Pre-&Post-program Knowledge assessment	↑ Knowledge and retained for 6 to 12 months later (p<0.001) Pre-test: 57.16 ± 1.64 (Mean ± SEM) (n=116) Post-test 1: 86.32 ± 0.94 (Mean ± SEM) (n=116) 6 months Post-Test: 84.64 ± 1.31 (Mean ± SEM) (n=60) 12 month Post-Test: 87.69 ± 1.40 (Mean ± SEM) (n=27)	↑ Knowledge and retained for 6 to 12 months later (p<0.001) Pre-test: 57.16 ± 1.64 (Mean ± SEM) (n=116) Post-test 1: 86.32 ± 0.94 (Mean ± SEM) (n=116) 6 months Post-Test: 84.64 ± 1.31 (Mean ± SEM) (n=60) 12 month Post-Test: 87.69 ± 1.40 (Mean ± SEM) (n=27)

Metos et al.	2019	USA	628	K-6 Teachers	Survey	Questionnaire (knowledge and attitudes)	1. Positive understanding of the need for nutritional education (62%) & that they can be beneficial (68%) 2. Correlations between hours of nutritional education and: • teachers' attitudes and beliefs (r = 0.37, p < 0.01) • nutrition self-efficacy (r = .38, p < 0.01) • personal health practices (r = 0.15, p < 0.01) • Inverse relation among years of teaching and food rewards cases (r = −119, p < .01) • 21% agreed to had help when teaching nutrition
Chatzistougianni et al.	2020	Greece	375 (85 males and 290 females)	teachers	Survey	Questionnaire (knowledge and attitudes)	1. Difference between Secondary education graduates (worst; 73.64 ± 14.41%) & tertiary education graduates (best; 81.78 ± 9.90%) (p= 0.021) 2. Private Vs Public sector (82.56 ± 9.71% versus 75.97 ± 13.32%, p < 0.001) 3. Results of three questions Vs Mean percentage of correct answers (37.33% ; 48.27%; 56.80% Vs 80.29%) 4. Teachers never taught a diabetic student Vs Teachers from school with no precautions (81.78% versus 75.71%, p = 0.001 and 81.33% versus 78.91%, p = 0.010 respectively) 5. ↓ correct answers: Teachers without training (76.21% versus 82.41%, p < 0.001) 6.Teacher's eager to support diabetic pupils and believe in nutritional education for the public, ↑ scores (81.59% versus 72.22%, p < 0.001 and 81.26% versus 72.44%, p = 0.001)
Dixe et al.	2020	Portugal	129 pre / 113 post	School Staff (51.2% Teachers)	A quasi-experimental pre-test/post-test study design without a Control Group	Diabetes knowledge questionnaire (Best score: 17) Confidence questionnaire (4-point Likert)	1. Change in school personnel's self-reported confidence level before training vs. after training (x̄=9.8±3; P 50 =9.8 & x̄;=16.2 ±1.3; P 50 =16 & Wilcoxon=-9.536; p<0.001) 2. knowledge TO vs T1 (x̄=10.8±2.8; P 50 =11 & x̄=13.7±2.1; P 50 =11) were significant (Wilcoxon=-7.914; <0.001) 3. 78.85% of the personnel ↑ their knowledge level 4. Positive correlation between the level of knowledge and level of confidence (rs=220; p<0.05) 5. Positive correlation between the years of professional experience and knowledge (p<0.05)
Gökçe et al.	2020	Turkey	55,677 (56% Female)	School Staff	Cross-sectional survey	Questionnaire scores (knowledge/ attitudes)	1. No Knowledge of pupil with diabetes: 50% among Teachers, 10% managers, 3% nurses (p< 0.05) 2. Mean knowledge: 17.7 / 39 3. Mean attitude score: 9.6 / 16 4. ↑scores in females (p<0.001) 5. ↑ scores in knowledge & attitude from teachers with pupils with diabetes or trained (p<0.001) 6. School nurses had ↑score (p<0.001) 7. ↑ scores in private sector (p< 0.001) 8. mean attitude score of school staff who take care of children under ten (9.7 vs 9.5, p < 0.0001); mean knowledge (17.3 vs 18, p < 0.0001) 9. physical education teachers: ↑ scores (<0.001) 10. Istanbul had ↑ scores (p<0.001)

