**Title: The impact of, and views on, school food intervention and policy in young people aged 11-18 years in Europe: a mixed methods systematic review**

## Running title: School food intervention and policy in young people: a systematic review

## Reviewers

Kelly Rose RNutr, BSc (Hons), PGCE[1 2]

Dr. Claire O'Malley PhD [1 2]

Fatemeh Eskandari MSc [1 2]

Professor Amelia A Lake RNutr, RD, PhD[1 2]

Dr. Laura Brown RNutr PhD [1]

Professor Louisa Jane Ells RNutr, PhD [3]

[1] Centre for Public Health Research, School of Health and Life sciences, Teesside University, United Kingdom

[2] Fuse - Centre for Translational Research in Public Health, Newcastle upon Tyne, UK

3 School of Clinical and Applied Sciences, Leeds Beckett University, Leeds, UK

**Keywords: school, diet, adolescent, food policy**

**Corresponding author:** Kelly Rose k.rose@tees.ac.uk

**Acknowledgements:** Mrs Carol Dell Price, Teesside University for her guidance with literature searches and Prof Alan Batterham, Teesside University for his advice with data analysis.

**Conflicts of interest:** None

Abbreviations: BMI Body Mass Index; EI energy intake; FV Fruit and vegetables; RCT Randomised control trial; SSB Sugar sweetened beverages; SES Socioeconomic status

## Summary

Understanding the social and environmental influencers of eating behaviours has the potential to improve health outcomes for young people. This review aims to explore the effectiveness of school nutrition interventions, and the perceptions of young people experiencing a nutrition focused intervention or change in school food policy. A comprehensive systematic search identified studies published between 1/12/2007 to 20/2/2020. Twenty-seven studies were included: 22 quantitative studies of nutrition related outcomes and five qualitative studies reporting views and perceptions of young people (combined sample of 22,138 participants, mean ages 12-18 years). The primary outcome was nutrition knowledge/dietary behaviours, with secondary outcomes exploring Body Mass Index (BMI) and wellbeing. Due to the heterogeneity of studies, a narrative results description is presented. The findings demonstrate that school nutrition programmes can be effective in reducing sugar, sugar sweetened beverages (SSB), saturated fat, and increasing fruit and vegetable (FV) intake. The lived experiences of young people in a school context provide valuable insights which should be considered in the development of effective school food policy and interventions. This review affirms the significant role that schools can play in supporting good nutrition in all young people and provides opportunities to inform the school food agenda.

## Introduction

Currently there are approximately 1.8 billion adolescents in the world [1], who will become the future workforce and parents, therefore government investment in interventions within this age group has the potential to provide high economic yield [2, 3].

A focus on the social and environmental influences of eating behaviours has potential to enhance the understanding of how to improve health outcomes for young people [4]. Unhealthy dietary behaviours known to contribute to obesity such as skipping breakfast, irregular eating

patterns, and the consumption of fast food and high sugar beverages are prevalent in this age group [5]. Evidence also suggests that young people from areas of socioeconomic deprivation are less likely to consume fruit and vegetables (FV), and more likely to consume energy dense fast foods [4, 6]. These behaviours are contributing to young people not meeting recommended nutrient intakes [7], and have been targeted as part of public health strategies such as the UK Government's childhood obesity plan, the UK national sugar levy [8-10] and the WHO commission on ending childhood obesity [11]. However, intervention strategies using educational messages and activities to increase awareness and knowledge have limitations, and have failed to sustain increased consumption of FV in this specific age group [12, 13]. Facilitators that may help to promote healthy dietary behaviours include: easy access to healthful choices, a personal inclination to value one's appearance, a measure of self-control, role modelling and encouragement of healthy eating practices [5, 14-16].

Poor nutritional quality of school food is an established barrier to healthy eating in adolescents, which is further exacerbated by the low cost, accessibility and taste preference for fast food [17]. The school environment creates opportunities to intervene and reach a large group of the population [13, 18-21]. However, the relationship between school food provision and policy, and its effect on total dietary intake in adolescence is poorly understood [21, 22]. School food standards in Europe have shown limited success in sustaining improvements in young people's healthy food consumption [23-26]. Findings from previous reviews suggest school policies, multicomponent healthy eating school interventions, and those combined with physical activity can be effective in improving dietary intake. However, evidence was limited with regards to the impact of school interventions or policies on BMI [18, 25, 26]. The limited effects and expense of school-based programmes may be a barrier to the development and willingness to implement obesity prevention strategies [18 22] . The Food Education Learning

Landscape UK report describes how poor school food environments and social values, can be considerable barriers to gaining good nutrition in this age group [27].

## Review question/objectives

This review addresses the research question: Are school nutrition interventions or policies, effective in improving dietary intake in adolescents? The aim of this review was to provide an evidence update on the effectiveness of school based European interventions, building on learning from three previous reviews published 2007-2009 [18, 25, 26]. The review was limited to European studies only in order to provide updated evidence following on from the development of school nutrition programmes in the European Region [28]. The objectives of this review were to (a) examine the impact of European school food interventions, on nutrition, weight status and wellbeing outcomes and (b) explore the experiences and perceptions of adolescents in Europe who have been subject to a school food intervention or national school food policy.

## Methods

This mixed method systematic review followed the Joanna Briggs Institute Reviewers Manual [29], and the objectives, methods and analysis were set 'a priori' and published in PROSPERO CRD42019119921. This review has been reported according to Prisma guidelines [30] (supplementary Table S1).

