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REVIEW

Effectiveness of nutrition interventions in Australian secondary schools: A systematic review

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Abstract

Issue Addressed: Dietary intake of Australian adolescents is suboptimal. Schools are an ideal setting for health promotion initiatives to develop healthy lifestyle behaviours among adolescents. However, we do not know which nutrition-focused, school-based interventions are effective at improving health outcomes in adolescents in Australia. Therefore, the aim was to evaluate the effect of nutrition interventions on health outcomes in Australian secondary school students.

Methods: MEDLINE, EMBASE, CINAHL, ERIC and Informit were systematically searched on 4th November 2022. Studies in any language evaluating nutrition interventions implemented in Australian secondary schools were included. Studies evaluating interventions conducted in primary schools or outside the school setting were excluded, as were any grey literature, systematic reviews and meta-analyses. Screening and data extraction were performed in duplicate. Quality was assessed using the Mixed Methods Appraisal Tool.

Results: Thirteen studies ($n = 27\ 224$) reporting on nutrition interventions implemented in Australian secondary schools were included. Studies were conducted in five different states and a capital territory within Australia and were mostly randomised controlled trials. Most studies reported a significant improvement on nutrition-related health outcome measures (dietary behaviour $n = 6$, nutritional knowledge and attitudes $n = 4$ and anthropometric $n = 1$).

Conclusions: This review found limited studies reporting on nutrition interventions in Australian secondary schools. However, most were shown to be effective in improving nutrition-related health outcomes.

So What? Since there were limited studies in peer-reviewed journals, more research in this area is needed to confirm the effectiveness of nutrition interventions in Australian secondary schools and to assess long-term effects on student's health outcomes.

KEYWORDS

Australia, effectiveness, nutrition intervention, school health services, school-based, schools

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1 | INTRODUCTION

Good nutrition, such as nutrient-dense foods, is important for proper growth and development during adolescence. The World Health Organization (WHO) defines adolescence as a transitional stage between childhood and adulthood, between the ages of 10 and 19, and is a unique stage of human development characterised by rapid physical, cognitive and psychosocial growth.¹ A healthy, balanced and nutritious diet ensures nutrient requirements are met, promoting health and well-being and protecting against non-communicable diseases such as diabetes, cardiovascular disease, stroke and cancer.² Establishing healthy food behaviours during childhood is also beneficial long term, as it will be conveyed into adulthood. Furthermore, a balanced diet can improve mental health,³ cognitive skills such as memory and concentration³ and academic performance.⁴

The transition from childhood to adolescence is usually associated with a shift to unhealthy eating practices. These are seen as a reduction in the consumption of fruit and vegetables and instead opting for more energy-dense, nutrient-poor choices such as sugar-sweetened beverages and high-fat foods.^{5,6} Research highlights an increasing trend in the consumption of fast foods rich in unhealthy fats, sodium and sugar among adolescents, increasing their risk of developing chronic health conditions in adulthood.^{6–10} Furthermore, surveys focused on nutrition among adolescents have revealed inadequate intakes of vitamins and minerals.⁸ In Australia, there has been a rise in unhealthy dietary practices among adolescents, along with sedentary lifestyle behaviours and reduced physical activity.^{11,12} Food choices may also differ between genders, as research has highlighted that girls make healthier food choices than boys.¹³ In 2017–2018, the Australian Institute of Health and Welfare¹¹ reported adolescents aged 15–18 did not meet the national fruit (two serves/day) and vegetable (five serves/day) guidelines recommended for their age. Furthermore, a greater proportion (71%) of young males (15–18 years old) consumed sugar-sweetened beverages once a week compared to females (54%). Thus, there is a need to improve nutritional intake in this population through interventions focused on improving dietary behaviours.

There has been a rapid rise in recognising the promising role of schools in promoting healthy behaviours among adolescents.^{14,15} Schools have been identified as an ideal setting for health promotion initiatives that aim to develop healthy lifestyle behaviours in adolescents through a healthy food environment.^{8,16} School settings also allow health initiatives to reach a larger audience with more diverse ethnic and socioeconomic backgrounds.⁶ Globally, multi-component nutrition interventions implemented in schools within developed countries have been reported to be effective.^{17,18} Furthermore, nutrition interventions using theoretical frameworks such as the Socio Ecological Theory of Behaviour Change, Social Cognitive Theory (SCT), Theory of Planned Behaviour and Transtheoretical Model have been reported as a feature of successful interventions.⁶ Additionally, interventions designed using WHO's Health Promoting Schools (HPS) framework have been reported to be effective in improving healthy eating behaviour among school students in some studies.¹⁹

The effectiveness of school-based interventions may also differ depending on the setting within which the intervention is delivered (pre-primary, primary or secondary schools). This is due to the varied food environments and school food policies in primary and secondary schools.²⁰ A systematic review published in 2022⁶ highlighted that nutrition interventions within a school-based setting have been reported across different age range of children including primary and secondary school students. Additionally, several umbrella reviews^{6,16} report their effectiveness in generating positive health behaviour changes. However, no review-level evidence reporting on nutrition interventions has been conducted for secondary schools in Australia. Research suggests that the school food environment, such as food provision, nutrition education and healthy school policies, can be instrumental in developing healthy lifestyle practices in secondary school students.²¹

Globally, previous systematic reviews have been conducted on the effectiveness of nutrition interventions in secondary schools.^{6,16} However, no systematic review has been conducted exclusively addressing nutrition interventions in secondary schools within Australia. Moreover, effective interventions identified in other countries have not been translated to the Australian setting, such as meal provision in schools and interventions focused on improving menus. Therefore, a comprehensive analysis of all available research within the Australian context is essential to inform details of future interventions. It will help identify age-appropriate, multi-component interventions that successfully improve Australian adolescents' health-related outcomes. Furthermore, it will provide a foundation for evidence-based public health prevention programs in Australia. Thus, the main objectives of this systematic review are to (1) describe the various nutrition interventions implemented in Australian secondary schools and (2) report their effectiveness in improving nutrition-related health outcomes of students.

2 | METHODS

This systematic review was reported per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The Cochrane Handbook for Systematic Reviews of Interventions²² was used to inform the review. It was preregistered in PROSPERO with registration no. CRD42022374357.

2.1 | Eligibility criteria

The inclusion criteria were (1) studies targeting students in secondary schools, (2) any intervention studies that included a nutrition component that had been implemented in a school setting, (3) studies conducted in Australia and (4) studies in any language. The list of all nutrition components used in the search strategy can be found in the Supporting Information, S1. The exclusion criteria were (1) studies targeting students in primary schools, (2) interventions that were conducted outside the school setting (e.g., community and home settings) and (3) any grey literature, systematic reviews and meta-analyses. Systematic reviews and meta-analyses were excluded as it was identified during pre-screening

that none had been conducted exclusively in Australia. Those done worldwide that included some Australian studies in their review, identified in pre-screening, were hand searched for the Australian studies.