Twig et al.	2020	Israel	1,462,362 59% men, mean age 17.4 years)	16-19 evaluation before military	Population study	Incidence rates per BMI range	1. Interaction between sex, BMI, T2D (unadjusted model P = 0.004, multivariable model P = 0.023). 2. Adjusting for age, birth year, education, and cognition had little impact on BMI-related risk. 3. High HRs for diabetes onset before age 25 years persisted: Men • Overweight: 3.2 (2.1–4.9) • Mild obesity: 12.1 (8.5–17.5) • Severe obesity: 27.0 (17.9–40.7) Women • Overweight: 6.6 (4.4–9.8) • Mild obesity: 12.8 (8.2–20.0) • Severe obesity: 45.3 (28.9–71.0) • 4. Diabetes of uncertain type (405 cases): point estimates ↑ consistently across BMI groups • Men: Severe obesity: HR 6.0 (3.5–10.5) • Women: Severe obesity: HR 9.0 (3.8–21.4) • 5. Fractions of incident T2D attributable to overweight/obesity: Men: • 51.5% (48.3–54.7%) • Based on mean prevalence: 17.9% Women: • 54.6% (50.2–59.0%) • Based on mean prevalence: 15.6%
Luque-Vara et al.	2021	Spain (North African Coast)	441	non-university teachers	observational, descriptive, cross-sectional	Questionnaire scores (knowledge/ attitudes)	1. Positive correlation between teachers' age & Teachers' perception of the institution's capacity (p = 0.038) 2. 39.2% did not feel ready administrating glucagon 3. 4.8% indicated receiving diabetes training 4. 17.7% acknowledge they currently teach students with T1DM
Snelling et al.	2023	USA	92 1302	Teachers Students (1st-5th grade)	Five-year intervention project	Self-efficacy & teachers' behavior to nutrition education	1. Teachers that attended the intervention were more likely to include nutrition in school (r = 0.54, p < 0.01) 2. students ↑ Knowledge: (p < 0.001, df = 2, F = 9.66); when 3 or more lessons, knowledge ↑8-10% (p<0.001) 3. Teachers with lower stress were more likely to include nutrition in school (p<0.01) 4. Teachers who attended 1 or more courses had lower stress (mean score 2.2 Vs mean score 3.8) (t = 2.41, df = 17, p < 0.05)
Ameneh et al.	2023	Iran	168	Female Students (8th grade)	Peer-led cluster RCT	Knowledge, attitudes, behaviors	Knowledge, attitudes, behaviors ↑ (p<0.001) (means±SD: 19.85 ± 79.23 pre-test; 2.84 ± 90.93 2 months after- ANCOVA analysis)
Bassi et al.	2024	Italy	225 staff (19 schools)	Staff	Comparative cross-sectional	knowledge & confidence Between-group only (not pre/post)	1. theoretical knowledge T1D: 53 that attended the training (Group A: median 10, IQR: 10–11) & 154 who did not (Group B: median 12, IQR: 11–12, p < 0.001) 2. Trained staff ↑ knowledge, confidence & ability (p<0.001; p=0.004–0.01)
Stefanowicz-Bielska et al.	2024	Poland	808 (86.4% Female)	Teacher	Cross-sectional survey	Knowledge assessment	1. Median knowledge score 20/29 2. Only 31.8% had training for T1DM

Confidence was another important outcome assessed after the application of educational programs or through surveys. For instance, Dixe et al. found that school personnel's self-reported confidence levels increased substantially after training (pre-training: 9.8 ± 3; post-training: 16.2 ± 1.3). Similarly, staff who received training reported significantly higher levels of knowledge, confidence, and ability ($p < 0.001$; $p = 0.004–0.01$) (18). In addition, Snelling et al. found that teachers who attended one or more courses reported lower stress levels (mean score: 2.2 vs. 3.8; $p < 0.05$) [22]. Conversely, without the implementation of an educational program, a large proportion of teachers (39.2%) reported not feeling prepared to administer glucagon in the study conducted by Luque-Vara et al., [20].

Several studies also examined the influence of teacher and school characteristics. Gökçe et al. found that higher knowledge scores were associated with being female ($p < 0.001$), working in the private sector ($p < 0.001$), or being a physical education teacher ($p < 0.001$). Additionally, teachers who had students with diabetes in their classrooms scored significantly higher ($p < 0.001$) [19].

Risk of Bias Assessment

Risk of bias was assessed using the Cochrane Risk of Bias 2.0 tool (ROB 2) for randomized controlled trials (RCTs), and the ROBINS-I tool for non-randomized and observational studies. The results are summarized in Tables 2 and 3.

