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# Searching for rigour in the reporting of mixed methods population health research: a methodological review

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## Abstract

The environments in which population health interventions occur shape both their implementation and outcomes. Hence, when evaluating these interventions, we must explore both intervention content and context. Mixed methods (integrating quantitative and qualitative methods) provide this opportunity. However, although criteria exist for establishing rigour in quantitative and qualitative research, there is poor consensus regarding rigour in mixed methods. Using the empirical example of school-based obesity interventions, this methodological review examined how mixed methods have been used and reported, and how rigour has been addressed. Twenty-three peer-reviewed mixed methods studies were identified through a systematic search of five databases and appraised using the guidelines for Good Reporting of a Mixed Methods Study. In general, more detailed description of data collection and analysis, integration, inferences and justifying the use of mixed methods is needed. Additionally, improved reporting of methodological rigour is required. This review calls for increased discussion of practical techniques for establishing rigour in mixed methods research, beyond those for quantitative and qualitative criteria individually. A guide for reporting mixed methods research in population health should be developed to improve the reporting quality of mixed methods studies. Through improved reporting, mixed methods

can provide strong evidence to inform policy and practice.

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## Introduction

Population health interventions are shaped not only by participants but also by the environments in which they occur (e.g. classrooms, community spaces, retail outlets); hence, understanding context is essential when evaluating interventions [1, 2]. Considering the importance of context in evaluating both implementation fidelity and outcomes, from a methodological standpoint mixed methods present an ideal tool for intervention evaluation [1]. According to Albright *et al.* [1], mixed methods provide the benefit of including quantitative methods to examine the intervention content (the ‘what’) and qualitative methods to explore the context (the ‘why’ and ‘how’) [1]. However, to determine the strength of evidence derived from mixed methods studies, we must also evaluate the methodological rigour of such work. Although guidance exists for assessing rigour in quantitative and qualitative methods individually, there is little direction for assessing rigour in mixed methods research.

It is estimated that 10% of school-aged children worldwide [3] and one-third of North American children [4, 5] are overweight or obese. Although schools provide an ideal environment for prevention, school and community characteristics shape these interventions [6–8]. Hence, this methodological review uses the empirical example of school-based

obesity interventions to examine how mixed methods have been used and how rigour has been addressed in this area of population health research.

Although several definitions for mixed methods exist, this review was informed by the six characteristics of mixed methods research described by Creswell and Plano Clark [9] (see Box 1). Mixed methods research provides a platform to combine the strengths of both quantitative and qualitative methodologies to offset their respective weaknesses. The fundamental indicator of mixed methods research, distinguishing it from research that simply uses both quantitative and qualitative methods, is integration. ‘Integration’ is the purposeful mixing of quantitative and qualitative methods, which can occur at different phases of the research process (i.e. data collection, analysis, interpretation and/or discussion) [10]. One way to capture possible variations in the timing and integration of methods is the ‘mixed methods designs’ proposed by Creswell and Plano Clark [9] (i.e. convergent parallel, explanatory sequential, exploratory sequential, embedded, multiphase, and transformative). The interpretations made from the individual quantitative and qualitative strands are ‘inferences’, whereas the conclusions made from both strands together are ‘meta-inferences’ [9].

**Box 1.** Characteristics of mixed methods research as outlined by Creswell and Plano Clark [9]

Mixed methods research involves:

- Collecting and analysing both quantitative and qualitative data.
- Integrating the quantitative and qualitative data.
- Prioritizing quantitative or qualitative data, or both have equal priority.
- Using and integrating these methods in one study or multiple phases of a research programme.
- The methods are theoretically informed.
- Using specific (mixed methods) research designs

Although there is ongoing discussion regarding which worldview(s) mixed methods research corresponds with, pragmatism is one of the most frequently adopted [9, 11, 12]. The pragmatic worldview aligns with population health research given its emphasis on problem solving, practice and interest in individual–environment interactions [13]. Pluye and Hong [14] highlight the value of mixed methods in public health research:

mix[ed] methods combines the power of stories and the power of numbers. In public health, stories have the power to change policies, and statistics traditionally provide a strong rationale to make changes (p. 30).

Mixed methods approaches are useful for understanding the contextual and environmental factors that influence behaviour, health, policies and programmes [15]. By using mixed methods, researchers can examine multiple perspectives and ecological levels, contextualize trends, compare and triangulate different findings, and assess both processes and outcomes [16, 17].

### Rigour in mixed methods research

Given the differences between quantitative and qualitative research methods, rigour is assessed in different ways [18, 19]. In quantitative research, the criteria for rigour include validity, reliability, replicability and generalizability [20]. Although the discussion regarding rigour in qualitative research is ongoing, Lincoln and Guba’s [21] criteria of credibility, transferability, dependability and confirmability are considered the ‘gold standard’ ([22], p. 179, [12], p. 527). Given the differences between assessing rigour in quantitative and qualitative methodologies, establishing rigour in mixed methods research is complex and requires additional consideration.

Rigour and quality are currently topics of great interest in the mixed methods literature and consensus in these areas has yet to be reached [23]. Tashakkori and Teddlie [12] refer to the literature on mixed methods quality as ‘chaotic’ (p. 813), noting inconsistencies in (i) the terms used, (ii) the

concepts that should be evaluated, (iii) whether quantitative and qualitative methods should be assessed separately and (iv) whether final conclusions based on both method types should be evaluated. There is poor consensus regarding quality issues that are specific to mixed methods research above monomethod (i.e. quantitative and qualitative) approaches [23]. However, several authors discuss the importance of assessing integration and the need to justify the use of mixed methods [20, 23–27]. Researchers should be transparent in their descriptions of the research process (i.e. providing thorough details of data collection, analysis, interpretation and integration for all methods) so that readers can judge quality [20, 24–26, 28]. Finally, the use of mixed methods and the inferences made should be based on the research question(s) [20, 25].

Although methodological reviews of mixed methods have been conducted in health services research [24, 26, 29–31] and health sciences research more generally [32], the authors were unable to find similar reviews of the public health literature. Given the different contexts of health services and public health research, investigating the use of mixed methods in population health is worthwhile. Using the empirical example of school-based obesity interventions, this methodological review examines how mixed methods have been used and how rigour has been addressed in this area of population health research. The school-based obesity intervention literature was examined to answer the following questions:

- 1) How have mixed methods been used in research related to assessing the implementation and outcomes of school-based obesity, physical activity and nutrition interventions?
- 2) How have mixed methods been reported in these studies?
- 3) How has rigour been addressed in these studies?

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## Materials and methods

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A systematic approach was used to search for mixed methods studies regarding school-based obesity,

physical activity and nutrition interventions. ‘Mixed methods studies’ were defined as those that ‘involve mixing [integration] within a single study’ ([33], p. 123). Including only ‘mixed methods studies’ allowed for the reporting quality of all mixed methods components (i.e. quantitative and qualitative data collection, analysis, integration and meta-inferences) to be reviewed within one paper. The first author conducted the literature search, data extraction and critical appraisal. In August 2014, English-language articles published since January 2000 were identified through a search of five electronic databases (PubMed [Medline], Scopus, EMBASE, PsycInfo and ERIC) using the search terms in Table I. Figure 1 provides a summary of the review process. First, titles and abstracts of all studies were examined and the exclusion criteria (Table II) were applied to determine which studies should be excluded and which studies required further investigation through reading the full-text article. Second, the full-text articles were reviewed using the inclusion and exclusion criteria. Reasons for exclusion at this stage are given in Fig. 1. After the review process, the reference lists of the remaining articles were hand-searched for additional sources, resulting in four more articles meeting the inclusion criteria.

For each of the 23 articles included in this review, a data extraction tool developed from four resources [24, 34–36] was used to collect information regarding the study purpose, theoretical framework, intervention, design, methods, analysis, rigour and findings (Appendix). Rigour was assessed by examining criteria for quantitative (i.e. validity, reliability, replicability and generalizability) [20] and qualitative (i.e. credibility, transferability, dependability and confirmability) [21] research. Additionally, the Good Reporting of a Mixed Methods Study (GRAMMS) guidelines [24] (Box 2) were used to assess considerations unique to mixed methods rigour (derived from the previously discussed literature) and to appraise article quality. These guidelines were chosen over other quality appraisal tools because they explicitly applied to mixed methods research, assessed all individual methods (both quantitative and qualitative)

within the design and included specific, practical questions to guide the appraisal. A subset of the questions presented by O’Cathain *et al.* [24] were chosen for each guideline; these questions focused on reporting quality. Questions related to quantitative and qualitative rigour were omitted as these topics were assessed in more detail in the data extraction tool. Questions regarding research proposals were excluded, as were those related to characteristics of the research team, because this information was not in the reviewed articles.