2.2 | Study selection

Five electronic databases were searched, including MEDLINE, EMBASE, CINAHL, ERIC and Informit, from database inception on 4 November 2022. An initial search strategy was designed in PubMed and translated to the other databases using PolyGlott.²³ A full search strategy can be found in Supporting Information, S1.

All search results were exported into an EndNote X7.1 Library and deduplicated using the Systematic Literature Review Accelerator.²⁴ Remaining references were imported into Covidence 2022 for eligibility screening. Titles and abstracts were screened in duplicate and conflicts were resolved through discussion with a third author. Following this, full text of each study was sourced and screened in duplicate. Conflicts were resolved through discussion with a third author. Reason for exclusion at full text (wrong intervention, wrong patient population, full text not available and wrong setting) was recorded. The reference lists of included studies were hand-searched to retrieve any additional relevant articles.

2.3 | Data extraction

All data were extracted by one author (AC and LB) and checked by a second using a table template. Relevant data from identified papers were extracted using the following elements: first author, year of publication, study design, location, sample size, study characteristics, participant characteristics, intervention characteristics, outcome measures and key findings. Nutrition-related outcome measures, in addition to all other outcome measures reported in the studies, were extracted. The socioeconomic status of the schools was extracted from each study and was categorised inductively into either 'most disadvantaged', 'least disadvantaged' or 'less disadvantaged'. Basic statistical analysis was performed to provide a percentage for each category. Study investigators did not contact any authors as no data were missing from the included studies. Extracted intervention components were categorised inductively. If enough randomised controlled trials (RCTs) or pseudo-RCTs were identified with homogenous samples and outcomes, a meta-analysis would be conducted.

2.4 | Quality assessment

Two authors independently appraised the methodological and design quality of the included studies using the Mixed Methods Appraisal Tool (MMAT) version 2018,²⁵ and a third author resolved disagreements. The checklist followed a 'Yes', 'No' and 'Cannot tell' question structure. It included two initial screening questions for all study designs and five questions within each study design category

(qualitative, RCTs, non-randomised, quantitative descriptive and mixed methods) to assess the quality of the studies.

3 | RESULTS

3.1 | Selection process

The database search identified 6271 studies, and two studies were identified by hand-searching. After removing duplicates and screening titles and abstracts, 44 studies were retrieved for full-text screening. Six studies were described in more than one paper. A total of 25 papers describing 13 studies ($n = 27\,224$) were included in this systematic review. Reasons for exclusion were mainly related to the intervention (not containing a nutrition component) and population (conducted in a primary school). The study selection process is illustrated as a PRISMA flow chart in Figure 1.

3.2 | Characteristics of included studies

Table 1 displays the characteristics of the included studies. Studies were conducted across five states and territories within Australia, including New South Wales ($n = 7$),²⁶⁻⁴⁴ Queensland ($n = 3$),^{26,45,46} Victoria ($n = 1$),^{47,48} Western Australia ($n = 1$),²⁶ Australian Capital Territory ($n = 1$)⁴⁹ and across Australia ($n = 1$).⁵⁰ Of the 13 studies, 6 studies^{26-37,47,48} were cluster RCTs, 1 study³⁸⁻⁴⁰ was a two-by-two factorial RCT, 4 studies^{41-44,49,50} were quasi-experimental, while 2 studies^{45,46} were mixed-method case studies. Studies ranged in duration from 25 days to 4 years (ongoing at the time of this review). Sample sizes of the studies range from $n = 66$ to $n = 8992$. Participants were secondary school students from grades 7-11. Six studies focused on individual grades, six studies focused on a combination of two or more grades and one study focused on all grades. One study²⁷⁻³¹ had only girls as participants, and six studies^{32-36,38-40,42-44,46,49} had reported both boys and girls as participants. The percentage of female participants in these six studies ranged from 45% to 56% of the total. Six studies^{26,37,41,45,47,48,50} did not disclose participant's gender information. The socioeconomic status of the schools was reported by 10 studies.^{28-45,47-50} From the 10 studies, 45% ($n = 64$) were 'most disadvantaged' schools, 28% ($n = 38$) were 'least disadvantaged' schools ($n = 40$), and 27% ($n = 37$) were 'less disadvantaged' schools. The types of schools were reported by nine studies.^{28-32,35-41,43-50} From the nine studies, 70% ($n = 94$) were 'government' schools, 13% ($n = 18$) 'independent schools' and 8% ($n = 11$) 'Catholic' schools. A few schools were reported to be 'independent or Catholic' (9%; $n = 12$).

3.3 | Nutrition interventions implemented in Australian secondary schools

All studies adopted a multi-component approach, and the majority followed a theoretical framework in implementing the intervention.