Eligible studies were primary research studies conducted in the UK and Europe, published from 2008 onwards, and reported the effect and or experience of nutrition focused interventions or policy approaches for young people aged 11-18 years. The age of

adolescence is generally recognised as 10-19 years, although 10-24 years has been proposed as a closer reflection of the adolescent growth stage [31]. For the purposes of this school-based review the term adolescent is defined as 11-18 years inclusive, in order to represent the secondary/high school age of young people in the UK and Europe. There were no restrictions on study design, these are stated in the results. All included studies were conducted within mainstream, state or privately funded school settings. Studies based in special educational needs settings, and those only reporting on physical activity, young people with mental health conditions or eating disorders were excluded. All studies that had a nutritional component were included, incorporating both single and multicomponent interventions. Secondary outcomes were wellbeing and BMI.

## Search strategy and selection of studies

The search strategy was run in January 2020 and included records from January 2008. The search was carried out in the following databases; Google Scholar, CINAHL, MEDLINE, ERIC, PsycINFO, EThos, Science Direct, Web of Science, Prospero and Cochrane (search strategy and full search example in supplementary Table S2 and S3). The reference list for key identified reports and records were checked for additional studies. All papers were uploaded into Endnote version x9 (Clarivate. Web of Science group, USA) for the de-duplication and screening. The first author (KR) screened all titles and a second reviewer (FE) screened 20% as part of a quality assurance process. Consensus or a third reviewer resolved any disagreements (CO).

## Assessment of methodological quality

Included studies were assessed for validity and risk of bias by two reviewers (KR, FE) using the standardised critical appraisal tools from the Joanna Briggs Institute [29, 32-36]. The tools

utilised were study design specific and not modified [37]. Attempts were made to contact authors for further information and/or clarification. However, no additional information was provided. Disagreements in assessments were resolved through discussions or a third reviewer (KR, FE, CO).

## Data extraction

The TiDier checklist was used to extract details regarding the interventions delivered within all included studies (Supplementary Table S11) [38] [29, 34]. Two reviewers (KR, FE) independently extracted data from quantitative studies using the data extraction tool from JBI-MAStARI [29, 34]. Study characteristics including: details of interventions, methods, population demographics, in addition to the quality assessment, outcomes of interest and recommendations were extracted from each study [29, 34] (Table 1). The qualitative data was extracted independently by two reviewers (KR, FE) using the standardised data extraction tool from JBI-QARI [34].The phenomena of interest, characteristics and verbatim data including the outcomes relevant to the review were extracted by both reviewers (KR, FE).

## Quantitative data synthesis

The primary outcome data extracted from each quantitative study was the effect on nutrition related measures. The variation of these results is explored in the findings. Wellbeing outcomes were also noted; these were reported in 3 of the included studies as measured by 'Adolescent lifestyle profile' (ALP) or Strength and difficulty questionnaires [39-41]. BMI was the secondary outcome extracted from studies where available. A statistician (AB) was consulted to check the heterogeneity of the quantitative data, and suitability for meta-analysis. Heterogeneity was explored with subgroup analyses and meta regression. Statistical

pooling was not a possible due to heterogeneity. Therefore, a narrative synthesis of the data was performed following the SWIM guidelines [42].

### Qualitative extracted data synthesis

Data was coded using an approach outlined by Thomas and Harding [43]. This enabled the identification of themes which captured the experiences of adolescents within a range of school food environments. Following discussion of common themes emerging from the coding process (CO, KR), a meta synthesis adapted from meta-ethnography steps [44] was conducted. The results are presented following steps adapted from Atkins *et al* [44]; (1) Analysis of the qualitative data and identification of themes; (2)'Translation' of the themes across studies; (3) Synthesis of the translation into principal themes; (4) Expressing the synthesis.

### Data synthesis for mixed methods synthesis

A convergent segregated approach was taken as described in the JBI Reviewers manual [45]. Quantitative and qualitative data were integrated by taking a configurative analysis approach. Comparison of quantitative and qualitative evidence and analysis of interventions/policies in addition to the experiences of pupils were used to link findings and purposeful data. Findings are presented as a narrative description [45, 46].

## Results

Figure 1 presents the PRISMA study selection flowchart. A total of 12,918 citations were identified after removal of duplicates. Following title and abstract screening, 54 full text papers were evaluated against the inclusion criteria. No further studies were found from the reference list searches. Reasons for study exclusions are shown in supplementary Table S4.

For the quantitative section of the review, 22 publications reported data from nine RCTs [47-55], 12 Quasi-experimental studies [39-41, 56-63] (one of which was mixed methods [39], where only the quantitative data met the inclusion criteria) and one cross sectional study [23]. For the qualitative component of the review, five publications were included [16, 64-67].