**Box 2.** The GRAMMS guidelines as described by O’Cathain *et al.* [24]

- 1) “Describe the justification for using a mixed methods approach to the research question
- 2) Describe the design in terms of the purpose, priority and sequence of methods
- 3) Describe each method in terms of sampling, data collection and analysis
- 4) Describe where integration has occurred, how it has occurred and who has participated in it
- 5) Describe any limitation of one method associated with the presence of the other method
- 6) Describe any insights gained with mixing or integrating methods” ([24], p. 97)

## Results

Twenty-three articles representing 20 interventions were included in this review. Summaries of included articles are provided in Table III (study purpose, intervention details and key findings) and Table IV (study design and methods). The studies took place in the United States ( $n=9$ ), Australia ( $n=6$ ), Canada ( $n=4$ ), the Netherlands ( $n=2$ ), Denmark ( $n=1$ ) and England ( $n=1$ ). Eleven interventions were related to nutrition, seven were related to physical activity, and two examined obesity, physical activity and nutrition. Ten articles assessed implementation of interventions, seven investigated intervention outcomes, and six explored both implementation and outcomes. As noted in Table IV, the majority of studies examined interventions in elementary schools (kindergarten to Grade 8) ( $n=16$ ). Seven studies involved interventions targeting special populations: five focused on low-income schools and two examined an intervention specific to indigenous schools. The majority of interventions occurred during the school day ( $n=13$ ), five were specific to instructional time, one was at recess, and one occurred before and after school.

A variety of interventions were examined, including changes to food offered in school cafeterias and vending machines, existing curricula (i.e. physical education and home economics), and curriculum supplements related to nutrition, physical activity

**Table I.** Search terms

Concept	Search terms
Mixed Methods	‘mixed method*’ OR ‘mixed approach*’ OR ‘mixed stud*’ OR ‘mixed’ OR triangulation OR ‘quantitative AND qualitative’ OR ‘multi* method*’ OR ‘survey* AND interview’ OR ‘survey* AND focus group*’
School Intervention	(school* OR student*) AND (intervention* OR program* OR ‘health promotion’ OR ‘health education’ OR ‘health policy’ OR ‘public health’)
Obesity	obesity OR overweight OR obese OR BMI OR nutrition OR diet OR ‘food habits’ OR ‘food preferences’ OR ‘physical activity’ OR ‘physical education’ OR exercise OR ‘active transportation’ OR ‘physical fitness’
Age Group	child OR adolescent OR youth

## Illustrations

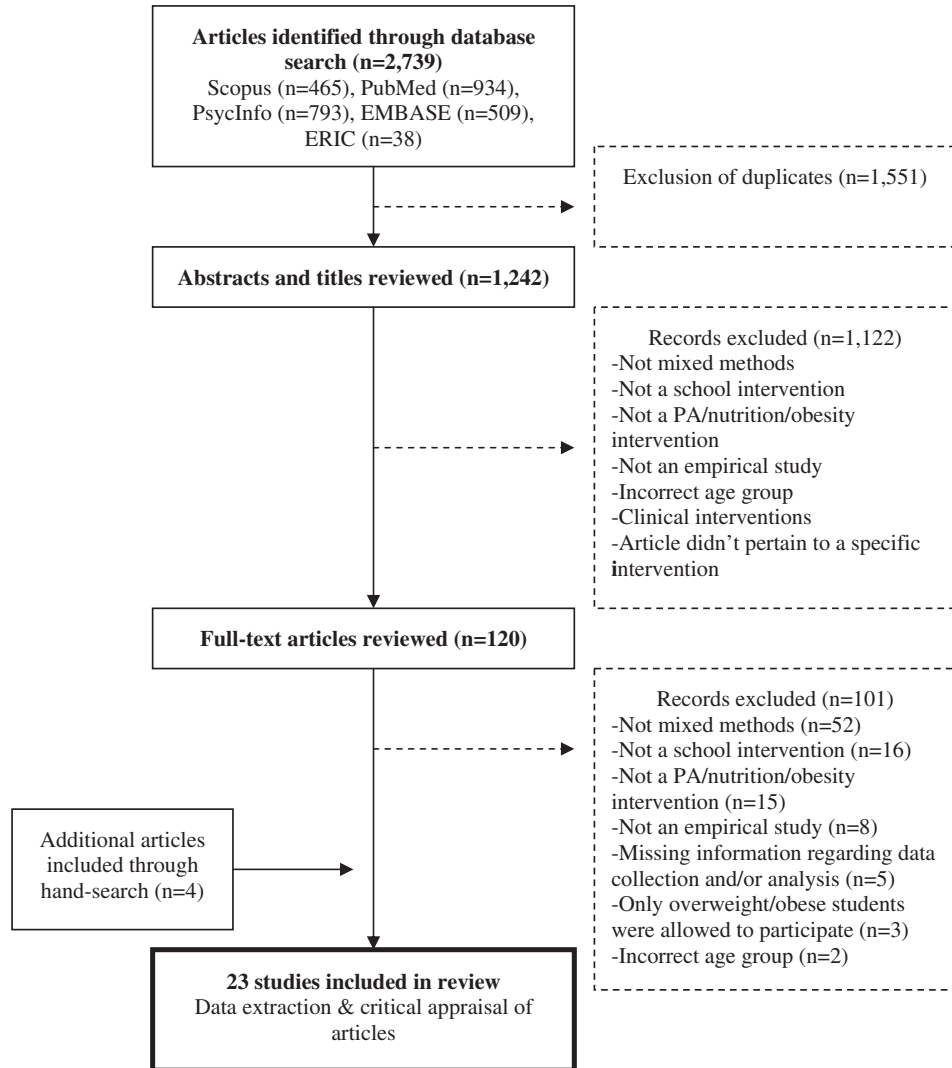


Fig. 1. Summary of article review process.

and obesity. Four studies investigated interventions that incorporated a family component, by including take-home activities, providing parents with information, or holding family events at schools. The remaining results focus on the study methods, which are organized using the GRAMMS guidelines (Table V).

### Mixed methods design and justification

Less than half of the articles ( $n = 10$ ) specified they were using a mixed methods approach. The remaining articles used 'mixed-mode' ( $n = 3$ ) and 'triangulation' ( $n = 1$ ), or simply discussed using both quantitative and qualitative methods ( $n = 9$ ). Only eight articles justified the use of mixed methods

**Table II.** Inclusion and exclusion criteria for article review

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> <li>• Empirical studies</li> <li>• School-based interventions for obesity, nutrition, and/or physical activity (including after-school initiatives that occur at school)</li> <li>• Interventions for elementary and secondary school students aged 5–18</li> <li>• Studies that included at least one qualitative and one quantitative method in the same article, a description of the analysis of both types of data, and integration</li> <li>• English-language full-text peer-reviewed articles published (or in press) since 2000<sup>a</sup></li> <li>• Articles accessible through the University of Waterloo library</li> </ul>	<ul style="list-style-type: none"> <li>• Review articles or articles that described a research programme's methodology without any results</li> <li>• Studies that did not analyse obesity, nutrition and/or physical activity interventions</li> <li>• Interventions that were not for elementary and/or secondary school students</li> <li>• Interventions that did not occur in a school setting</li> <li>• Clinical interventions</li> <li>• Interventions that were restricted to only overweight or obese participants</li> <li>• Studies in which a survey consisted of closed- and open-ended questions (and no other qualitative methodology)<sup>b</sup></li> <li>• Studies that did not include integration of quantitative and qualitative methods (collection and/or analysis)</li> <li>• Studies that were missing information regarding data collection and/or analysis</li> </ul>

<sup>a</sup>This timeframe was chosen because the first reference book on mixed methods (Tashakkori and Teddlie's *Handbook of Mixed Methods in Social and Behavioral Research*, 1st edn) was published in 2003. Hence, the three previous years were included as a buffer.

<sup>b</sup>This decision aligns with Curry and Nunez-Smith [27] and Kroll and Neri [10], who do not consider studies in which the only qualitative component is open-ended questions in a survey to be mixed methods. In a review of mixed methods studies in health care, Östlund *et al.* [30] also excluded these papers.

(Table V; Guideline 1): with all eight mentioning this approach enhanced their understanding of the research problem. Further, two discussed how the qualitative findings increased their confidence in the quantitative findings and two stated that using both quantitative and qualitative methods would strengthen the findings and reduce the limitations of the individual methods within the design. Finally, despite Creswell and Plano Clark's [9] criterion of a theoretically informed design, only six articles identified a theoretical perspective or framework informing the study.

Overall, the mixed methods designs were poorly described (Table V; guideline 2). Although all articles stated the study purpose, less than half ( $n = 10$ ) discussed the purpose of the design. Only four articles stated the priority of methods; of these, two prioritized qualitative, one prioritized quantitative, and one considered qualitative and quantitative as equal priority. All but four articles discussed the sequence of methods; however, mixed methods

terminology (e.g. concurrent, sequential timing) was not necessarily used. Eight articles described when integration occurred; only one article [37] actually used the term 'integrate'. This article [37] was also the only one to include a visual overview of the study design, including the data collection, analysis and stage of integration.