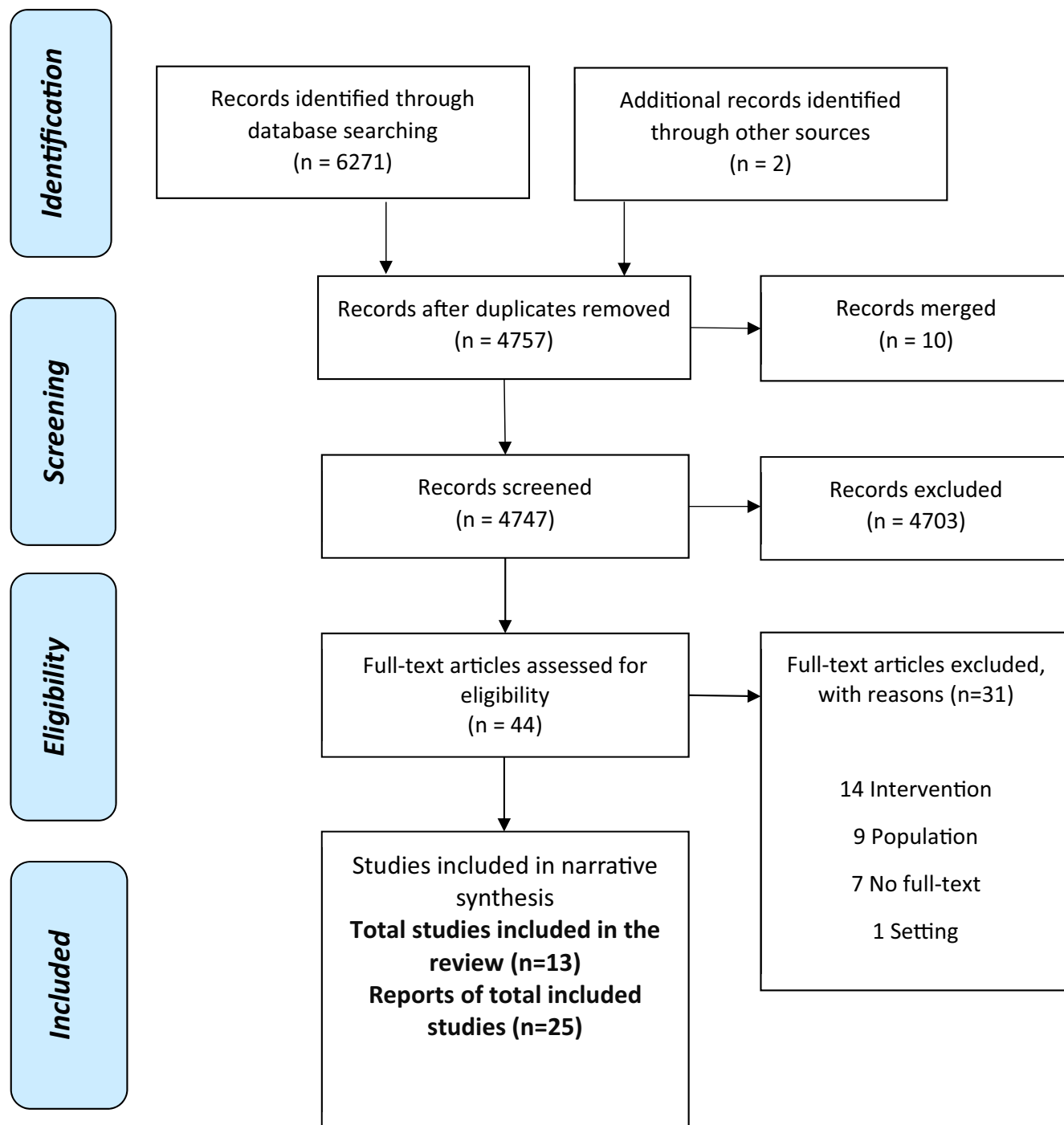


FIGURE 1 PRISMA flow chart of the selection process. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Almost half of the studies used WHO HPS Framework or WHO Health System Framework (building blocks). Table 2 shows the intervention details of the studies, summarising the aim, description of nutrition intervention, nutrition intervention components, and theory used. All interventions summarised in this review were multi-component. Five main intervention components were identified from analysing the studies—educational, environmental, parental/community involvement, physical activity and multimedia. Twelve studies^{26–36,38–50} contained an educational component, 10 studies^{27–}

^{36,38–40,42–46,49,50} contained an environmental component, 10 studies^{27–36,38–49} contained a parental/community involvement component, 8 studies^{26–33,37–40,42–44,47–49} contained a multimedia component and 4 studies^{26–33,41} contained a physical activity component. A mix of theories were used to guide the development of the intervention components. Eight of the included studies^{26–36,38–40,46–49} used a single theory, three studies^{37,42–45} used a combination, and two studies^{41,50} did not use a guiding framework or theory. WHO HPS Framework was used in four studies,^{34–36,38–40,42–44,46} one

TABLE 1 Characteristics of included studies.

Study references	Program name	Location	Duration	Participants	Setting
<i>Cluster randomised controlled trials</i>					
Teesson et al. ²⁶	Health4Life	NSW, QLD and WA	4 years (ongoing)	Grade 7 students (n = 7200)	72 secondary schools Government, Catholic and Independent (n = 72)
Brown et al. ⁴⁷ Brown et al. ⁴⁸	Supporting Healthy Image, Nutrition and Exercise (SHINE)	Melbourne – Vic	4 years (ongoing)	Grade 7 students (n = 3600)	15 secondary schools Government (n = 9) Catholic or independent (n = 6) Most disadvantaged (n = 2) Less disadvantaged (n = 6) Least disadvantaged (n = 7)
Lubans et al. ²⁷ Lubans et al. ²⁸ Dewar et al. ²⁹ Dewar et al. ³⁰ Collins et al. ³¹	The Nutrition and Enjoyable Activity for Teen girls (NEAT girls)	Hunter Region and Central Coast – NSW	12–24 months	Grade 8 students (n = 357) 100% female Mean age 13.2	12 secondary schools Government (n = 12) Most disadvantaged (n = 12)
Lubans et al. ³² Lubans et al. ³³	Program X	Newcastle – NSW	6 months	Grade 8 students (n = 124) 57% female Mean age 14.1	6 secondary schools Less disadvantaged (n = 6)
Ooi et al. ³⁴ Ooi et al. ³⁵ Sutherland et al. ³⁶	Switch Ur Sip	Hunter Region – NSW	6 months	Grade 7–9 students (n = 862) 51% female	6 secondary schools Catholic (n = 2) Independent (n = 4) Most disadvantaged (n = 5) Less disadvantaged (n = 1)
Delaney et al. ³⁷	Click & Crunch High Schools	NSW	2 months	Grade 7–11 students (n = 1331)	9 secondary schools Government (n = 3) Independent or Catholic (n = 6) Most disadvantaged (n = 3) Least disadvantaged (n = 6)
Kajons et al. ³⁸ Gowland-Ella et al. ³⁹ Gowland-Ella et al. ⁴⁰	Thirsty? Choose Water!	Central Coast, Illawarra, Shoalhaven and South West Sydney – NSW	12 months	Grade 7 students (n = 8992) 45% female	61 secondary schools Government (n = 42) Catholic (n = 6) Independent (n = 13) Most disadvantaged (n = 20) Less disadvantaged (n = 20) Least disadvantaged (n = 21)
<i>Quasi-experimental studies</i>					
Malakellis et al. ⁴⁹	It's Your Move!	Canberra – ACT	3 years	Grade 7–10 students (n = 717) 44% female Mean age 12.9	6 secondary schools Government (n = 6) Most disadvantaged (n = 3) Less disadvantaged (n = 3)

(Continues)

TABLE 1 (Continued)