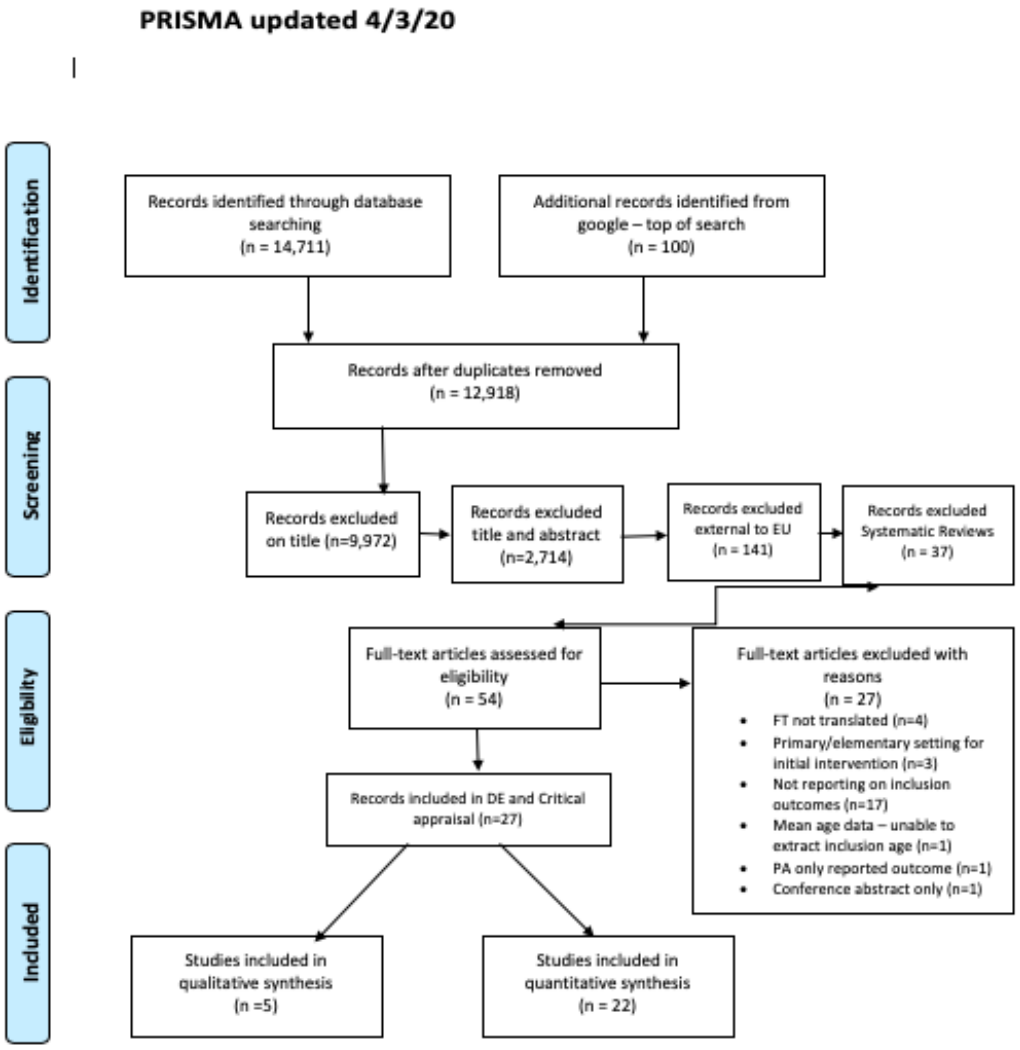


Figure 1: Prisma flow diagram displaying process of included records [30]

## Methodological quality

### *Quantitative studies*

Nine RCT studies [47-55] were included in this review. Overall quality scores ranged from seven to nine out of 13 (Table 1 and supplementary Table S7); no study scored above a nine due to the nature of a school intervention making it challenging to blind participants and delivery staff to the intervention, however assessors were also not blind to the intervention. Overall the studies were deemed to be of good quality, with one study limited by inadequate randomisation of students at school level [47]. In two studies there was a lack of clarity with respect to similarity of groups at baseline [48, 53]. The risk of selection bias was judged to be low in the majority of studies.

For the 12 quasi experimental and one cross sectional study, quality scores ranged from five to nine out of nine (Table 1 and supplementary Tables S8 and S9) and demonstrate weaknesses in reliability measures due to the widely recognised issues with food recall self-reporting bias in the cross-sectional study [23]. The lower scoring studies did not include a control group [56-58]. Overall data quality was good, with limitations detailed in the publication [61].

***Qualitative studies***

Five studies were critically appraised and deemed to be of very good quality [16, 64-67] (Supplementary Table S10). All five studies scored 10/10 demonstrating congruency between methodology and the research aims, data collecting methods and analysis. Contributing to a high level of integrity in presenting the data and adequate representation of the young person's voice.

*Characteristics of Randomised Control Trials (RCT)*

A total of 10,726 participants were included from across nine trials (Table 1), with 5,974 from the intervention group (average age 13±1 years); and 4,752 from the control group (average age 13±1 years). A variety of sample sizes were observed across the nine included RCTs: four studies [49, 50, 53, 55] had less than 1,000 participants (the least being n=213) [50], four between 1,000 - 2,000 participants [47, 48, 51, 54] . The largest study was the Italian single intervention study with a sample of 3,110 participants [52]. Most trials were undertaken in the Netherlands (n= 3) [47, 48, 51] and were based on the same national programme (DOiT). Two were from Italy [52, 54] and one from the UK [49], Greece [50] and Finland [53]. One study included only female participants [49], whilst the other RCTs were mixed gender, although some studies conducted subgroup analyses and reported differences in outcomes according to gender [48, 51, 55]. Two of the trials specifically targeted schools from within areas of economic disadvantage [49, 55]. Whilst the remainder reported a nationally or regionally representative socio-demographic. Of the nine studies, five were multicomponent involving multiple intervention strategies [47, 48, 50, 51, 53] and four focused on a single intervention strategy [49, 52, 54, 55]; with three utilising digital technology [49, 54, 55]. All of the multicomponent interventions were grounded in behaviour change and evidence-based theories to support a change in health-related behaviours. All nine studies investigated the effectiveness of school interventions on nutrition outcomes for young people between the ages of 12 to 16 years, for nutrition outcomes measured see supplementary Table S5. The method of nutritional assessment varied across the studies; all were self-reported with various methods of validated food recall or dietary habits (n=6) [47, 49-53]; FV intake (n=6) [47, 49, 52-55]; brown bread intake (one study specifically reported on brown bread as separate to wholegrain options) [49]; sugar consumption in the form of SSB and or sweets (n=3) [48, 51, 53]; healthy snack consumption [47, 48, 51, 53] and breakfast frequency (n=4) [47, 51, 52, 55] . The secondary outcome of interest (BMI) was reported in five out

of the nine trials. Inconsistent reporting of data collection, time points, reported data and analytical methodologies prevented any meta-analysis of the findings. Wellbeing was not measured in any of the included RCTs.