Only three studies identified the mixed methods design used. However, for studies that did not indicate design, the methods description was examined to categorize them using the design prototypes described by Creswell and Plano Clark [9]. The most frequent design was convergent parallel ( $n = 14$ ), followed by explanatory sequential ( $n = 5$ ), multiphase ( $n = 2$ ), exploratory sequential ( $n = 1$ ) and embedded ( $n = 1$ ). Ten studies used one quantitative and one qualitative method; eight studies combined two or three quantitative methods with qualitative, and nine studies linked two or three qualitative methods with quantitative. Looking at the specific methods combined, 12 articles used



**Table III.** Summary of study characteristics: study purpose, intervention details and key findings

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
Arzjevska <i>et al.</i> [38]	Australia	<ul style="list-style-type: none"> <li>– Extent of implementation</li> <li>– Facilitators and barriers to implementation</li> </ul>	N	E and S	<ul style="list-style-type: none"> <li>– New South Wales (Australia) Healthy School Canteen Strategy</li> <li>– Traffic light (green, yellow, red) categories for food for sale in school cafeteria; majority of food served should be green.</li> </ul>	<ul style="list-style-type: none"> <li>– Positive change to cafeteria menus but varying implementation across schools</li> <li>– Local context, school type, cafeteria practices and student characteristics influence implementation</li> </ul>
Austin <i>et al.</i> [47]	Australia	<ul style="list-style-type: none"> <li>– Barriers and facilitators to adoption, implementation and maintenance of intervention</li> </ul>	PA	E	<ul style="list-style-type: none"> <li>– Low-income schools</li> <li>– PLAY (promoting lifelong active youth) Zone</li> <li>– Playground markings, games manual, playground equipment (e.g. balls, skipping ropes), peer leader training manual</li> </ul>	<ul style="list-style-type: none"> <li>– Adoption based on school personnel (principals, school champions), funding, student interest, availability of staff to implement</li> </ul>
Bouck <i>et al.</i> [64]	Canada	<ul style="list-style-type: none"> <li>– Examine how programme was implemented</li> <li>– Programme facilitators and barriers</li> </ul>	N	E	<ul style="list-style-type: none"> <li>– Northern Fruit &amp; Vegetable Pilot Program</li> <li>– Free fruit and vegetable snacks three times per week</li> <li>– Curriculum-based component regarding benefits of fruits and vegetables</li> </ul>	<ul style="list-style-type: none"> <li>– Facilitators: teacher role-modelling, sufficient funding</li> <li>– Barriers: delivery, quality, wastage and variety of produce</li> <li>– Minimal curriculum implementation</li> <li>– 14–17% of sales were healthier choice products</li> <li>– Vending machine revenues declined</li> <li>– Price, value, taste decreased likelihood of students purchasing healthier choices</li> </ul>
Callaghan <i>et al.</i> [42]	Canada	<ul style="list-style-type: none"> <li>– Sales of healthy snacks, student perceptions of intervention</li> </ul>	N	S	<ul style="list-style-type: none"> <li>– Healthy Vending Machine Pilot Project</li> <li>– Replacement of half of school vending machine products with healthier choices</li> </ul>	<ul style="list-style-type: none"> <li>– Increased students' knowledge, preferences and consumption of vegetables, increased involvement in home cooking</li> </ul>
Chen <i>et al.</i> [65]	USA	<ul style="list-style-type: none"> <li>– Evaluate short-term impacts on participants' knowledge, attitudes, behaviours</li> </ul>	N	E	<ul style="list-style-type: none"> <li>– Classroom cooking curriculum and family take-home cooking component to promote ethnic produce (i.e. locally available fresh vegetables/legumes)</li> </ul>	<ul style="list-style-type: none"> <li>– Increased students' knowledge, preferences and consumption of vegetables, increased involvement in home cooking</li> </ul>

(continued)

**Table III.** *Continued*

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
de Meij <i>et al.</i> [37]	The Netherlands	Barriers and facilitators to adoption, implementation and institutionalization of intervention	PA	E	<ul style="list-style-type: none"> <li>- Low-income schools in Northern California</li> <li>- JUMP-in: multi-component programme to promote daily physical activity and sport participation</li> <li>- Sports clubs and PA breaks during school</li> <li>- Curriculum and take-home component</li> <li>- Parent information</li> <li>- Schools in low-income areas of Amsterdam</li> </ul>	<ul style="list-style-type: none"> <li>- Barrier: required collaboration between organizations, need for adaptation of intervention to local contexts</li> </ul>
Gibson <i>et al.</i> [66]	USA	Monitor fidelity, implementation, reach, dose, and maintenance of intervention - Describe context of implementation	PA	E	<ul style="list-style-type: none"> <li>Physical Activity Across the Curriculum-90 min of physically active lessons per week; incorporating physical activity into other subjects</li> </ul>	<ul style="list-style-type: none"> <li>- Significantly greater PA levels for intervention students compared with controls</li> <li>- Higher enjoyment among intervention students compared with controls</li> </ul>
Gittelsohn <i>et al.</i> [39]	USA	Trends in school climate during intervention - Impact of school climate on intervention	N, PA, O	E	<ul style="list-style-type: none"> <li>- Pathways</li> <li>- Classroom curriculum related to healthy eating and PA</li> <li>- Reduce fat in foods served in school cafeteria</li> <li>- Physical education three times per week, exercise breaks, guided play at recess</li> <li>- Family events</li> <li>- Indigenous schools</li> <li>- Change foods offered at school to include more fruits and vegetables and increase nutrient quality</li> </ul>	<ul style="list-style-type: none"> <li>- Barriers: administration, poor family participation</li> <li>- Positive association between school climate and classroom curriculum component</li> </ul>
Goldberg <i>et al.</i> [43]	USA	Development, implementation, evaluation of school food service intervention	N	E	<ul style="list-style-type: none"> <li>- More fruit, vegetables, whole grains, low-fat dairy available</li> <li>- Attitudes of stakeholders toward programme improved</li> </ul>	<ul style="list-style-type: none"> <li>- More fruit, vegetables, whole grains, low-fat dairy available</li> <li>- Attitudes of stakeholders toward programme improved</li> </ul>

(continued)



Table III. Continued

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
He <i>et al.</i> [67]	Denmark	<ul style="list-style-type: none"> <li>– Implementation of policy, influence of attitudes and behaviours</li> <li>– Explore impacts of policy</li> </ul>	N	E and S	<ul style="list-style-type: none"> <li>– School where more than 60% of students eligible for free or reduced price lunches</li> <li>– Schools with organic food policy: a specific portion of food available is organic</li> </ul>	<ul style="list-style-type: none"> <li>– Food services policies in place</li> <li>– Increased intention to eat organic foods but no effect on behaviour</li> <li>– Students in schools with organic policies purchased school meals more often than schools without these policies</li> <li>– High student and volunteer satisfaction</li> </ul>
Kong <i>et al.</i> [68]	USA	<ul style="list-style-type: none"> <li>– Investigate feasibility of walking school bus programme</li> </ul>	PA	E	<ul style="list-style-type: none"> <li>– Walking school bus: structured walking group to and from school run by parent volunteers</li> <li>– Four health themes incorporated into walk (related to PA, screen time, fruits and vegetables, sugar-sweetened beverage intake)</li> </ul>	<ul style="list-style-type: none"> <li>– Participants found walking school bus to be a supportive and safe environment that encouraged social interaction and PA</li> </ul>
Longley and Sneed [48]	USA	<ul style="list-style-type: none"> <li>– Process and outcomes of policy</li> <li>– Examined policy environment pre- and post-federal legislation</li> </ul>	N	E and S	<ul style="list-style-type: none"> <li>– Child Nutrition &amp; WIC Reauthorization Act</li> <li>– Schools that had school meal programmes must develop wellness policy that addresses obesity (this study only looked at nutrition component)</li> </ul>	<ul style="list-style-type: none"> <li>– 35% increase in wellness components from pre- to post-legislation</li> <li>– Use of nutrition guidelines for foods served, fundraising, vending machines</li> <li>– Less progress in policy implementation and monitoring than development</li> </ul>
Martens <i>et al.</i> [45]	The Netherlands	<ul style="list-style-type: none"> <li>– Examine implementation, teachers' and students' perceptions of programme</li> </ul>	N	S	<ul style="list-style-type: none"> <li>– Krachtover</li> <li>– Nutrition education programme to increase fruit consumption and breakfast frequency/quality, decrease</li> </ul>	<ul style="list-style-type: none"> <li>– Barriers: using food for fundraising, time</li> <li>– Teachers liked most programme components</li> <li>– Higher satisfaction of Krachtover curriculum compared with traditional curriculum (controls)</li> </ul>