Study references	Program name	Location	Duration	Participants	Setting
Simons and Simons ⁴¹	Health Lifestyle Program	Sydney – NSW	3 years	Grade 7, 8 and 10 students	4 secondary schools Most disadvantaged (n = 2) Less disadvantaged (n = 2)
Shah et al. ⁴² Foley et al. ⁴³ Shrewsbury et al. ⁴⁴	Students As LifeStyle Activists (SALSA)	Western Sydney – NSW	25 days	Grade 8 and 10 students (n = 3722) 55% female	22 secondary schools Government (n = 19) Catholic (n = 3) Independent (n = 1) Most disadvantaged (n = 16) Least disadvantaged (n = 6)
O'Dea ⁵⁰	Body Basics	Across Australia	Unknown	Grade 7–10 students	~1000 secondary schools
<i>Case studies (mixed methods)</i>					
Perry et al. ⁴⁵	Nutrition Education Program	Rural QLD	12 months	Grade 8 students (n = 253) Mean age 13	2 secondary schools Government (n = 2)
Viola ⁴⁶	Outreach School Garden Project	Doomadgee and Dajarra – North-West QLD	6 months	Grade 7–9 students (n = 66) 56% female	1 secondary school Government (n = 1) Most disadvantaged (n = 1)

Abbreviations: ACT, Australian Capital Territory; NSW, New South Wales; QLD, Queensland; Vic, Victoria; WA, Western Australia.

study⁴⁹ used WHO Health System Framework (building blocks), and three studies^{27–33,42–44} used Bandura's SCT. Frameworks used by one study only included Action Research Model,⁴⁵ PRECEDE Model,⁴⁵ Freire's Empowerment Education Approach,^{42–44} Choice Architecture,³⁷ New South Wales Healthy School Canteen Strategy,³⁷ Cognitive Behavioural Theory^{47,48} and Staged Prevention Approach.²⁶

3.4 | Effectiveness of interventions in improving nutrition-related health outcomes of students

Most studies in this review reported a significant intervention effect on at least one nutrition-related health outcome measure reported in this review, as shown in Table 3. Nutrition-related health outcomes include dietary behaviours, nutritional knowledge and attitudes and anthropometry. Six of the 13 studies reported a significant improvement in dietary behaviour and 4 studies reported a significant improvement in nutritional knowledge and attitude outcome measures. One study reported significant improvements in anthropometric outcome measure. Due to the heterogeneity of the reported outcomes, a statistical analysis or meta-analysis was not conducted.

3.4.1 | Changes in dietary behaviour outcome measures

Significant improvements were reported for fruit and vegetable intake,^{32,33} consumption of energy-dense/low nutrient foods,^{32,33} sugar-sweetened beverage intake,^{34–36} water intake,^{38–40} grain intake,⁴⁵ breakfast consumption^{42–44} and water bottle usage.^{38–40} Furthermore, one study³⁷ reported a significant improvement in mean percentage of 'Everyday' items and 'Should not be sold' items. Two studies^{27–31,49} reported no significant effects for percentage of energy from core food groups and energy-dense nutrient-poor foods, and consumption of fruits and vegetables, soft drinks and cordials, or snack foods, while one study²⁶ is still underway (expected completion December 2022) and has not reported any changes in dietary behaviour outcome measures at the time of this review.

3.4.2 | Changes in nutritional knowledge and attitude outcome measures

Significant improvements were reported for knowledge about nutrition,⁴⁵ sugar-sweetened beverages^{38–40} and availability of healthy eating programs.⁴⁹ Attitudes concerning nutrition were significantly improved in one study.⁴¹ One study⁴⁶ reported no significant effects for drawing foods that represent healthy choices and correctly indicating the category a particular food item belonged to on the 'Healthy Food Pyramid'.

TABLE 2 Intervention details.

Program name and references	Aim	Description of nutrition intervention (what was delivered, by whom and how)	Nutrition intervention components						Theory used
			EDU	ENV	PCI	PA	MM		
Health4Life ²⁶	To evaluate the effectiveness of the Health4Life program on lifestyle risk behaviours (alcohol use, smoking, poor diet, physical inactivity, poor sleep and sedentary recreational screen time)	Weekly web-based modules that targeted poor diet as 1 of 6 risk factors; Delivered once per week via interactive cartoon storylines; Accompanied by activities delivered during health education and a smartphone application	X			X		X	Staged Prevention Approach
SHINE ^{47,48}	To explore the potential economic impacts of implementation and scale-up on a healthy weight and body image intervention	Multiple brief online education modules on nutrition over 8 weeks (delivered by teachers); Intervention replaced the usual Health and Physical Education classroom-based curriculum; Available for parents to access via a website	X		X			X	Cognitive Behavioural Theory
NEAT girls ²⁷⁻³¹	To evaluate the effects of the NEAT Girls program designed to prevent unhealthy weight gain in adolescent girls living in low-income communities	Three nutrition workshops providing dietary information and focus on the preparation of healthy, inexpensive meals (delivered by a dietitian); Nutrition handbook that includes home challenges to promote healthy eating; Newsletters to parents that contain information to support healthy eating habits at home; Text messages or emails sent to students to encourage healthy eating or provide strategies to overcome barriers to healthy eating	X	X	X	X	X	X	Bandura's Social Cognitive Theory
Program X ^{32,33}	To examine the mechanisms of physical activity and dietary behaviour change in the Program X intervention	Interactive summary lecture on healthy eating (delivered by the research team); Nutrition messages incorporated into sports sessions (delivered by teachers); Nutrition handbooks for parents; Monthly healthy eating information and support included in newsletters and messages then emailed to parents	X	X	X	X	X	X	Bandura's Social Cognitive Theory
Switch Ur Sip ³⁴⁻³⁶	To assess the effectiveness of a school-based SSB intervention in reducing daily SSB consumption and daily percentage energy from SSBs of secondary-school students	Two nutrition education lessons related to SSBs (delivered by teachers); Six fortnightly health messages sent to students and parents via an electronic communication channel; Month-long school challenge to encourage students with plans to reduce SSB from their diets (carried out by a student committee); Reduced availability of SSBs in canteens and vending machines; Increased SSB pricing by 20%; Installation of two water bottle refill stations in school grounds	X	X	X			X	Health Promoting Schools Framework
Click & Crunch High Schools ³⁷	To assess the impact of embedding choice architecture strategies into an online lunch ordering system on the nutritional quality of the school canteen lunch purchases of secondary school students	Changes to the online canteen system (Flexischools); Each menu item was labelled with either a green circle ('Everyday' foods), an amber circle ('Occasional' foods), or a red circle ('Should not be sold' or 'Caution' foods); Menu items were		X				X	Choice Architecture and NSW Healthy School Canteen Strategy

(Continues)

TABLE 2 (Continued)