### *Characteristics of quantitative studies – observational*

The total participants across the 13 studies was 11,129. Eight studies included a control group [40, 41, 59-63, 68], incorporating 4,617 participants in the intervention arms and 3,532 in the control arms (Ensaff [63], due to data collection methods did not report a control group number), and participants were aged between 11 – 18 years. The number of participants across quasi-experimental studies varied widely, with treatment groups ranging from 45 [41] to 1892 participants [59]. The cross-sectional study included data collected from 298 participants in 1999, and 215 participants in 2009.

The observational studies originated from a variety of countries from across Europe: two from Spain [58, 60] and Turkey [41, 62], and one from the UK, Norway, Portugal, Greece, Finland, Italy, Netherlands, and France. The cross-sectional study was undertaken in the UK. These studies include mixed gender participants, and whilst the majority of publications report a mixed socioeconomic demographic, two studies were carried out in schools within areas of raised deprivation [57, 63]. Of the 13 studies, seven were multicomponent studies and one utilised a digital component (text messages) [61]. A further five focused on a single intervention strategy: two of these utilised interactive digital technologies [40, 56], the Norwegian study investigated the effectiveness of a national free fruit scheme [59], and the cross-sectional study was based on a sample evaluation of a national school food policy [23].

All 13 studies investigated the effectiveness of school-based interventions/programmes on nutrition outcomes: nutrition knowledge (n=4) [40, 41, 62, 68], food choice competencies or dietary habits (n=9) [39, 56-60, 62, 63], nutrient intake (n=1) [23], FV intake (n=6) [39, 41, 57, 59, 61, 68], sugar consumption in the form of SSB and or confectionary (n=3) [59-61] , healthy snack consumption (n=3) [59, 61, 68] and breakfast frequency (n=3) [39, 57, 60].

For the secondary outcomes; psychosocial outcomes were assessed in three studies [39-41], using a validated measure; BMI, was analysed in six of the 13 studies. However, methods of BMI data collection (including growth references and analysis) varied. A summary of the observational studies is presented in Table 1.

### *Characteristics of qualitative studies*

Five qualitative studies met the review inclusion criteria (supplementary Table S6), including a total of 283 participants, (average age 18 years). The largest study (n=111) was conducted in six Danish schools [16], with the smallest study (n=25) providing perspectives from Dutch prevocational school students [67]. All the qualitative studies were published from 2014, with three published in 2019. Two of the five studies originated from the Netherlands [64, 67], two from the UK [65, 66] and one from Denmark [16]. All five studies reported data from mixed genders, although differences observed were noted. None of the studies specifically targeted lower socioeconomic groups.

Three of the studies explored experiences of national school food policies rather than bespoke interventions [65-67]. One study examined young people's responses to different potential canteen scenarios [67], another study examined lived experiences of a non-compulsory Dutch

National programme 'Healthy School Canteen program',[64] and the final study explored the experiences of young people participating in a fruit and vegetable scheme [16].

## Findings from included studies

### *Randomised control studies*

#### *Primary outcome – impact on nutritional status*

All the RCTs measuring self-reported dietary intake [47-55] reported improvements in dietary habits (Table 1). The varied exposures of interest incorporate dietary intake and behaviours in each study; these included sugar intake, FV, snacks, breakfast and energy and nutrient intake (supplementary Table S5). Of these studies, only one measured nutrition knowledge , Viggiano et al [52] and reported a significant improvement in 'adolescent food habit checklist' scores (AFHC), for the intervention group at 6 months for both middle and high schools compared to control; mean scores for intervention group 14.4 (95 % CI 14.0; 14.8) vs control group 10.9 (95 % CI 10.6; 11.2) p<0.001. However, at 18 months the effect only remained significant for high school students.

### *Nutrient and energy intake change*

A health promotion study in Greece integrated nutrition education in the classroom with parental communication [50]. The trial was the only RCT to measure energy intake and specific nutrients. Mihas et al reported a positive impact on multiple dietary components including a decrease in mean energy intake (EI) (KJ/d) at 12 months; P<0.001 (mean EI KJ/d in intervention group 8112.4 (SD 1412.4) vs control 8757.9 (SD 1608.3) , a decrease in saturated fat intake (% of EI) at follow up (mean total saturated fat intake as % EI at baseline to 12 months: intervention group 2.4 (SD 2.0) to 10.3 (SD 1.9) vs control at baseline 12.8

(SD 2.3) to 13.4 (2.8)) and a significant increase in mean fruit portion intake at 12 months; P<0.001 (Table 1).

***Nutrition behaviour and dietary change***

Increasing FV intake was a focus of the majority of the RCTs, with four [47, 50, 54, 55] of the six studies [49, 53] measuring FV intake reporting significant increases in fruit and/vegetable consumption in the intervention arm ( Table 1). The RCTs investigating nutrition behaviours and dietary change reported on frequency or quantities; breakfast, SSB or sugar intake, FV or specific food types.