Table III. Continued

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
Morgan and Hansen [56]	Australia	– Explore teachers' perspectives on how physical education could be improved	PA	E	<ul style="list-style-type: none"> <li>consumption of high-fat snacks</li> <li>– Program specific to low SES students</li> <li>– Physical education in primary schools</li> </ul>	<ul style="list-style-type: none"> <li>– Program components teachers did not like frequently not implemented</li> <li>– Insufficient planning, implementation, assessment, reporting and evaluation of PE programmes occurring</li> <li>– Teachers who planned and implemented more likely to assess, evaluate and report</li> <li>– Main barriers were categorized as institutional, leading to less time devoted to PE and reduced lesson quality</li> <li>– PE provides opportunities for improved fitness, positive learning and behaviour outcomes, developing social skills</li> </ul>
Morgan and Hansen [69]	Australia	– Explore teachers' perceived barriers to delivering physical education (PE)	PA	E	<ul style="list-style-type: none"> <li>– Physical education in primary schools</li> </ul>	<ul style="list-style-type: none"> <li>– PE provides opportunities for improved fitness, positive learning and behaviour outcomes, developing social skills</li> </ul>
Morgan and Hansen [70]	Australia	– Explore outcomes of physical education	PA	E	<ul style="list-style-type: none"> <li>– Physical education in primary schools</li> </ul>	<ul style="list-style-type: none"> <li>– PE provides opportunities for improved fitness, positive learning and behaviour outcomes, developing social skills</li> </ul>
Naylor <i>et al.</i> [40]	Canada	– Examine implementation and impact of intervention	PA	E	<ul style="list-style-type: none"> <li>– Action Schools! BC</li> <li>– Provided opportunities for PA throughout day, goal of 150 min of moderate intensity PA per week (including physical education)</li> </ul>	<ul style="list-style-type: none"> <li>– Time spent in PA greater in intervention schools</li> <li>– High satisfaction among teachers</li> <li>– Positive school climate, programme flexibility</li> <li>– School Nutrition Action Groups a valuable catalyst for whole school approach to nutrition</li> </ul>
Orme <i>et al.</i> [46]	England	– Examine extent of student participation, perspectives of staff and student participants	N	E	<ul style="list-style-type: none"> <li>– Food for Life Partnership programme</li> <li>– Nutrition programme including School Nutrition Action Groups (focus on improving nutrition in school)</li> </ul>	<ul style="list-style-type: none"> <li>– Principals had positive perception of policy</li> <li>– Increase in number of school canteens breaking event, decrease in number making a</li> </ul>
Pettigrew <i>et al.</i> [71]	Australia	– Policy impact on school canteens	N	E and S	<ul style="list-style-type: none"> <li>– West Australian School Healthy Food and Drink Policy</li> <li>– Traffic light system to label food based on nutrition information</li> </ul>	<ul style="list-style-type: none"> <li>– Principals had positive perception of policy</li> <li>– Increase in number of school canteens breaking event, decrease in number making a</li> </ul>

(continued)

Table III. Continued

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
Prusak <i>et al.</i> [72]	USA	<ul style="list-style-type: none"> <li>– Explore students' perceptions of physical education</li> </ul>	PA	E	<ul style="list-style-type: none"> <li>– No 'red' foods (high in fat, sugar and/or salt) allowed in canteens</li> <li>– 60% of menu must be 'green'</li> <li>– District-wide physical education curriculum</li> </ul>	<ul style="list-style-type: none"> <li>– profit, increase in number reporting a loss in profit</li> <li>– Facilitators to enjoyment: fun environment, impact on health knowledge/behaviours, teachers' engagement and management skills, coordinator of PE programme, professional development</li> <li>– Majority of children do not take HEFN courses</li> <li>– Courses perceived as less valuable than other subjects</li> <li>– Outdated curriculum and resources</li> <li>– Fewer trained teachers in subject</li> <li>– Social norms changing regarding cooking/eating = lower demand for HEFN courses</li> <li>– Implemented as intended, extent of component implementation increased over time</li> </ul>
Slater [44]	Canada	<ul style="list-style-type: none"> <li>– Examined student enrolment and teacher/superintendent perceptions of Home Economics, Food &amp; Nutrition (HEFN) courses in Manitoba</li> </ul>	N	M and S	<ul style="list-style-type: none"> <li>– Home Economics, Food &amp; Nutrition (HEFN) courses offered in Manitoba schools</li> </ul>	<ul style="list-style-type: none"> <li>– Outdated curriculum and resources</li> <li>– Fewer trained teachers in subject</li> <li>– Social norms changing regarding cooking/eating = lower demand for HEFN courses</li> <li>– Implemented as intended, extent of component implementation increased over time</li> </ul>
Steckler <i>et al.</i> [41]	USA	<ul style="list-style-type: none"> <li>– Implementation, reach, extent, fidelity of intervention</li> </ul>	O, PA, N	E	<ul style="list-style-type: none"> <li>– Pathways</li> <li>– Classroom curriculum</li> <li>– Reduce fat in school cafeteria foods</li> <li>– Physical education, exercise breaks, guided play at recess</li> <li>– Family events</li> <li>– Indigenous schools</li> </ul>	<ul style="list-style-type: none"> <li>– Outdated curriculum and resources</li> <li>– Fewer trained teachers in subject</li> <li>– Social norms changing regarding cooking/eating = lower demand for HEFN courses</li> <li>– Implemented as intended, extent of component implementation increased over time</li> </ul>

(continued)

**Table III.** *Continued*

Study	Country	Study purpose	Target area <sup>a</sup>	Age group <sup>b</sup>	Intervention details	Key findings
Whittemore <i>et al.</i> [51]	USA	<ul style="list-style-type: none"> <li>– Examine reach, adoption, implementation</li> <li>– Student participation and satisfaction levels</li> </ul>	O, PA, N	S	<ul style="list-style-type: none"> <li>– HEALTH[e]TEEN</li> <li>– School-based internet obesity prevention programme</li> <li>– Education and individual feedback on healthy eating and PA</li> <li>– Two schools offered in classroom, 1 school offered as homework</li> </ul>	<ul style="list-style-type: none"> <li>– High student participation and satisfaction (higher in schools with classroom implementation)</li> <li>– Higher satisfaction and participation among girls than boys</li> </ul>

<sup>a</sup>Target area of intervention: N, nutrition; PA, physical activity; O, obesity.

<sup>b</sup>Age group targeted by intervention: E, Elementary (Grades 1–8); S, secondary (Grades 9–12); M, middle school (Grades 6–8).

both surveys and interviews; 5 articles used surveys, interviews and focus groups; and 3 articles combined surveys and focus groups.

### Quantitative methods

Surveys ( $n = 20$ ) were the most frequently used quantitative method, followed by tracking sheets ( $n = 7$ ), programme/school administrative data ( $n = 5$ ), anthropometric measures [i.e. height, weight, and body mass index (BMI)] ( $n = 1$ ) and the System for Observing Fitness Instruction Time (SOFIT) ( $n = 1$ ). The majority of surveys used was study-specific ( $n = 17$ ); only three studies described a standardized survey (e.g. Knowledge, Attitudes, Behaviours Questionnaire; Adapted Food Frequency Questionnaire; and Attitude Toward Physical Education Survey). Instruments were categorized as ‘tracking sheets’ if the data were not already collected by the school or programme. For example, Ardzejewska *et al.* [38] used a standardized tool to categorize cafeteria food based on nutrition information, and teachers completed activity logs, checklists and/or calendars as intervention records [39–41]. In contrast, programme/school administrative data referred to information already being collected by the programme or school. For example, Callaghan *et al.* [42] and Goldberg *et al.* [43] used school food sales data, and Slater [44] used provincial enrolment data for home economics courses.

When the GRAMMS guidelines were applied to examine the method descriptions, all but four described the role of each quantitative method clearly and adequately (Table V; Guideline 3). The remaining articles simply stated the method and sample group, but did not describe the purpose of the method, topics covered, or the types of questions asked. These were commonly articles that used multiple quantitative methods, but this was not always the case. Five articles’ quantitative analyses were not considered appropriately sophisticated, as they only presented frequencies, percentages and/or descriptive statistics. Aligning with O’Cathain *et al.* [24], these studies were assigned a ‘no’ for this question, as there was no investigation of underlying characteristics (e.g.