Program name and references	Aim	Description of nutrition intervention (what was delivered, by whom and how)	Nutrition intervention components						Theory used
			EDU	ENV	PCI	PA	MM		
Thirsty? Choose Water! ^{38–40}	To determine if a behavioural intervention and/or the provision of chilled water stations increase water consumption in year 7 secondary students and changes students' knowledge, attitudes and behaviour regarding SSBs	positioned in order of healthiness; Before each lunch order being confirmed, the student received feedback summarising the nutritional content of the order; When a student chose an item from a healthy food category, they received a positive prompt, or if they chose an unhealthy item, they would get a prompt to include a fruit or vegetable snack or water Two 50 min lessons incorporating messages around water and SSBs incorporated into PDHPE lessons (delivered by teachers); Learning activities and resources included videos; Teachers had website access to ready-to-use PowerPoint presentations; Key messages around water and SSBs were reinforced via promotional materials; Messaging was also facilitated through the school-based vaccination program (delivered by nurses); Installation of one chilled drinking fountain	X	X	X	X	X	Health Promoting Schools Framework	
It's Your Move! ⁴⁹	To reduce unhealthy weight gain among adolescents through comprehensive school- and community-based systems changes to facilitate healthier lifestyles	Comprehensive 'Food at School policy' encompassing the whole food at school system. Strategies used included traffic light colour coding of food sold at the canteen, provision of healthy food at school events, healthy morning tea for staff, cooking classes outside of school for students and their families, increased access to water fountains, and health promotion presentations from community leaders	X	X	X	X	X	World Health Organization's Health System Framework (building blocks)	
Health Lifestyle Program ⁴¹	To influence attitudes and increase knowledge about health matters to improve lifestyle and to strengthen the systematic approach to the education of school children in matters of health	Nutrition lessons designed to teach students about sensible dieting, healthy food choices and food sustainability (delivered by teachers); Integrated nutrition education into the global teaching program	X	X	X	X	X	None	
SALSA ^{42–44}	To assess the impact of the SALSA program on Year 10 peer leaders' energy balance-related behaviours, and their intentions regarding these behaviours	A lesson on food choices (delivered by year 10 peer leaders); Lesson designed to integrate with the school curriculum; Teachers present to provide general supervision; Lesson included a video giving information about healthy food for young people and a 'lunch box lotto' game to increase awareness about a healthy lunch	X	X	X	X	X	Bandura's Social Cognitive Theory, Freire's Empowerment Education Approach, Health Promoting Schools Framework	

TABLE 2 (Continued)

Program name and references	Aim	Description of nutrition intervention (what was delivered, by whom and how)	Nutrition intervention components					
			EDU	ENV	PCI	PA	MM	Theory used
Body Basics ⁵⁰	To provide adolescents with information and activities to promote better nutrition, physical activity and sensible attitudes towards weight control and body image	Lessons on the topic of food and nutrition (influences on eating habits, food groups, fats, healthy eating pyramid, dietary guidelines, fad diets, sensible weight control) (delivered by teachers); Educational materials included nutrition fact sheets, lesson plans, overhead projection sheets, nutrition handouts, food and nutrition video, food and nutrition board game and healthy weight range poster	X	X				None
Nutrition Education Program ⁴⁵	To determine the feasibility of implementing a food and nutrition education program for Grade 8 in a rural high school setting	Rewritten home economics and health and physical education curriculum. Objectives: Raise awareness of the importance of nutrition behaviour for health; Deliver general and specific nutrition knowledge to increase behavioural capability; Raise awareness of the influence of taste, mood, advertising and convenience of food on adolescent food selection; Create positive attitudes towards healthy eating habits Addressed issues related to the canteen. Objectives: Increase variety of healthy foods; Increase involvement of students in its organisation and function; Commence writing a school canteen policy Facilitate increased communication with parents concerning the health of their children and themselves	X	X	X			Action Research Model, PRECEDE Model
Outreach School Garden Project ⁴⁶	To assess how effective school gardens are as a nutritional education tool in an Indigenous Australian school setting	Integrated nutrition education into school curriculum (delivered by teachers); School Garden used as a nutrition tool Activities included a weekly diary of the progress of the school garden, conversions of g/kg using the foods in the garden, group presentations about the school garden, action songs related to nutrition and the garden; Tuck shops included healthy items on the menu; Students participated in food preparation at tuck shop; Cooked nutritious lunch provided to the students at \$1/day; Established links with elders or community members who had gardens or wanted to start a garden	X	X	X			Health Promoting Schools Framework

Abbreviations: EDU, educational component; ENV, environmental component; MM, multimedia component; PCI, physical activity component; PA, parent/community involvement.

3.4.3 | Changes in anthropometric outcome measures

Significant improvements were reported for BMI z-scores and prevalence of overweight/obesity in one study.⁴⁹ Three studies^{27-31,34-36,41} reported no significant effects for weight, height, BMI, BMI z-scores and per cent body fat. One study^{47,48} is still underway (expected completion December 2022) and has not reported any changes in anthropometric outcome measures at the time of this review.

3.4.4 | Other outcome measures

Six studies^{26-33,42-44,47-49} reported on physical activity and sedentary behaviour outcome measures (participation in physical activity, time spent being physically active and number of steps per day) and six studies^{26-31,42-45,47-49} reported on social-cognitive outcome measures (self-efficacy, perceptions of environment, social support and outcome expectations). Included studies also reported on process, program and cost evaluation measures. Process/program evaluation measures included program attendance, adherence, acceptability, satisfaction, experiences, perspectives and benefits. Cost evaluation measures included total cost of the intervention and economic impacts of implementation and scale-up.

3.5 | Quality assessment

The overall quality assessment, using the MMAT,²⁵ of the 25 reports that make up the 13 included studies can be seen in Figure 2, and the quality assessment of each report can be seen in the Supporting Information, S1. Overall, most reports assessed using only the criteria for qualitative or quantitative categories (domains 1.0–4.0) were considered good quality—this included RCTs and quasi-experimental studies. Reports assessed using the criteria for a combination of qualitative, quantitative and mixed method categories (domains 1.0, 3.0 and 5.0) were considered of poor quality—this included case studies of mixed method. The main criteria with a larger proportion of reports assessed as ‘No’ or ‘Cannot tell’ included questions related to blinding of outcome assessors (2.4), appropriateness of measurements regarding the outcome and intervention (3.2), adequacy of the interpretation of qualitative and quantitative results (5.4) and adherence to quality criteria of each tradition of the methods involved (5.5).

4 | DISCUSSION

This systematic review aimed to evaluate the effect of school-based nutrition interventions on health outcomes in Australian secondary school students. Thirteen studies on nutrition interventions conducted in Australian secondary schools were identified. Most nutrition interventions from the included studies in this review were reported

to be effective in improving students' dietary behaviours and nutritional knowledge and attitudes when inclusive of an educational, environmental, parent/community involvement and multimedia component (multi-component).