The Dutch multicomponent study investigating energy balance related behaviours (DOiT)[51] found no overall significant effect in all measured outcomes, although some gender specific intervention effects were observed for: female adolescents' consumption of SSB ml/day which significantly decreased at 20 months (SSB ml/day mean change -188 (95% CI -344.0; -32.3); and males 20 months increase in breakfast frequency (mean change 0.29 days/week (95% CI=0.01; 0.58)).

An individual female only intervention of a computerised tailored vs a generic leaflet, demonstrated no impact on fruit and vegetable consumption, however, though small in magnitude, statistically significant increases were observed for servings of brown bread in the intervention group [49]. In Finland, a multicomponent intervention based on Bandura's social cognitive theory [53] incorporated improved healthy food in school provision, nutrition education and parental involvement. Gender separated analysis reported a decrease in the consumption of sweets as a percentage of snacks consumed in school hours at 12 months in the intervention arm compared with control, with no significant effect in male participants.

An overall sample difference in change in the reduction of sucrose as % of energy intake was observed at 12 months with a mean change of -2.3% in the intervention group vs a mean change 0.1%. in the control group (p=0.01).

Bessems et al conducted a multicomponent programme evaluation utilising experiential learning and cognitive driven activities based on behaviour change theories. At both 4 weeks and 6 months follow up, limited effects were observed in most measured dietary outcomes. However, a significant increase in fruit portions/day was reported (mean increase of 0.15 servings of fruit/day post intervention at 6 months p<0.001) [47].

The three trials investigating a reduction of sugar or SSB, were all multicomponent [48, 51, 53] and reported significant beneficial effects of the intervention on decreasing sugar consumption, although this was only observed in females in Van Nassau [51]. Hoppu et al [53] reported a significant mean change in sucrose intake at 12 months. Singh et al [48], reported a significant reduction in SSB at 12 month follow up.

***Secondary outcome - BMI change***

Five RCTs measured BMI change, which was one of the primary outcomes in four trials [48, 50-52] (Table 1), however only two [50, 52] reported a significant effect. The 12-week nutrition intervention in Greece [50] reported a significant reduction in BMI units ($kg/m^{2}$); p<0.001 in the intervention arm at 12 months. The play-based learning board intervention study [52] also reported a sustained reduction in BMI z score at 6 months (Table 1).

***Quantitative studies – observational***

*Primary outcome – impact on nutritional status*

***Nutrition Knowledge***

Three of the thirteen studies measured nutrition knowledge [41, 62, 68] (Table 1). An intervention based on promoting the Mediterranean diet reported a significant positive difference in post-intervention test scores using a nutrition knowledge scale questionnaire when compared to the control group [62]. Ardic et al [41] utilised the 'nutrition knowledge scale for adolescents', and also reported significant improvements in the intervention vs control group at 12 months. A quasi-experimental controlled nutrition health evaluation, undertaken as part of the School for health in Europe programme, reported significant improvements in nutritional knowledge scores after 2 school years in the intervention schools using a scale questionnaire [68] (mean score baseline 4.82 (SD ±1.53) vs. post intervention 5.25 (SD ±1.10) p0.017), with the most positive results reported in the urban intervention school (mean score baseline 4.47 (SD ±1.79) vs. post intervention 5.21 (SD+ 1.10) p=0.005).

***Nutrition behaviour and dietary change***

Nutrition behaviour and dietary change was examined in eight of the observational studies [40, 41, 57-60, 62, 68]. Sahingoz et al [62] examined scores from the Mediterranean Diet Quality Index (KIDMED) assessment, providing an indication of dietary quality, which significantly ($p<0.05$) improved after an 18 week intervention compared to control.

The food aid and nutrition uncontrolled programme in Greece [57] reported a significant positive change in KIDMED scores at 12 months in adolescent females (mean score baseline 4.91(SD 5.0), post intervention mean 5.11 (SD 5.0) p=0.042), with no significant effect for male participants. This study also used food frequency recall questionnaires, which identified a significant 12-month increase in the intervention-focused foods consumed on a weekly basis, these included milk, fruit, vegetables and wholegrain products (Table 1). Findings also

revealed an association between higher food insecurity and an increase in the consumption of wholegrains post intervention.

The Cope healthy Teen controlled programme measured nutrition behaviours using the Adolescent Lifestyle Profile (ALP) [56] and found a significant improvement in nutrition behaviour scores in the intervention group at 12 month follow up ($p<0.01$). This study also reported a significant ($p=0.001$) increase in mean FV consumption scores at 12 months compared to baseline and control. The mHealth study [40] also measured nutrition behaviours using the ALP with significant improvement reported for nutrition scores at 6 months in the intervention group compared to baseline. Sevil et al [60] reported a reduction in soft drink consumption and increase of breakfast consumption, with significant improvements in unhealthy diet scores, at one year follow up compared to control group ($p<0.001$). This controlled study used the WHO health behaviour in school children survey and reported mean difference to control group post intervention; 0.6 (SE 0.1) 95% CI 0.2;0.9, for unhealthy diet scores. The use of healthy/unhealthy food was measured in the Finnish controlled study via a paper questionnaire [68] and found the intervention participants consumed significantly more healthy foods (including vegetables, salads, berries, chicken, fish, rye bread) at follow up more than control participants ($p=0.023$). The Italian 'EAT' multicomponent controlled pilot study reported significant improvements in dietary habits as a secondary outcome as measured by a questionnaire for high energy snacks and SSB consumption expressed as times/week, in all weight groups (normal/overweight/obesity) two years follow up: (SSB in the normal weight group; mean difference in change between intervention and control group at two years −1.12 (95% CI −1.52; −0.72). The overweight/obesity group SSB consumption/week also demonstrated significant improvements: mean change between intervention and control group at 2 year follow up; -