**Table IV.** Summary of study characteristics: mixed methods design and methods

Study	Mixed methods design	Quantitative methods	Qualitative methods	Integration
Ardziejewska <i>et al.</i> [38]	EXPLANatory Sequential (QUANT-qual)	<ul style="list-style-type: none"> <li>- Tracking Sheets: categorize products in canteen based on kilojoules, saturated fat, sodium, fibre (four school cafeterias)</li> <li>- Surveys: school implementation and maintenance of interventions, pre-intervention, and 1, 6, 12 months post-intervention (8 schools, 1 survey per school)</li> <li>- Teacher survey (<math>n = 10</math>) to assess curriculum component</li> <li>- Tracking Sheets: Wastage tracking to measure amount of produce wasted (programme staff completed weekly wastage-tracking sheet) (24 schools)</li> <li>- Program/School Administrative Data: tracked vending machine sales (healthier choices and total sales) (four schools)</li> </ul>	<ul style="list-style-type: none"> <li>- Interviews (<math>n = 7</math>) with principals and canteen manager from each school (explored quantitative findings, operation of canteen, implementation, facilitators and barriers)</li> <li>- Interviews (<math>n = 8</math>) with principals and teachers to follow up on survey</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual connected (qual expanded on quant findings)</li> </ul>
Austin <i>et al.</i> [47]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Surveys: school implementation and maintenance of interventions, pre-intervention, and 1, 6, 12 months post-intervention (8 schools, 1 survey per school)</li> </ul>	<ul style="list-style-type: none"> <li>- Interviews with programme staff (<math>n = 8</math>), teachers (<math>n = 10</math>), principals (<math>n = 8</math>), site coordinator (<math>n = 1</math>) and representative from programme partner (<math>n = 1</math>)</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in results by theme</li> </ul>
Bouck <i>et al.</i> [64]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Teacher survey (<math>n = 10</math>) to assess curriculum component</li> <li>- Tracking Sheets: Wastage tracking to measure amount of produce wasted (programme staff completed weekly wastage-tracking sheet) (24 schools)</li> <li>- Program/School Administrative Data: tracked vending machine sales (healthier choices and total sales) (four schools)</li> </ul>	<ul style="list-style-type: none"> <li>- Four focus groups on students' (<math>n = 40</math>) perceptions of healthier choices in vending machines</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in discussion (minimal)</li> </ul>
Chen <i>et al.</i> [65]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Surveys: <ul style="list-style-type: none"> <li>- Student feedback (<math>n = 450</math>): student participation during in-class lesson</li> <li>- Parent feedback (<math>n = 168</math>): student/parent involvement in take-home component</li> </ul> </li> <li>- Student pre-post survey (<math>n = 378</math>): before the first and after the last in-class lessons</li> <li>- Parent pre-post survey (<math>n = 172</math> intervention, <math>n = 100</math> control): impact of intervention on family</li> <li>- Survey: completed by school staff and city sport coordinators (9 schools, 2 city districts but no <math>n</math> value given)</li> </ul>	<ul style="list-style-type: none"> <li>- Five focus groups with parents (<math>n = 28</math>): intervention experiences, perceptions, outcomes, limitations, suggestions for change</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in discussion (minimal)</li> </ul>
de Meij <i>et al.</i> [37]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Surveys: completed by school staff and city sport coordinators (9 schools, 2 city districts but no <math>n</math> value given)</li> </ul>	<ul style="list-style-type: none"> <li>- Interviews (baseline and 2 years after intervention) exploring child's sports participation (teachers of nine</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in results (minimal)</li> </ul>

(continued)

**Table IV.** *Continued*

Study	Mixed methods design	Quantitative methods	Qualitative methods	Integration
Gibson <i>et al.</i> [66]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Tracking sheets: school and environmental scan, SWOT (strengths, weaknesses, opportunities, threats) analysis completed by intervention team</li> <li>- Teachers completed workshop evaluation survey (<math>n = 106</math>)</li> <li>- Teachers completed weekly online survey to track programme activities (84% response rate)</li> <li>- Teachers completed two end-of-year evaluation forms (<math>n = 80</math>, <math>n = 75</math>)</li> <li>- Principal surveys (<math>n = 22</math>)</li> <li>- SOFIT to measure PA levels of students in class (<math>n = 3465</math> intervention students, <math>n = 1050</math> control students)</li> <li>- Programme Data: attendance at training workshop</li> </ul>	<ul style="list-style-type: none"> <li>- intervention schools, sports coordinators of two city districts but no <math>n</math> value given</li> <li>- Document review (meeting minutes, emails, other programme documents)</li> <li>- Six focus groups with teachers (<math>n = 79</math>) about their perceptions of programme, barriers, outcomes and suggestions for change</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in discussion (minimal)</li> </ul>
Gittelsohn <i>et al.</i> [39]	Embedded	<ul style="list-style-type: none"> <li>- Tracking Sheets: physical education calendars kept by teachers, attendance of students and adults at family events</li> <li>- Survey: students completed 11 questions from Knowledge, Attitudes, and Behaviors Questionnaire</li> <li>- No sample sizes stated</li> <li>- Pre-intervention survey completed by food services staff (<math>n = 15</math>)</li> <li>- Post-intervention survey completed by food services staff (<math>n = 20</math>)</li> <li>- Mid-intervention survey completed by principals and kitchen leaders' to examine perceptions of monthly tasting events and identify challenges (<math>n = 18</math>)</li> <li>- Post-intervention: students chose their three favourite foods from tastings throughout the year (<math>n = 869</math>)</li> </ul>	<ul style="list-style-type: none"> <li>- Interviews (<math>n = 118</math>) with school administrators, teachers and food service vice managers</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual merged in analysis: qual data turned into indices that were combined with quant data in regression</li> </ul>
Goldberg <i>et al.</i> [43]	Multiphase	<ul style="list-style-type: none"> <li>- Pre-intervention survey completed by food services staff (<math>n = 15</math>)</li> <li>- Post-intervention survey completed by food services staff (<math>n = 20</math>)</li> <li>- Mid-intervention survey completed by principals and kitchen leaders' to examine perceptions of monthly tasting events and identify challenges (<math>n = 18</math>)</li> <li>- Post-intervention: students chose their three favourite foods from tastings throughout the year (<math>n = 869</math>)</li> </ul>	<ul style="list-style-type: none"> <li>- Key informant interviews with school representatives and community members (<math>n = 19</math>)</li> <li>- Thirteen focus groups with food service staff (<math>3, n = 24</math>), students (<math>5, n = 40</math>) and parents (<math>5, n = 39</math>)</li> <li>- Qualitative methods informed design and implementation of intervention</li> </ul>	<ul style="list-style-type: none"> <li>- Mixed within a programme-objective framework</li> <li>- (qualitative needs assessment led to intervention development, which was evaluated quantitatively)</li> </ul>

(continued)



Table IV. Continued

Study	Mixed methods design	Quantitative methods	Qualitative methods	Integration
He <i>et al.</i> [67]	Convergent Parallel	<ul style="list-style-type: none"> <li>Post-intervention survey mailed to parents to assess awareness of intervention (<math>n = 216</math>)</li> <li>Program/school administrative data: production records (food offered), sales records from school food services</li> <li>Students completed the Adapted Food Frequency Questionnaire (<math>n = 83</math> intervention, <math>n = 79</math> control)</li> </ul>	<ul style="list-style-type: none"> <li>Focus groups (<math>n = 24</math> intervention, <math>n = 25</math> control) to explore students' experiences and perceptions about school meals, healthy/organic food</li> <li>Focus group with volunteers to discuss results of surveys, overall programme, and suggestions for change (no <math>n</math> value given)</li> <li>Interviews with parent coordinators (<math>n = 2</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual analysed separately, integration in discussion (minimal)</li> <li>Quant and qual analysed separately, integration in discussion (minimal)</li> </ul>
Kong <i>et al.</i> [68]	Convergent Parallel	<ul style="list-style-type: none"> <li>Anthropometric measures: BMI (pre- and post-programme) (<math>n = 25</math>)</li> <li>Tracking sheets: student and volunteer attendance</li> <li>Surveys: student and parent satisfaction (<math>n = 25</math>, <math>n = 9</math>)</li> <li>Survey of school food services directors (<math>n = 363</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Interviews with parent coordinators (<math>n = 2</math>)</li> <li>Document review: 50 state policies reviewed pre- and post-legislation</li> <li>Telephone interviews with food services directors about wellness policy committee development, process, barriers, status (<math>n = 31</math>)</li> <li>Participant observation: in-class observations of lessons</li> <li>Implementation 'journals': consisted of open-ended questions regarding intervention activities, time, materials, teacher impressions, student reactions (<math>n = 10</math>)</li> <li>Interviews with teachers (<math>n = 15</math>): programme implementation, student reactions, challenges</li> <li>Teacher interviews (<math>n = 31</math>) regarding perceptions of PE and suggestions for improvement</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant survey developed from qual interview findings)</li> <li>Quant and qual analysed separately, integration in results</li> </ul>
Longley and Sneed [48]	Multiphase	<ul style="list-style-type: none"> <li>Student survey: process and perceptions of programme (<math>n = 1201</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 189</math>) regarding physical education (PE) programmes</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant survey informed qual sampling)</li> </ul>
Martens <i>et al.</i> [45]	Convergent Parallel	<ul style="list-style-type: none"> <li>Student survey: process and perceptions of programme (<math>n = 1201</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 189</math>) regarding physical education (PE) programmes</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual analysed separately, integration in results</li> </ul>
Morgan and Hansen [56]	EXPLA/Natory Sequential (QUANT-qual)	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 189</math>) regarding physical education (PE) programmes</li> </ul>	<ul style="list-style-type: none"> <li>Teacher interviews (<math>n = 31</math>) regarding perceptions of PE and suggestions for improvement</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant survey informed qual sampling)</li> </ul>

(continued)