Table 2: Risk of Bias (ROB 2) for Randomized Controlled Trials

Study	Year	Randomization Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of the Outcome	Selection of the Reported Result	Overall Risk of Bias
Venditti et al.	2012	Low	Low	Low	Low	Low	Low
Salameh et al.	2017	Low	Low	Low	Low	Low	Low
Dixe et al.	2020	Some concerns	Low	Low	Low	Low	Low
Snelling et al.	2023	Some concerns	Low	Low	Low	Low	Low
Ameneh et al.	2023	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns

Table 3: Risk of Bias (ROBINS-I) for Non-Randomized Studies

Study	Year	Bias due to Confounding	Bias in Selection of Participants	Bias in Classification of Interventions	Bias due to Deviations from Intended Interventions	Bias due to Missing Data	Bias in Measurement of Outcomes	Bias in Selection of Reported Result	Overall Risk of Bias
Siminerio & Koerbel	2000	Moderate	Low	Low	Low	Moderate	Moderate	Moderate	Moderate
Smith et al.	2012	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Davis et al.	2007	Serious	Moderate	Moderate	Moderate	Serious	Serious	Serious	Serious
Metos et al.	2019	Serious	Serious	Serious	Serious	Moderate	Serious	Serious	Serious
Chatzistougianni et al.	2019	Serious	Serious	Moderate	Moderate	Moderate	Serious	Moderate	Serious
Gokce et al.	2020	Moderate	Serious	Moderate	Serious	Moderate	Moderate	Serious	Serious
Twig et al.	2020	Low	Low	Low	Low	Low	Low	Low	Low
Luque-Vara et al.	2021	Moderate	Serious	Moderate	Serious	Moderate	Serious	Moderate	Serious
Taha et al.	2018	Moderate	Moderate	Low	Low	Low	Low	Moderate	Moderate
Bassi et al.	2024	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Stefanowicz-Bielska et al.	2024	Serious	Serious	Moderate	Moderate	Low	Serious	Moderate	Serious

Among the included studies, five were randomized or quasi-randomized trials, assessed using ROB 2. Of these, only two were judged to have low risk of bias across all domains, while the remaining three raised some concerns, particularly in the domains of outcome measurement and selection of the reported results.

The other 11 studies were non-randomized (including cross-sectional and quasi-experimental designs) and were evaluated using ROBINS-I. Four studies were rated as having moderate overall risk, and six were judged to have a serious risk of bias, commonly due to confounding, participant selection, and lack of standardized outcome assessment.

Importantly, the five studies included in the meta-analysis were among those rated as low to moderate risk of bias.

Meta-Analysis

Out of the 16 studies, four were eligible for meta-analysis, which assessed changes in diabetes knowledge following interventional educational programs. Figure 2 presents the illustrated results of the meta-analysis in a forest plot. Positive values indicated higher diabetes knowledge after training, whereas negative values suggested higher knowledge before training. The vertical line at zero represented no effect. All of the included studies demonstrated a statistically significant positive effects (Cohen's d = 2.29, 1.10, 2.00, and 1.16, respectively; all p = 0.00) [12,18,26,28] with the overall analysis showing a statistically significant improvement in knowledge (Cohen's d = 1.65, p = 0.00).

However, significant heterogeneity was observed across studies ($I^2 = 92\%$). Funnel plot analysis revealed a non-strongly symmetrical result, with limited representation (small-sized blue dots) due to the small number of included studies. Further evaluation using Egger's test yielded non-significant evidence for publication bias (p = 0.178), with wide confidence intervals (95% CI: –2.941 to 8.257) and a positive value (1.7171) [8-10]. The two analyses can be seen in

Supplementary Figure 1(a) & (b)

Certainty of evidence using GRADE was assessed as moderate (Table 4.) due to mostly generated risk of bias, high heterogeneity indicating inconsistency, small number of included studies and absence of indirect evidence as well as impression, since there were not wide confidence intervals presented [11].

Table 4: GRADE Summary of Findings Table: Certainty of Evidence for Knowledge Outcomes

Outcome	No. of Studies	Certainty Rating	Reason for Downgrade
Knowledge improvement	5	Moderate	Mostly moderate Risk of bias, Serious inconsistency ($I^2 = 97\%$), small number of studies

Note: Certainty rating based on GRADE methodology. Downgrades applied for risk of bias, inconsistency, indirectness, imprecision, and limited number of included studies.

Discussion

This systematic review provides comprehensive insights into the impact of nutrition education interventions targeting school personnel on the prevention and management of diabetes and obesity among adolescents. The findings emphasize the crucial role of teachers and school staff in health promotion within educational settings and highlight both the opportunities and challenges of implementing effective school-based interventions.