0.81 (95% CI -1.48; -0.14) and snack consumption (mean change -0.67 (95% CI -1.23; -0.11)) [61]. Multiple outcomes of specific food consumption, measured via questionnaire to explore change in dietary habits over time, were measured in the evaluation of the Norwegian school fruit scheme. However, the only significant effect was seen in the increased odds of daily fruit consumption (OR 1.75, 95% CI 1.25;2.43) compared to control group p0.001[59].

***Nutrient and energy intake change***

The cross sectional evaluation of school lunches in England [23] measured energy and nutrient intake via a participant self-report food diary and follow up interview. Although the findings were limited, the study did report a significant decrease in mean energy intake over the 10 year time period (mean difference pre-post intervention: −232 kcals (95% CI -276;-189); p<0.001); a reduction in % energy from fat, (mean difference −9.9 (95% CI -11.4;-8.6); saturated fat (mean difference −1.9% (95% CI -2.7;-1.3); and a reduction in sodium (mean difference −390 mg, (95% CI -453;-328). However, the evaluation also reported a less favourable post intervention decrease in dietary fibre (mean difference −0.7 g (95% CI -1;-0.4); and iron intake (mean difference −0.7 mg (95% CI -0.9;-0.5) [86]. A further study conducted in Spain [58] collected monthly food recall and food frequency consumption from participants via a validated 24-hour recall tool. The data is reported separately by gender, however at 12 months follow up a significant reduction was reported for daily energy (kcals), fat intake and cholesterol for both boys and girls [58].

***Food choice competency***

Change in 'food choice competency'; a young person's capacity to choose a healthy balanced meal or option, for school lunches was measured in 2 studies [56, 63], although the quasi experimental study by Turnin [56] reported student's digital food selections via interactive

personalised software kiosks, rather than actual food choice. This study reported student food choice over 3 consecutive digital selections of lunch, and found significant increases in dairy products, starchy foods, and FV post intervention; alongside a decrease in cheese, pastry and dessert. The quasi-experimental food choice architecture study conducted by Ensaff et al [63] showed that participants were 2.5 times more likely to choose the intervention designated items (including; vegetarian specials, salads, fruit pots) during the intervention period, and 7.5 times more likely to choose a salad item versus baseline.

### *Secondary outcome - BMI change*

Of the 13 observational quantitative studies, five measured BMI change [39, 41, 56, 58, 61]. Ermitici et al [61] reported a significant reduction in BMIz as a result of the multicomponent intervention when compared to control (mean change; -0.18, 95% (CI -0.27; -0.09) p=0.003). However BMI findings reported by Busch et al [39] and Turnin et al [56] were inconsistent, and Ardic et al [41] found no significant effect on BMI. Yet, Campos Pastor et al [58] did report a significant reduction in BMI after a one school year nutrition education intervention compared to baseline in all intervention participants ($p<0.001$).

### ***Secondary outcomes – wellbeing***

Three of the observational studies measured wellbeing outcomes [39-41]. The COPE teen programme in Turkey, measured anxiety and depression using the Beck Inventory [69] and reported no significant change for depression, although anxiety decreased at 12 months follow up in the intervention group. [41]. The mhealth evaluation study [40] utilised the Adolescent Lifestyle Profile for the measurement of multiple outcomes including stress management, spiritual health and positive life perspective. At 6 months, the study reported a significant improvement in positive life perspective in the intervention arm compared to

baseline, and suggested that older adolescents tended to be more able to manage stress [40]. Busch et al [39] examined psychosocial impact via a validated Strength and Difficulties Questionnaire but reported no significant intervention effects.

### *Qualitative data synthesis*

The qualitative studies reported pupils lived experiences in a range of school settings in relation to school food provision programmes/policy. Details of the studies are presented in supplementary Table S6. The studies present young people's views and perceptions of the following programmes: Healthy eating programme [64], Programme providing free FV [16], School food environment (in countries with regulated food policy) [65], newly implemented school food standards [66] and student responses to various school food choice scenarios (in a country with school food policy) [67].

The following eight themes were identified and expressed narratively (Table 2):

1) Autonomy and a need to be part of the decision: Participants describe their view that the school is not giving them any power over decisions and that they are not in control[64, 66, 67];

2) Social influence: Fitting in with peers [16, 64-66];

3) Food aesthetics and freshness*:* Most apparent in the free school fruit and vegetable scheme [16]; with aesthetics of school food offerings also mentioned by participants in two other studies [65, 67];

4) Convenience*;* Having FV ready to eat and lunch options to consume on the go e.g. pizza slices were shown to be more appealing in three studies[64, 66, 67];

5) Cost: Unhealthy options were shown to be more appealing due to the lower cost [64, 65, 67], with free FV viewed as advantageous, and the high expense of the school canteen perceived negatively.

6) Familiar foods and food preferences: Participants generally preferred unhealthy options and expressed negativity towards familiar foods being changed to healthier products [64, 66, 67].
7) Importance of having a balance of healthy and unhealthy options: Studies show that young people are aware of the value of the healthy options and their importance to health, believing there should be a balance both healthful and unhealthful options on offer [64, 65, 67].
8) Social aspect of the school break or lunch times: Young people viewed their social time with friends as more important than their food choice, [16, 66] and perceive that social aspects of the school dining environment are important [67].