**Table IV.** *Continued*

Study	Mixed methods design	Quantitative methods	Qualitative methods	Integration
Morgan and Hansen [69]	EXPLANatory Sequential (QUANT-qual)	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 189</math>) regarding barriers to PE programmes</li> </ul>	<ul style="list-style-type: none"> <li>Teacher interviews (<math>n = 31</math>) regarding perceptions and experiences of PE, confidence teaching PE, factors influencing PE delivery (prompts specific to survey answers)</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant survey informed qual sampling, qual expanded on quant)</li> </ul>
Morgan and Hansen [70]	EXPLANatory Sequential (QUANT-qual)	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 189</math>) reflecting on previous 12 months' PE (frequency, duration, general content covered, student outcomes)</li> </ul>	<ul style="list-style-type: none"> <li>Teacher interviews (<math>n = 31</math>) (prompts specific to survey answers)</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant survey informed qual sampling, qual expanded on quant)</li> </ul>
Naylor <i>et al.</i> [40]	Convergent Parallel	<ul style="list-style-type: none"> <li>Teacher training survey: satisfaction with training workshop</li> <li>Teacher post-intervention survey: satisfaction with intervention</li> <li>Tracking sheets: weekly activity logs kept by teachers</li> <li>specific <math>n</math> values not given</li> </ul>	<ul style="list-style-type: none"> <li>Telephone interviews with administrators (<math>n = 7</math>) and school facilitators (<math>n = 2</math>) about implementation factors, experience and suggestions for change</li> <li>Focus groups with teachers (<math>n = 28</math>), students (<math>n = 26</math>), parents (<math>n = 16</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual analysed separately, integration in results (minimal)</li> </ul>
Orme <i>et al.</i> [46]	Convergent Parallel	<ul style="list-style-type: none"> <li>Teacher survey (<math>n = 75</math>) on programme activities pre- and post-intervention</li> </ul>	<ul style="list-style-type: none"> <li>Teacher interviews mid-way through intervention (<math>n = 6</math>) and post-intervention (<math>n = 24</math>)</li> <li>Student focus groups (<math>n = 77</math>) about perceptions of implementation and involvement</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual analysed separately, integration in results (minimal)</li> </ul>
Pettigrew <i>et al.</i> [71]	EXPLORatory Sequential (QUAL-quant)	<ul style="list-style-type: none"> <li>Online principal survey (<math>n = 310</math>) about school characteristics and school canteen procedures based on interviews</li> </ul>	<ul style="list-style-type: none"> <li>Principal interviews (<math>n = 10</math>) regarding implementation experience, perceptions of policy, consequences of policy</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (qual informed development of quant)</li> </ul>
Prusak <i>et al.</i> [72]	EXPLANatory Sequential (QUANT-qual)	<ul style="list-style-type: none"> <li>Students completed Attitude Toward PE Survey (<math>n = 277</math>) regarding students' perceived enjoyment and utility of PE</li> </ul>	<ul style="list-style-type: none"> <li>Student focus groups (<math>n = 24</math>) to understand students' attitudes and perceived impact of PE</li> <li>Student interviews (follow up on focus group to allow students to share their individual views) (<math>n = 24</math>)</li> <li>Observations of teaching</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual connected (quant informed qual sampling, qual expanded on quant findings)</li> </ul>
Slater [44]	Convergent Parallel	<ul style="list-style-type: none"> <li>Administrative data to determine enrolment in Home Economics Food and Nutrition (HEFN) courses (Grades 7–12) across Manitoba for 2000–10</li> </ul>	<ul style="list-style-type: none"> <li>Interviews with Home Economics teachers (<math>n = 13</math>) and superintendents (<math>n = 3</math>) regarding perceptions of HEFN</li> </ul>	<ul style="list-style-type: none"> <li>Quant and qual analysed separately, integration in discussion (minimal)</li> </ul>

(continued)

Table IV. Continued

Study	Mixed methods design	Quantitative methods	Qualitative methods	Integration
Steckler <i>et al.</i> [41]	Convergent Parallel	<ul style="list-style-type: none"> <li>- Tracking sheets: teacher and food services staff attendance at training workshop; teachers completed checklists for each curriculum unit and lesson throughout implementation; PE teachers completed PE calendar</li> <li>- Survey: teachers and food services staff completed training workshop evaluation; student survey on nutrition and PA knowledge, attitudes and practices at end of each year</li> <li>- Program data: attendance at family events</li> </ul>	<ul style="list-style-type: none"> <li>- Teacher interviews at end of each semester related to implementation experience</li> <li>- Food services manager interviews at end of each semester related to implementation experience</li> <li>- (sample sizes not given)</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in results (presented based on theme)</li> </ul>
Whittemore <i>et al.</i> [51]	Concurrent mixed methods (Convergent Parallel)	<ul style="list-style-type: none"> <li>- (sample sizes not given)</li> <li>- Parent survey; demographic questionnaire about students' age, gender, race/ethnicity (no <i>n</i> value given)</li> <li>- Student survey (<i>n</i> = 384); programme satisfaction (3 months after programme implementation)</li> </ul>	<ul style="list-style-type: none"> <li>- Document Review: meeting minutes with teachers and administrators regarding programme</li> <li>- Teacher interviews regarding perception of programme, implementation process, student engagement (no <i>n</i> value given)</li> </ul>	<ul style="list-style-type: none"> <li>- Quant and qual analysed separately, integration in results (minimal)</li> </ul>

**Table V.** Appraisal using the GRAMMS guidelines [24]

GRAMMS guideline	Yes	Yes, but improvements are possible	No	Not enough information	Not applicable
1) Describe the justification for using a mixed methods approach to the research question					
Is the use of mixed methods research justified?	5	3	15	0	0
2) Describe the design in terms of the purpose, priority and sequence of methods					
Is the design for mixing methods described?					
Priority of methods	1	3	19	0	0
Purpose	3	7	13	0	0
Sequence	10	9	1	3	0
Stage of integration	1	7	15	0	0
Has rigour of the design been adhered to?	12	9	0	2	0
3) Describe each method in terms of sampling, data collection and analysis					
Is the role of each QUANTITATIVE method clear?	15	4	4	0	0
Is each QUANTITATIVE method described in sufficient detail?	11	8	4	0	0
Is the QUANTITATIVE analysis sufficiently sophisticated?	16	1	5	1	0
Is the role of each QUALITATIVE method clear?	19	2	2	0	0
Is each QUALITATIVE method described in sufficient detail?	14	5	4	0	0
Is the QUALITATIVE analysis sufficiently sophisticated?	14	6	1	2	0
4) Describe where integration has occurred, how it has occurred, and who has participated in it					
Is the type of integration stated?	1	0	22	0	0
Is the type of integration appropriate to the design?	15	8	0	0	0
5) Describe any limitation of one method associated with the presence of the other method	0	1	16	6	0
6) Describe any insights gained from mixing or integrating methods					
Is there clarity about which results have emerged from which methods?	20	2	1	0	0
Are inferences appropriate?	21	1	0	1	0
Are the results of all the methods considered sufficiently in the interpretation?	16	4	1	2	0
Has rigour been compromised by the process of integration?	2	0	16	5	0

school type, size) that might contribute to the findings. Additionally, one study only stated the analysis software used [41].

### Qualitative methods

Interviews ( $n = 19$ ) were the most frequent qualitative method, followed by focus groups ( $n = 9$ ), document reviews ( $n = 3$ ), participant observation ( $n = 2$ ) and implementation journals ( $n = 1$ ) where teachers kept a written record of programme implementation. The most frequently interviewed key

informant groups were teachers, administrators and food services staff. For focus groups, students were the most frequent participant group. Martens *et al.* [45] used implementation journals, in which teachers were asked to track time, activities, materials, their reflections, as well as students' reactions to the programme. When the GRAMMS guidelines were used to examine the method descriptions, all but two articles described the role of each qualitative method clearly, and all but four described the methods in adequate detail (Table V; Guideline 3). Articles

with inadequate detail did not include the qualitative sample size, describe the topics covered, or give examples of questions asked. All but three articles used adequately sophisticated qualitative analyses. The remaining articles provided inadequate detail about specific analysis strategies employed (e.g. only stated the results of qualitative methods were combined with the quantitative methods [43]); used terms (e.g. thematic analysis) but did not describe their specific process [46]; or simply stated the analysis software [41].

### Integration

Although all articles included in this review had evidence of integrating quantitative and qualitative methods, these descriptions should be more detailed. Few articles described when and how integration occurred (Table V; Guideline 4); only de Meij *et al.* [37] stated the type of integration. However, when the articles were examined to determine the type of integration, 14 articles analysed the quantitative and qualitative data separately, integrating them in the final interpretation. Seven connected the quantitative and qualitative methods in collection (i.e. the quantitative data were collected first and informed the qualitative data collection). Gittelsohn *et al.* [39] transformed qualitative data from interviews into school climate and classroom curriculum indices, which were then combined with quantitative data in a regression. Finally, Goldberg *et al.* [43] mixed the quantitative and qualitative data within a programme-objective framework [9]: a qualitative needs assessment led to the development of an intervention, the outcomes of which were evaluated quantitatively.

Generally, studies did not discuss how the use of multiple methods compensated for the limitations of individual methods within the design (Table V; Guideline 5). Only one article discussed how the qualitative findings provided deeper understanding of the quantitative findings [47]. All but one article [37] were clear on which results had emerged from each method (Table V; Guideline 6). Inferences were deemed appropriate for all articles except one, for which not enough information was available

to make a decision [37]. Twenty articles considered all methods in the meta-inferences. However, Longley and Sneed [48] only reported the quantitative findings; it appeared the interview findings simply informed the development of the quantitative survey. In two articles [37, 43], it was impossible to tell whether all methods had been considered because of insufficient information. For example, the discussion in one article [43] was not specific to the results presented.