This review found limited nutrition interventions implemented in Australian secondary schools published in peer-reviewed literature. Likewise, a similar systematic review¹⁴ conducted in Europe also found few nutrition interventions targeting school-aged adolescents ($n = 13$). The characteristics of the nutrition interventions in this review were similar to those presented elsewhere.¹⁴ For example, the interventions in the European study¹⁴ were all RCTs or quasi-experimental designs, and varied by duration, sample size and setting characteristics. Furthermore, the majority followed a theoretical framework, several adopted a multi-component approach, and the components identified were educational, environmental and parent/community involvement.

An important observation noted within this review was the use of theoretical frameworks and multi-component approach adopted in interventions targeted towards Australian secondary school students. Of the studies reporting successful outcomes in this review, all except two followed a theoretical framework. Additionally, nutrition interventions included in those studies all adopted a multi-component approach, and the majority combined an educational, environmental, parental/community involvement and multimedia component. These findings are similar to previous systematic reviews that analysed the effectiveness of school-based nutrition interventions.^{6,8,51-53} For example, Chen and Wilkosz⁵¹ reported that all successful interventions in their review aligned with a theory and adopted a multi-component approach combining nutrition, physical activity and technology. Meiklejohn et al.⁵² reported that all successful nutrition interventions in their review were multi-component in design, and more than 70% used a theoretical framework. An umbrella review by Capper et al.⁶ identified that dietary interventions that contributed to positive outcomes commonly combined an educational and environmental component (multi-component), used online/media and messaging, involved peers or parents, and used a behavioural theory. Moreover, findings from a review by Chaudhary et al.⁸ suggest that school-based interventions that include educational, food-focused, and family-involvement components are effective in improving dietary behaviours and nutrition-related attitudes, but not nutrition-related knowledge among participants. Our findings suggest that the combined use of an educational component, environmental component and community/parental component should be considered when designing interventions for Australian secondary school students in future interventions, given the success of these components in improving nutritional outcomes of students. Overall, the findings suggest that use of a multi-component approach and theoretical framework(s) might play a relevant role in successful nutrition interventions.

The weight-focused studies included in this review reported no effectiveness in improving anthropometric outcome measures, except one study.⁴⁹ Research highlights that health-centred rather than weight-centred approach may be a more appropriate intervention for

TABLE 3 Results of individual studies.

Program name and references	Outcome measures and evaluation measures						Data collection		Results summary		
	DB	A	Anthro	SB	SCV	PE	CE	Tools	Time points	Efficacy and quantitative results	Process/cost evaluation and qualitative results
Health4Life ²⁶	X			X	X	X		Online self-report survey	T1: Baseline T2: Post-intervention (6–8 weeks after baseline) T3: 12 months post T4: 24 months post T5: 36 months post	Clustered RCT is still underway (expected completion December 2022), and efficacy has not yet been estimated for outcome measures It is hypothesised that eHealth school-based intervention may have the potential to improve health outcomes by addressing the big 6 risk factors during adolescence	Process outcomes such as satisfaction and relevance of the program will be assessed after completion of Health4Life using an online evaluation questionnaire
SHINE ^{47,48}		X		X	X	X	X	Portable digital scale Portable stadiometer Questionnaire Survey In-person interviews	T1: Baseline T2: Post-intervention T3: 12 months post T4: 24 months post T5: 36 months post	RCT is still underway (expected completion December 2022), and efficacy has not yet been estimated for outcome measures	Benefit of the intervention included the potential for economies of scale afforded by online delivery Key alterations to the intervention program included the need to incorporate more engaging content for students and the need to enhance the integration of teacher tracking and assessment tools within the online delivery platform Most respondents reported taking less time to plan SHINE HPE lessons, as compared to usual HPE lessons (69%) The mean time taken to plan SHINE HPE lessons compared to usual HPE curriculum lessons was timesaving of 141 min over the 8 weeks of intervention delivery

(Continues)

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection	Time points	Results summary	Process/cost evaluation and qualitative results
	DB	KA	Anthro	SB & PA	SCV				
NEAT girls ²⁷⁻³¹	X	X	X	X	X	X	T1: Baseline T2: 12 months post T3: 24 months post	No significant effects on anthropometry, physical activity outcomes, dietary behaviours (percentage of energy from core food groups and EDNP foods), or social-cognitive variables (self-efficacy, behavioural strategies, perceived environment, social support, outcome expectations) in the intervention group Significant effect for recreational computer use ($p < .02$) and sedentary activities summed in intervention group ($p < .04$)	The total intervention cost was estimated to be \$41 562, equating to an intervention cost of \$19 per intervention group student The girls were satisfied with the program. The enhanced school sports sessions (41.7%) and the nutrition workshops (38.7%) were the two intervention components enjoyed the most
Program X ^{32,33}	X			X			T1: Baseline T2: 6 months post	Significant effects for physical activity level in both girls and boys ($p < .001$), fruit and vegetable intake in girls ($p < .05$), and number of energy-dense/low-nutrient snacks consumed in boys from the intervention group ($p < .043$) No significant intervention effect on sedentary behaviour	Attendance at school sports sessions was high (80%) in both treatment and control groups After completion of the intervention, only a small percentage of participants (11%) reported wearing their pedometer every day Almost two thirds of participants indicated that their parents had never read or signed their physical activity and nutrition handbooks

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection		Results summary			
	DB	A	Anthro	SB	PA & SCV	PE	CE	Tools	Time points	Efficacy and quantitative results	Process/cost evaluation and qualitative results
Switch Ur Sip ³⁴⁻³⁶	X		X					Australian Child and Adolescent Eating Survey Online student survey Portable digital scale Portable stadiometer	T1: Baseline T2: Mid-point (3 months) T3: Endpoint (6 months)	Significant effects at the 3-month mid-point for mean daily SSB intake ($p < .03$) and mean daily percentage of energy from SSBs in girls from the intervention group ($p < .05$) No significant effects at the 6-month endpoint for anthropometric outcomes or dietary behaviours in the intervention group	The external motivation provided by email support was relatively ineffective. Approximately one half of the participants reported that their involvement in Program X had encouraged them to join a gym or fitness club, and two thirds suggested that their involvement had made them more active with their family members.
Click & Crunch High Schools ³⁷	X						X	Students' purchasing data through 'Flexischools'	T1: 2-month baseline period T2: 2-month follow-up period (immediately after the 2-month intervention)	Significant effect for the mean percentage of online lunch items per student that was 'Everyday' ($p < .001$) and 'Should not be sold' in the intervention group ($p < .001$) No significant effect for the mean percentage of online lunch items that were 'Occasional', or the average energy, saturated fat, sugar or sodium content of lunch orders in the intervention group	No difference in mean weekly revenue from high school students' online lunch orders

(Continues)