*Synthesis of quantitative and qualitative findings*

Findings from the quantitative and qualitative studies were juxtaposed to explore whether quantitative studies considered the priorities as perceived by young people in the qualitative findings, and whether results supported or contradicted one another. The following are the observations emerging from this synthesis. Firstly, findings from three studies emphasised the importance of autonomy over food choice [16, 64-66]. Where national policy was implemented without the young person's input, students viewed the food choice as "too healthy" [66] perceiving the food standards as negative and undermining their sense of autonomy. Where food standards were not being as efficiently implemented in a school, young people viewed this as not supportive to their health [65]. This aligns with the quantitative studies where young people did not feel their freedom of choice was being undermined, either within a whole school approach where education and behaviour change strategies coexist [41, 48, 53, 61] or single food interventions. For example, Ensaff et al [63] use of choice architecture techniques to 'nudge' young people towards the healthier choice. Also, the food competency choice study by Turnin et al [56] enabling students to choose their lunch virtually,

with helpful guidelines, appealing to young people's sense of autonomy in addition to acknowledging the awareness of the importance of healthy options in school [64, 65, 67].

Social acceptance was the most dominant theme from the qualitative data [16, 64-66]. In the school environment where peer and friendship groups exist naturally, social influence is an opportunity to be explored via interventions within school culture. This is evident where multicomponent 'whole school' interventions seek to educate, particularly when embedded into the curriculum, and incorporate behaviour change strategies. The quantitative findings suggest that where these are combined, nutrition knowledge and dietary behaviours/quality is significantly improved [40, 41, 48, 50, 53, 57, 61, 68]. A quantitative study that capitalises on young people's sense of bonding with peers, is the 'Peer led' social marketing-based study [55] which resulted in a significant impact on fruit consumption post intervention. Linked to the importance of social aspects [67], is the success of play/game based interventions, such as the nutrition education game board intervention [52] and the game based approach utilising digital technology [40].

Young people indicate the importance of cost [64, 65, 67] in their food choices, with the high expense of healthy food options perceived to be a barrier to improved nutrition. Two quantitative studies complement this finding: Kastorini et al [57] include school lunch within their multicomponent intervention, where students with high levels of food insecurity demonstrated an improvement in dietary quality post intervention; and the Norwegian free fruit scheme [59] demonstrated positive effects in fruit consumption. The free or low-cost interventions also support the qualitative theme around food familiarity being fundamental to improving nutrition habits [64, 66, 67], and providing low risk opportunities to try a range of non-familiar foods. The appearance, freshness and convenience of food choices were important to participants [16 66 64, 66, 67], and should be a consideration for studies where complimentary FV

or meals are provided to increase uptake. However, this was not a theme that was supported by the quantitative evidence. The theme highlighting the importance of social aspects of the dining hall, was also unsupported by the quantitative evidence, although challenges such as time, queuing, aesthetics and behaviour focus [70] [67] remain essential in the consideration of a 'whole school approach'.

## Discussion

This review has shown that school-based programmes have the potential to improve young people's nutrition intake and dietary habits by helping to reduce sugar, SSB, saturated fat, increasing FV, and facilitating more healthy food choices in the school setting. In addition, this review expands and updates the evidence base of school interventions/food policy in Europe, to support improved dietary outcomes and eating behaviours in young people. The first objective was to examine the impact of European school food interventions, on nutrition, weight status and wellbeing. As suggested in previous reviews [71], the most promising evidence derives from combined multicomponent lifestyle interventions embedded into the school day via policy, which are also less disruptive and easier for schools to implement over time [13, 18, 26, 63, 72]. Thus, adding to the evidence that schools implementing a 'whole school approach' can be effective in improving young people's nutrition outcomes. The impact of national policy findings however were limited due to a lack of national school food standards evaluations, and demonstrates that the recommended '5 step' systematic approach including consistent evaluation is still not established practice in most of the WHO European region [73]. The second objective was to explore the experience and perceptions of young people in Europe who have participated in a school food intervention or experienced a change in national school food policy. This review provides evidence to demonstrate that a sense of autonomy and social aspects are important determinants in young people's food choices.

The rate of school nutrition intervention publications has significantly increased in Europe since 2008 [25] [18, 26], and the nature of the interventions have also changed to reflect digital advances. This review aligns with prior systematic review findings [25, 26] and demonstrates overall that educational interventions, and nutritional guidelines can support modest reductions in saturated fat intake, and reduced-price or free FV can increase consumption [16, 23, 57, 59]. Four studies in this review, which measured nutrition knowledge, reported significant improvements in both nutrition knowledge and behaviours [41, 52, 62, 68]. Suggesting that knowledge, although far from the being the answer, remains important within the complex system of influencing adolescent eating behaviours. This review also provides an update to the comprehensive WHO European 'Food and Nutrition policy for schools report [73], showing that many of the recommendations such as breakfast provision, free fruit schemes, and national school food policies have been implemented in multiple European countries. This review also reaffirms the need for healthy food and nutrition policy to be a high priority for all schools.

The weight related outcomes from this review align with a previous international review [18]; which also reported inconsistent results, and heterogeneity in study design and outcome reporting. The limited effects on weight related outcomes remain a challenge, despite a recent increase in school studies measuring BMI, missing data, and heterogeneity in measurement methodology and data reporting remains an issue.