### Rigour

Quantitative rigour was assessed through the reliability and internal validity of the data and quantitative instruments, as well as the generalizability and replicability of the findings (Table VI). Generalizability was discussed if articles stated whether the findings could extend beyond the specific study context. Internal validity was demonstrated if the validity of the instruments was stated (either through the use of statistical tests or they had been validated previously) or there was random assignment of intervention and control groups. Reliability was demonstrated through statistical tests for instrument reliability (e.g. Cronbach's alpha). Seventeen studies discussed the generalizability of their findings, ten used internally valid measures, nine used reliable measures, and no studies discussed replicability. One study [37] stated that the reliability and validity of the instruments were unknown.

Articles were examined for evidence of qualitative rigour (i.e. credibility, transferability, dependability and confirmability—see Table VII for definitions) and the techniques for establishing qualitative rigour as outlined by Lincoln and Guba [21]. All articles had evidence of qualitative rigour (i.e. mentioned techniques in Table VII); however, only five articles explicitly mentioned qualitative rigour or the associated criteria. All articles but one [43] had evidence of credibility; the most common techniques were triangulation ( $n = 19$ ), audio recordings ( $n = 18$ ), transcripts ( $n = 17$ ) and including participant quotes ( $n = 16$ ) (Table VII). Aligning with Lincoln and Guba [21], studies were

**Table VI.** Evidence of quantitative rigour

Quantitative rigour criteria	Number of articles		
	Yes	No	Not addressed
Was there discussion of 'generalizability' of the findings?	17	6	—
Were outcome measures and/or quantitative instruments 'internally valid'?	10	2	11
Were outcome measures and/or quantitative instruments 'reliable'?	9	1	13
Was there discussion of 'replicability' of the findings?	0	23	—

considered to have used triangulation if they employed different data sources, methods, and/or investigators and compared the results of each.

Nineteen articles had evidence of transferability, through thick description ( $n = 14$ ) and purposeful sampling ( $n = 10$ ). Thick description was demonstrated when authors provided a detailed description of the participating schools and interventions, so readers could determine whether the findings would apply in other contexts. For purposeful sampling, articles either used the term or described that the selection process was not random; instead, information-rich cases were chosen. Fourteen articles had evidence of dependability; the most frequent was computer-assisted analysis ( $n = 9$ ). Computer-assisted analysis is one way to establish an audit trail, allowing for review of the analysis process and to ensure consistency in the findings [49, 50]. Finally, only three articles had evidence of confirmability through the use of a researcher journal ( $n = 3$ ) and confirmability audit ( $n = 1$ ).

The GRAMMS guidelines include two questions specific to mixed methods rigour. All but two studies adhered to the rigour of the design (Table V, Guideline 2), indicating 'methods [we]re implemented in a way that remain[ed] true to the design' ([25], p. 541). For the remaining two, sample sizes were not given so we could not determine whether sampling was appropriate for the specific design. In 16 studies, integration did not compromise rigour (Guideline 6); however, for nine of these articles, qualitative and quantitative findings were reported separately. For five of the remaining articles, not enough information was available (e.g. it was difficult to determine which methods the results came

from or whether all qualitative findings were presented). Finally, for two articles [41, 51], it appeared that integration had compromised rigour because minimal qualitative results were presented. In the following section, the findings will be discussed in light of the previous literature.

## Discussion

Although this review confirms that mixed methods approaches are being used to study school-based obesity interventions, the findings indicate that the reporting of mixed methods in this field is lacking sufficient detail as to preclude the drawing of strong conclusions. Studies investigated both implementation and outcomes, aligning with suggestions that mixed methods can be used to explore both the context and outcomes of interventions [1, 16, 17, 52]. The most common combination of methods was one quantitative and one qualitative method, with surveys and interviews being used together most frequently. Although a variety of qualitative methods were used, photovoice was not, which is interesting given its links to empowering research participants [53–55].

### Reporting quality of mixed methods studies

Similar to other reviews of mixed methods studies in the health field [24, 26, 30–32], the quality of mixed methods reporting in the reviewed studies leaves room for improvement. Less than half of the articles specified using 'mixed methods'. If the use of mixed methods in population health research is to expand,



**Table VII.** Evidence of qualitative rigour

Criterion/Technique <sup>a</sup>	Number of articles
Credibility	22
Triangulation (method, source and/or investigator)	19
Audio recording	18
Transcripts	17
Use of participant quotes	16
Peer debriefing	3
Member checking	3
Negative case analysis	2
Transferability	19
Thick description	14
Purposeful sampling	10
Dependability	10
Computer-assisted analysis	9
Dependability audit	1
Confirmability	3
Researcher journal	3
Confirmability audit	1

Credibility is the degree a description could be recognized by those who have experienced it and understood by those who have not [73]. Use of participant quotes, audio recording and transcripts all fit within Lincoln and Guba's [21] referential adequacy. Transferability refers to whether the findings could fit into contexts outside of the study situation [73]. Dependability refers to the consistency of the findings [73]. Computer-assisted analysis is one way to establish an audit trail, allowing for review of the analysis process and to ensure consistency in the findings [49, 50]. Confirmability refers to how the researcher influences data interpretation (e.g. his/her biases, motivations and perspectives) [73].

<sup>a</sup>Although some techniques can contribute to multiple criteria, each technique is only presented once. We followed Lincoln and Guba's [21] definitions and organization of the techniques for establishing qualitative rigour.

studies must be labelled 'mixed methods' if they meet the established criteria (e.g. Box 1) to provide examples for future studies. Further, only eight articles justified using mixed methods; this is consistent with another review, which suggested the absence of justification might reflect authors' limited understanding of mixed methods [31].

Only three studies identified the mixed methods design used, aligning with reviews of health services research [24, 31]. Some articles did not describe the individual methods adequately, leaving out details expected in monomethod studies (e.g. sample size, topics covered by each method and analysis details), consistent with previous findings [26]. Further

details regarding integration and meta-inferences were needed, especially as they are the distinguishing features of mixed methods. Finally, none of the articles discussed limitations associated with using mixed methods; instead, they focused on limitations of the individual methods used. In order for mixed methods research to grow and for its quality to improve in the population health field, researchers must reflect on the specific challenges of using mixed methods.

When the GRAMMS guidelines were applied, no single criterion was met by all studies and no studies met all criteria. Of the reviewed papers, Morgan and Hansen [56] received the most 'yes' and 'yes, but improvements are possible' responses. However, they did not identify the study as mixed methods or provide a mixed methods design. Interested readers should also refer to Ardzejewska *et al.* [38] for a sample of an appropriately detailed design description and de Meij *et al.* [37] for an appropriate mixed methods design illustration. Further guidance for designing and reporting mixed methods studies can be found in Creswell and Plano Clark [9] and Curry and Nunez-Smith [27]. Overall, there is a clear need for detailed reporting of mixed methods in the school-based obesity intervention literature to allow for more comprehensive assessment of findings, which should lead to increased validity of evidence, improved research designs and ultimately, better interventions.

### Rigour of mixed methods studies

Although few articles used the term 'rigour', evidence for both quantitative and qualitative rigour was provided. For the quantitative components, the most frequently discussed criterion was generalizability, then validity, followed by reliability. No studies discussed replicability, aligning with findings that social policy researchers did not consider replicability as important as the other three criteria when assessing the quality of quantitative studies [20]. Only five studies specifically discussed qualitative rigour; however, all studies had evidence of techniques for establishing qualitative rigour (e.g. triangulation, thick description). Evidence for

credibility was most commonly reported, followed by transferability and dependability. Only three studies had evidence for confirmability. To evaluate the quality of mixed methods studies (and their findings), researchers must increase reporting of quantitative and qualitative rigour, especially regarding replicability, reliability, validity, dependability and confirmability.

What is particularly interesting regarding the mixed methods rigour literature is that unlike its quantitative and qualitative counterparts, the practical techniques for establishing and assessing rigour are not evident. Hence, in addition to a lack of consensus regarding what to look for, there is almost no discussion of how to establish rigour. In both quantitative and qualitative research, there are a variety of techniques researchers can employ throughout the research process to address rigour. Further discussion in the literature is needed regarding practical techniques mixed methods researchers can use to establish rigour beyond those addressing the quantitative and qualitative criteria. That is, guidance is needed for establishing and assessing rigour for all components of a mixed methods study concurrently, instead of addressing the quantitative and qualitative components separately.

### **Implications for future mixed methods studies in population health research**

The low quality of reporting in the reviewed papers is intuitive for three reasons. First, the conclusions align with previous reviews of mixed methods articles in the health field [24, 26, 30–32]. Second, guidance on mixed methods is just beginning to emerge in the population health literature (see Refs. [14, 16, 27, 52]). Third, it is worth noting that none of these studies were published in mixed methods journals; many academic journals enforce strict word limits, which are sometimes insufficient for the descriptions required in mixed methods studies [26, 52]. However, several journals offer the option to post supplementary materials online; we encourage authors to take advantage of these opportunities to provide more detail regarding their methods and how they established rigour in their studies.