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection		Results summary				
	DB	A	Anthro	SB	PA & K	SCV	PE	CE	Tools	Time points	Efficacy and quantitative results	Process/cost evaluation and qualitative results
Thirsty? Choose Water ³⁸⁻⁴⁰	X	X				X			Online survey Water meters & data loggers on water stations School profile & environmental scan	T1: Baseline T2: Post-intervention (6-8 months) T3: Follow-up (12 months)	Significant effect for SSB intake in the intervention group receiving both interventions ($p < .01$), number of students taking a water bottle to school and filling it up in the group receiving the environmental intervention ($p < .05$), water intake in boys receiving the environmental intervention ($p < .05$), and changes in knowledge about SSBs, dehydration effects and changes in daily SSB consumption in the group receiving the behavioural intervention ($p < .05$)	Interventions were readily implemented in schools, with a high level of acceptability for both interventions among both students and staff and immunisation nurses Feedback on the teachers' workshop was positive The program content was highly regarded, and teachers reported confidence in sharing new knowledge with colleagues and delivering lessons Resource kit feedback was positive, with 95% of teachers intending to use it in the future Adherence to study protocol was good, with 75% of teachers reporting intervention delivery within 2 weeks 61% of schools rated the 'Toilet talkers' poster as extremely/very effective. Likewise, 38.5% rated the hi-vis vests and 33% the canteen table talkers as extremely/very effective 86% of respondents reported the chilled water station was well received by students Schools reported that the chilled water station, data loggers and water bottle counters were very beneficial

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection	Time points	Results summary	Process/cost evaluation and qualitative results
	DB	KA	Anthro	SB	PA & SCV				
It's Your Move ⁴⁹	X	X	X	X	X	Portable digital scale Portable stadiometer Adolescent Behaviours, Attitudes and Knowledge Questionnaire Paediatric Quality of Life Inventory 4.0	T1: Baseline T2: 3-year follow-up	Significant effect for BMI z-scores, prevalence of overweight/obesity ($p < .05$) and awareness of healthy eating programs at school ($p < .05$) in the pooled intervention group Significant effect for depressive symptoms in the intervention school aimed at improving mental well-being through the promotion of healthy eating and physical activity ($p < .05$) No significant effect for any dietary (consumption of fruits and vegetables, soft drinks and cordials, or snack foods) and physical activity behaviours, body image perceptions or the home or school environment in the intervention group	Nurses considered the post-vaccination waiting period a good opportunity to deliver health promotion messages
Health Lifestyle Program ⁴¹	X	X	X	X	X	Questionnaire	T1: Baseline T2: 3-year follow-up	Significant improvement in the attitude of boys in relation to fitness ($p < .05$), nutrition ($p < .001$), nutrition knowledge ($p < .001$) and health ($p < .05$) No significant effect on anthropometric outcomes	
SALSA ⁴²⁻⁴⁴	X	X	X	X	X	Online questionnaire	T1: Pre-intervention T2: Post-intervention (~25 days)	Significant effects for physical activity ($p < .004$), fruit and vegetable intake	91% of year 10 peer leaders reported they would recommend the SALSA

(Continues)

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection		Time points	Results summary	Process/cost evaluation and qualitative results
	DB	A	Anthro	SB	PA &	SCV	PE			
Body Basics ⁵⁰									<p>Efficacy and quantitative results</p> <p>($p < .01$), SSB intake ($p < .01$) and eating breakfast ($p < .004$) in year 10 peer leaders</p> <p>Significant effect for sedentary behaviours in peer leaders from average and above average communities ($p < .05$)</p> <p>Significant effects for sedentary behaviour ($p < .001$), fruit intake ($p < .001$), veg intake ($p < .05$) and SSB intake ($p < .001$) in Year 8 students</p> <p>Significant shifts were seen in peer leaders' intentions to change dietary behaviours and reduce recreational screen time ($p < .01$)</p>	<p>program to other high school students</p> <p>72% of year 8 students reported that they would recommend participating in the SALSA program to their peers</p> <p>The average actual cost of implementing the SALSA program in 2014–2015 was \$1388 per school and \$9.97 per student, showing that it is a relatively low-cost program to implement</p>
										<p>81% of adolescents reported the program as valuable and 82% indicated they would like to participate again.</p> <p>The 'Healthy Weight Range for Teenagers' poster was the most highly rated component among this group</p> <p>98% of teachers reported the program to be 'very valuable' or 'valuable', 100% said they would continue to use the program and 89% rated the program as 'excellent' or 'good'. Fact files were rated the most highly among this group</p>

Body Basics⁵⁰

Questionnaire

X

T1: Post-intervention

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection		Results summary			
	DB	A	Anthro	SB	PA & SCV	PE	CE	Tools	Time points	Efficacy and quantitative results	Process/cost evaluation and qualitative results
Nutrition Education Program ⁴⁵	X	X		X	X			In-depth interviews Needs assessment questionnaire	T1: Pre-intervention T2: Post-intervention (12 months)	<p>Significant effects for nutrition-related knowledge in students at the program school ($p < .05$)</p> <p>Significant effect for the belief that mood influences food selection ($p < .05$), males selecting 'food and nutrition' as the issue likely to have the greatest influence on their future health ($p < .05$), the nomination of 'classes at school' as their 'major source of nutrition information' ($p < .001$), the proportion of students responding positively to the statement 'I want to make my diet healthier' ($p < .05$), and females reported intake of grain serves at the program school ($p < .05$)</p>	<p>Sixteen planning sessions were held by the working group during the trial, and the median attendance was 8 of the 10 members</p> <p>Four of the five outcome objectives and all curriculum objectives were addressed</p> <p>Turnover of Grade 8 students during the implementation period was less than 5%, and all but two of the seven Grade 8 classes completed all topics in the curriculum</p> <p>Most initiatives planned for parent and community involvement were undertaken, as were all but one initiative planned for the canteen</p> <p>Time allocated to food and nutrition education in the Grade 8 curriculum was increased two and one-half fold</p> <p>The curriculum was successfully integrated across the two subjects in which it was taught</p> <p>A high degree of both working-group participant satisfaction with the planning process and teacher satisfaction with the curriculum developed</p> <p>All 16 students interviewed supported the changes made at the school</p>

(Continues)

TABLE 3 (Continued)

Program name and references	Outcome measures and evaluation measures					Data collection		Results summary			
	DB	K & A	Anthro	SB & PA	SCV	PE	CE	Tools	Time points	Efficacy and quantitative results	Process/cost evaluation and qualitative results
Outreach School Garden Project ^{4,6}	X	X						'My Healthy Dinner Plate Activity' 'The Pyramid Activity' Curriculum matrix Semi-structured interviews Reflective journal and event log	T1: Pre-intervention T2: Post-intervention (6 months)	No significant effects on nutrition knowledge and attitudes (drawing foods that represent healthy choices and correctly indicating the category a particular food item belonged to on the 'Healthy Food Pyramid') of Indigenous children	Teachers' feelings about the curriculum were generally positive Fifteen of the 16 students interviewed indicated that food preparation was the most satisfying part of the program

Note: Significant effects are highlighted in bold.