Although there is a growing body of evidence demonstrating a link between dietary intake and the potential to improve psychosocial outcomes [74-76], in this review only three studies

examined wellbeing outcomes [39-41]. Although the findings demonstrated limited overall effectiveness, in general studies were not powered to assess wellbeing.

## The role of school-based intervention in economically disadvantaged areas

The widening gap in health inequalities: increasing the risk of young people from areas of low socio-economic status (SES) living with obesity is of significant concern [77]. From the evidence identified in this review only seven out of 27 studies examining SES [47-49, 51, 55, 57, 63], and the Dutch RCTs based their evaluations in prevocational schools, which are more likely to have students from economically disadvantaged families [47, 48, 51]. Findings from these studies do however suggest that multicomponent interventions incorporating education and improved healthy food provision may be effective in improving nutrition outcomes in socio-economically disadvantaged young people. However the most promising approach in areas of deprivation seems to be complimentary FV and/ lunch, as this provides opportunities for young people to try a range of foods without economic risk, in addition to increasing FV intake from 'nudges' in the school dining hall [63]. This evidence therefore suggests that these school interventions are particularly important for those young people who are subject to existing socio-economic inequalities.

## The importance of young people's views

One of the most significant findings within this review, was the importance of peer influence on food choice [16, 55, 64-66]. Young people within an 'identity reshaping process' in present cultural 'norms' [15, 78] are more likely to be influenced by peers and social media rather than parents or family members. Research suggests adolescents prioritise social time, and being averse to queuing also influences school lunch choice [6]. Cost, convenience and individual

choice were also highlighted as a priority for young people [16, 64, 65, 67, 79], and though more healthful choices are made where choice is limited [80], this is not a popular approach for a student's value of autonomy [65]. Utilising 'libertarian paternalism' strategies where the school food environment is adapted to 'manipulate' or 'nudge' healthful choices, may be effective within wider whole school approaches [63]. This review finds agreement with research indicating that young people have a low risk perception of unhealthful food choices [6, 64, 67, 81]. This is important as it relates to the social norms and influences of adolescent culture; identifying that young people do have an understanding of the advantages of healthy eating but perceive it unimportant at their life stage. The complexity of the school food environment is considered in literature reporting on the canteen environment and its effect on food choice [82], where changes to the dining room environment and school food may have a significant positive impact on learning outcomes [70, 83]. The attitudes and perceptions of food service staff may also be linked to improved uptakes of healthy school options by young people [84].

**Understanding the challenges and barriers; school context**

The school environment allows for opportunities to improve nutrition through education in lessons and via school food provision. With challenges to sustaining and effectively implement interventions, understanding the opinions and lived experiences of young people and school staff remain instrumental in delivering effective school food education or provision. In a cross sectional study in the UK, a range of school lunch choices were offered and students, with the exception of those in receipt of free school meals, were less likely to choose the 'nutritionally valuable dish', instead opting for the more convenient and often less expensive energy dense and nutrient poor sandwich, pizza and dessert [63]. Evidence from the UK and other European countries such as Finland [53, 82] demonstrate that if given the opportunity, young people will often choose to leave school premises and buy energy dense

foods and sweetened beverages from local outlets. Although schools that prioritise health are more likely to have healthy food choices and adopt a whole school approach, Head Teachers do not consistently report a willingness to make healthy food a priority [85, 86]. As such, the willingness and capacity of a school to implement a programme is essential to the success of any programme. This becomes even more relevant in a COVID-19 scenario where there has been a huge disruption to the 'normal' school schedule.

## Limitations

The qualitative evidence base was small (n=5) in comparison to the quantitative (n=22), therefore more high-quality research on the lived experience of young people participating in school food programmes may support the development of sustainable whole school approaches. In addition, this review observes emerging evidence on the differences in school implementation and school context, therefore more research including this may support improved effectiveness of school nutrition programmes. The impact of school interventions on obesity, although reported more regularly than in reviews published prior to 2010 [26, 87], remain limited within Europe and UK, and therefore requires additional research using more consistent methodological approaches. A recent review, demonstrated the limited evidence on the usability of tools to measure health outcomes in a school setting, and identified a need for audit tools that are specifically designed for this setting [88].

Although date and geographical limits were applied to this review, these were critical to focusing on updating current evidence, given how rapidly school environment and influences can change over time.

## Recommendations for policy, practice and research

Effective and healthy school food approaches are critical to improving the dietary quality of young people, and potentially reducing the gap in health inequalities, as such healthy school food policy should remain a priority across Europe, with consistent evaluation, and shared good practice [73]. Whole school approaches where environmental and behavioural change, alongside food and nutrition education is embedded within school policy, hold most promise in improving dietary intake of young people. In practice, the views of young people in context can be highly influential to effective implementation of an intervention; therefore, it is important to design interventions in collaboration with young people. The student voice can help determine what success may look like to them, and what interventions they are more likely to engage with.

## Conclusion

This comprehensive review has updated evidence on the effectiveness of school interventions, to help inform the development of European policies. The evidence demonstrates school food interventions/policy have the potential to improve the dietary quality of young people by reducing saturated fat, simple sugars (including SSB) and increase consumption of FV. This review also identifies the significant role that schools can play in reducing widening health inequalities via a whole school approach. This is now more important than ever, given the exacerbation of food insecurity, and the continued challenges to providing school food [89, 90]. Therefore, it has never been timelier and more critical to take a whole systems approach to school food policy from a national perspective.

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