Clearly, there is a need to increase population health researchers' awareness about dialogue in the mixed methods literature regarding reporting quality. We encourage readers to review Curry and Nunez-Smith [27], which provides guidance for assessing and publishing mixed methods in health research, as well as other resources for writing effective mixed methods publications [9, 57–60]. However, further guidance is needed regarding how to report mixed methods studies [27]. Developing a guide for reporting mixed methods in health research would be valuable to improve authors' reporting and provide journal editors and reviewers with criteria to evaluate these studies. Ultimately, this guide could become a document similar to the CONSORT (CONsolidated Standards of Reporting Trials) guidelines for randomized controlled trials [61].

Finally, given the absence of discussion regarding integration in the reviewed articles, it would be useful for researchers to review Fetters *et al.* [62], which describes how to integrate quantitative and qualitative data. Developing a resource for health researchers that provides guidance for authors, editors and reviewers should increase the quality of mixed methods papers. More detailed reporting will provide readers with examples of how to conduct rigorous mixed methods research, informing their own projects. Ultimately, this should increase the quality of evidence to inform both policy and practice.

### **Limitations**

The findings of this methodological review should be considered in light of its limitations. First, comprehensive search strategies for the retrieval of mixed methods articles have yet to be developed. For instance, only one database (ERIC) had a subject heading for mixed methods. However, the authors consulted the literature to determine the search terms for mixed methods studies used in this review. Second, this review did not capture mixed methods research in which the quantitative and qualitative components are published in separate articles. However, the suggestions regarding reporting and rigour should still apply to these articles as the

same components would be presented across multiple papers. It should be noted that as no guidance exists for implementing the GRAMMS guidelines for quality appraisal, the appraisal results are based on the first author's interpretation of the questions. The first author conducted the literature search, data extraction and quality appraisal; hence, the review criteria were applied consistently across the studies. To minimize potential biases, the first author kept detailed records of all decisions made throughout the review process.

Additionally, this review and the associated quality appraisal were based on the information reported in the articles themselves. It is possible criteria may have been met but not reported due to limited word counts or the focus of the journal the study was published in. Nonetheless, the authors were specifically interested in how mixed methods approaches had been reported; similar to Sale and Brazil [63], this article provides suggestions for improving the quality of reporting based on the information stated in the articles.

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## Conclusions

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This review makes substantive and methodological contributions. First, the GRAMMS guidelines [24] were applied to assess studies outside the health services literature. Second, this review provides examples of how mixed methods have been used to study school-based obesity interventions. These examples and the suggestions for improvement could guide the development of future mixed methods studies in the field. In order for mixed methods studies in population health to provide strong evidence to influence policy and practice, reporting quality and rigour must be enhanced. Improved reporting is required for data collection and analysis, integration, inferences and justifying the use of mixed methods. Further, greater attention to quantitative and qualitative rigour was needed in the articles.

This review points to four directions for future research. First, it would be interesting to review mixed methods research in which the components are reported in different articles, to see whether the

quality of reporting is similar to this article's findings. Researchers may often publish the components separately given the limited word counts in journals and the value attributed to publication quantity. However, conducting this type of review would involve a more complex search strategy than the one employed in this study. Second, it would be worthwhile to conduct a review of mixed methods research using other empirical examples in population health (e.g. tobacco control, obesity interventions in non-school settings) to see whether the reporting of mixed methods is comparable to the results found in this review. Third, a guide for reporting mixed methods research in population health would be a worthwhile contribution to aid population health researchers in writing mixed methods articles. Finally, there is a need for further discussion in the literature regarding rigour in mixed methods research, and particularly regarding practical techniques that can be employed beyond the monomethod components. Considering that the field of mixed methods is still evolving, this discussion should also reflect the need to balance rigour with the innovation of new mixed methods approaches. By employing robust mixed methods designs and detailed reporting, mixed methods approaches can provide strong evidence to inform policy and practice.

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## Conflict of interest statement

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None declared.

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**Appendix A: Data Extraction Tool**

<b>Date of Review</b>		
<b>Title</b>		
<b>Author</b>		
<b>Year</b>		
<b>Mixed Methods</b>		
Did the study specify that it was mixed methods?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<b>Study Purpose</b>		
Was the purpose and/or research question stated clearly?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Outline the purpose of the study and/or research Q.		
<b>Theoretical perspective/framework</b>		
Was a theoretical perspective/framework identified?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Describe the theoretical perspective/framework		
<b>Mixed Methods Design</b>		
Was a mixed methods design given?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
If yes, what mixed methods design was given? If no, what design is it ? [9]	<input type="checkbox"/> Convergent Parallel	
	<input type="checkbox"/> EXPLANatory Sequential (Quant-qual)	
	<input type="checkbox"/> EXPLORatory Sequential (Qual-quant)	
	<input type="checkbox"/> Embedded	
	<input type="checkbox"/> Multiphase	
	<input type="checkbox"/> Transformative	
<input type="checkbox"/> Other		
Was a justification for using mixed methods given?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Describe the justification for using mixed methods.	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<b>Quantitative Design</b>		
Was a quant study design described?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Describe the study design.		
What was/were the quant method(s) used?	<input type="checkbox"/> Survey	
	<input type="checkbox"/> SOFIT	
	<input type="checkbox"/> Tracking sheets	
	<input type="checkbox"/> GIS	
	<input type="checkbox"/> Fitness testing	
	<input type="checkbox"/> Program/administrative data	
	<input type="checkbox"/> Anthropometric measures (height, weight, BMI)	
<input type="checkbox"/> Other		
Describe the quant method(s).		

<b>Quantitative</b>			
<b>Sampling</b>			
Quant sample n			
Sampling strategy (how was it done?)			
Sample characteristics (Who? How many? Inclusion/Exclusion)			
<b>Outcomes</b>			
Were outcome measures reliable?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> Not Addressed
Were outcome measures valid?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> Not Addressed
Was generalizability of the findings discussed?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
Was replicability of the findings discussed?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
Frequency of outcome measurement (pre, post, follow-up)			
Outcome areas and measures used.			
Analysis techniques used			
<b>Qualitative</b>			
<b>Design</b>			
Was a qual study design described?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
Describe the study design.			
	<input type="checkbox"/> Participant observation <input type="checkbox"/> Interviews <input type="checkbox"/> Focus group(s) <input type="checkbox"/> Implementation “journals” <input type="checkbox"/> Document review <input type="checkbox"/> Other		
What was/were the qual method(s) used?			
Describe the qual analysis used. Inductive? Deductive? Thematic? Other?			
<b>Sampling</b>			
Qual sample n			
Sampling strategy (how was it done?)			
Sample characteristics (who? How many?)			
Was sampling done until saturation was reached?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> Not Addressed
<b>Intervention</b>			
Study Location			
Intervention Target Area	<input type="checkbox"/> PA	<input type="checkbox"/> Nutrition	<input type="checkbox"/> Obesity
Target Group- Age	<input type="checkbox"/> Elementary (K-8)	<input type="checkbox"/> Secondary (9-12)	
	<input type="checkbox"/> Middle (6-8)	<input type="checkbox"/> Other	
Target Group- Special Population	<input type="checkbox"/> Girls Only	<input type="checkbox"/> Indigenous students	
	<input type="checkbox"/> Low Income	<input type="checkbox"/> Other	<input type="checkbox"/> None
Timing of intervention	<input type="checkbox"/> Instructional time	<input type="checkbox"/> Recess	
	<input type="checkbox"/> During the school day	<input type="checkbox"/> After school	

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Details of intervention (who delivered it, how often, setting, participants)

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**Mixed Methods Analysis**

Were quan and qual results integrated?  Yes  No

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Quan & qual analyzed separately, integration in final interpretation

Quan & qual data merged in analysis-TRANSFORMED

At what stage were results of quan and qual integrated?  Quan & qual connected in collection (1 informs 2)

Embedded (1 method embedded into other method)

Mixed within theoretical framework

Mixed within program-objective framework

Minimal integration

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Describe methods of data analysis and integration- where was the integration reported?

**Results**

What were the main results?

Were the quantitative results statistically significant ( $p < 0.05$ )

**Qualitative Rigour**

Was there any mention or evidence of qualitative rigour?  Mention  Evidence only

Comments on qualitative rigour?

Was there evidence of **credibility**?  Yes  No

What ways did the researcher ensure credibility?

Was there evidence of **transferability**?  Yes  No

What ways did the researcher ensure transferability?

Was there evidence of **dependability**?  Yes  No

What ways did the researcher ensure dependability?

Was there evidence of **confirmability**?  Yes  No

What ways did the researcher ensure confirmability?

**Conclusions/Implications**

Were there any relevant conclusions for the use of mixed methods?

Study limitations and/or biases

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Note: The GRAMMS guidelines were used to critically appraise each article. For a copy of the GRAMMS guidelines, please see Table V.