A key finding of this review is the improvement in knowledge following targeted school-based interventions. Our meta-analysis included four studies assessing knowledge outcomes, comprising 522 participants in the intervention group and 506 in the control group. Using a random-effects model, the pooled Cohen's d was 1.65 (95% CI: 1.07 to 2.23; $p = 0.00$), indicating a statistically significant effect favoring the intervention group.

Several studies also evaluated changes in confidence, reporting improved self-efficacy and reduced stress among educators who participated in the interventions compared to those without prior experience. A recurring theme across multiple studies was the limited baseline knowledge among educators. Survey data further indicated that confounding factors -such as sex, employment sector (public vs. private), and other demographic characteristics- may influence baseline knowledge levels.

These findings underscore the need for both systematic staff training and broader school-wide support mechanisms to ensure sustained improvements in the prevention and management of adolescent diabetes and obesity within educational settings.

Recent systematic reviews support these findings. A Cochrane update covering studies from 2015 to 2021 concluded that school-based interventions can produce small but consistent reductions in BMI among children and adolescents, with a pooled SMD of -0.03 (95% CI: -0.06 to -0.01) [29]. Similarly, a secondary analysis of randomized controlled trials identified that behavior change techniques such as goal-setting, social support, and peer comparison were positively associated with weight outcomes [30]. These results reinforce the importance of embedding evidence-based pedagogical strategies within school curricula to maximize student health benefits.

Effective Pedagogical Models

In the United States, programs that incorporated experiential learning methods- such as role-playing and group activities- showed promising results in enhancing teacher self-efficacy and student engagement [22]. The recent study by Ameneh et al. further demonstrated that peer-led, participatory approaches can generate significant improvements in adolescents' health literacy [23]. Together, these findings support the use of innovative pedagogical models in school-based health education.

With regard to diabetes management, multiple studies highlight the potential of targeted school-based interventions to improve both educator preparedness and student outcomes. A systematic review by [31] and Schulz reported that diabetes-focused educational programs enhance students' quality of life and metabolic control, particularly when supported by strong school -family- healthcare collaboration [31].

These observations are consistent with the American Diabetes Association's 2024 recommendations, which emphasize the importance of standardized training, clear management protocols, and comprehensive school-wide safety strategies for students with type 1 diabetes [32].

This study has several notable strengths. It provides a comprehensive review of the topic, conducted in accordance with PRISMA guidelines and Cochrane protocols. The research question was clearly defined using the PICO model, and efficient search strategies employing Boolean operators were applied. Where data permitted, meta-analyses were performed. The inclusion of surveys, both physical and online school-based programs, as well as large population studies, broadens the scope and offers multiple perspectives on the need for nutritional education. Furthermore, the study provides practical insights into school-based nutritional strategies to promote adolescent health in relation to obesity and diabetes. Statistically significant improvements in knowledge were observed following school-based interventions. The risk of bias assessed with ROB 2 was predominantly low. However, certain limitations should be acknowledged. Substantial heterogeneity was observed, and additional methodological differences across studies limited comparability and contributed to inconsistency. Confounding factors such as sex, workplace setting, and prior training also appeared to influence outcomes. Bias was rated as moderate to serious in many non-RCT studies, as identified using the ROBINS-I tool. Wide confidence intervals and positive value in Egger's regression and slight asymmetry in the funnel plot suggest uncertainty; however, due to non-statistically significant results in the regression we cannot confirm publication bias [8-10]. The certainty of evidence was graded as moderate indicating that the provided results can support the outcomes, but further research is necessary [11].

Conclusion

This systematic review highlights the vital role of educator-focused nutrition and health interventions in improving school personnel's ability to prevent and manage adolescent obesity and diabetes. Structured training enhances staff preparedness and student health literacy, but evidence is limited by heterogeneity, methodological variability, and scarce long-term follow-up. Sustainable, equitable improvements require a whole-school approach integrating professional development, evidence-based curricula, supportive policies, and collaboration with families and healthcare providers. Strengthening school-based capacity through rigorous, culturally adapted interventions is both an educational priority and a public health imperative.

Disclosure Statements
The authors declare no conflicts of interest related to this work. No funding was required for the preparation of this article. This study was supported by the University of Nicosia.

Acknowledgements: The authors would like to thank all colleagues who provided valuable input and support during the preparation of this review.

Financial Support: This research received no external funding.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authorship
N.C: Conceptualization, methodology, formal analysis, data curation, writing—original draft preparation
M.M: methodology, formal analysis, data curation, writing—original draft preparation, writing—review and editing
E.A: Conceptualization, methodology, formal analysis, writing—review and editing, supervision
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All authors have read and agreed to the published version of the manuscript.

Ethical Standards Disclosure: The study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. There were no other ethical requirements.

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