Abbreviations: Anthro, anthropometric; CE, cost/economic evaluation; DB, dietary behaviours; K & A, nutritional knowledge & attitudes; PA & SB, physical activity & sedentary behaviours; PE, process/program evaluation; SCV, social-cognitive variables; T, time point.

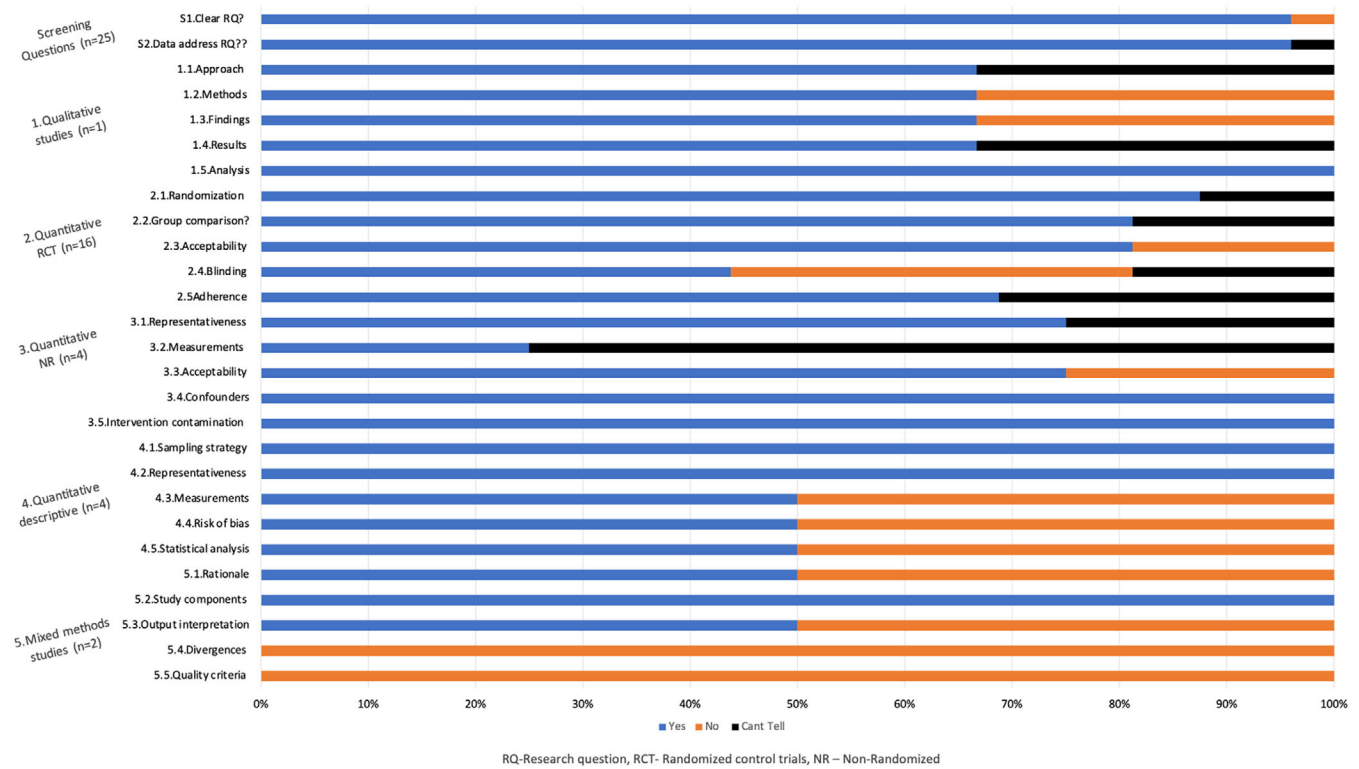


FIGURE 2 Quality appraisals of all reports from included studies based on the type of study design, using the MMAT. MMAT, Mixed Methods Appraisal Tool.

the treatment and prevention of obesity in children.⁵⁴ Health-centred approaches promote healthy lifestyles rather than weight loss which includes mindful eating, intuitive eating and weight-inclusivity.⁵⁵ Such non-weight-focused approaches emphasise body acceptance, active embodiment and avoid weight stigma which may be more appropriate for this age group.⁵⁶ A systematic review⁵⁷ reported that weight-neutral approaches could be more acceptable and feasible for adolescents who are overweight or obese in the short term (≤ 12 weeks). However, there is currently limited data on non-weight-centric approaches and none of the studies in this review adopted a non-weight-centric approach. Thus, future research can explore the effectiveness of non-weight-centric approaches on health outcomes in secondary school students in Australia.

Studies that reported no significant improvements in dietary behaviours and nutrition-related knowledge and attitudes were typically of longer duration (6–24 months). In comparison, the shortest duration nutrition intervention lasting 25 days reported significant improvements in dietary behaviours, though they did not include knowledge and attitude outcome measures. This does not align with other evidence from previously conducted systematic reviews, which have reported that interventions of longer durations of at least 6 months are more successful in improving dietary behaviours.^{58,59} The reason for this may be the facilitator delivering the intervention, which in this case was peer leaders. A systematic review conducted by Calvert et al.⁶⁰ concluded that peer-led interventions successfully influence positive behaviour change among students.

4.1 | Strengths and limitations

This is the first systematic review to focus on the effectiveness of nutrition interventions in Australian secondary schools. It followed a systematic approach, screened and extracted in duplicate, appraised quality and reviewed high-level studies, allowing for reliable conclusions to be made on their effectiveness. Furthermore, by limiting the search to Australia, the results are more relevant to the Australian context. However, by excluding grey literature, other high-quality studies reporting on nutrition interventions in Australian secondary schools may have been missed.

4.2 | Conclusion

In conclusion, this systematic review found that reporting of nutrition interventions implemented in Australian secondary schools has been limited. However, those implemented support using a theoretical framework and a multi-component approach. They showed improvements in nutrition-related health outcomes such as dietary behaviours and nutritional knowledge and attitudes in secondary school students. This suggests that researchers conducting nutrition interventions in Australian secondary schools may increase their success by focusing on these aspects. Future reviews should attempt to integrate grey literature and target the long-term sustainability of multi-component nutrition interventions and their long-term impact on health outcomes of adolescents in secondary schools.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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SUPPORTING INFORMATION

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

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