Nutrition education, cooking skills and obesity prevalence in children aged 4 – 12 years

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Intellectual Property and Publication Statements

The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

Chapter 2 incorporates the work of one jointly-authored publication:

> **Vaughan K**, Cade JE, Hetherington MM, Webster J and Evans, CEL. The impact of school-based cooking classes on vegetable intake, cooking skills and food literacy of children aged 4-12 years: A systematic review of the evidence 2001-2021. Appetite. 2024; 195 https://doi.org/10.1016/j.appet.2024.107238

The candidate was responsible for designing the study and registering the systematic review protocol on Prospero; conducting the literature search; screening; data extraction; risk of bias; quality assessment; interpreting the data; writing the initial draft; revising the paper with critical comments from co-authors and external reviewers, and managed the publication process as the corresponding author. JC, MH and CE also participated in duplicate screening. JW also conducted duplicate data extraction and quality assessment. All authors provided comments on early drafts and approved the final version of the manuscript.

Chapter 3 incorporates the work of one jointly-authored publication:

> **Vaughan K**, Cade JE, Hetherington MM, Cockroft JE, Heinen MM, Rippin HR and Evans CEL. Evaluation of the PhunkyFoods intervention on food literacy and cooking skills of children aged 7–9 years: a cluster randomised controlled trial in Yorkshire Primary Schools UK. Trials. 2022; 23:618. https://doi.org/10.1186/s13063-022-06558-5

This publication is a study protocol for the ‘Cooking in Yorkshire’; a cluster randomised controlled trial, which evaluates the PhunkyFoods intervention.

The candidate was responsible for pre-registration of the cluster randomised trial on the international trial registry https://doi.org/10.1186/ISRCTN68114155; designing the trial protocol using the SPIRIT template; revised the paper with critical comments from co-authors and external reviewers, and managed the publication process as the corresponding author. CE, JC and MH contributed to the study design and CE undertook the sample size calculation. All authors provided comments on early drafts and approved the final version of the manuscript.

Chapter 4 incorporates the work of one jointly-authored publication:

> **Vaughan K,** Vidal M, Cade JE, Hetherington, MM and Evans CEL. Evaluation of the school-based "PhunkyFoods" intervention: Cooking in Yorkshire – a cluster randomized controlled trial in the UK. Public Health Nutrition https://doi.org/10.1017/S1368980025000552

This publication is the trial results for the 'Cooking in Yorkshire' study. The candidate was responsible for ethics application; recruitment planning; steering group recruitment and management; collecting all the data at baseline and follow-up; stakeholder communication; data processing; data analysis in SPSS; writing the first draft and managed the publication process as the corresponding author. MV attended all follow-up data collection visits; managed the processing of CADET data in Table 10 by running ANCOVA analysis in STATA. MH participated in some baseline and follow-up data collection visits and checked the data in Table 10 using SPSS. MV carried out analysis in R to check data in Table 11. All authors provided comments on early drafts and approved the final version of the manuscript.

Chapter 5 incorporates the work of one jointly-authored publication:

> **Vaughan K**, Buoncristiano, M., Williams, J., Duleva, V., Hejgaard, T., Susovits, K., Abdrakhmanova, S., Petrauskiene, A., Racu, M., Spiroski, I., Hetherington, M. and Cade JE. A cross-sectional study of food preparation skills and obesity risk in European children aged 6 – 9 years from eight countries – World Health Organization European Childhood Obesity Surveillance Initiative (COSI) 2022-2024.

The candidate proposed additional questions on type of nutrition education and cooking skills at home to the WHO COSI team in December 2021, which were approved for inclusion in round 6. MB and JW at the WHO COSI team were responsible for the management of the COSI data collection and worked directly with the principal investigators in each country. VD, TH, KS, SA, AP, MR, and IS are Principal Investigators for the COSI and managed the data collection in Bulgaria, Denmark, Hungary, Kazakhstan, Lithuania, Republic of Moldova and Republic of North Macedonia. The candidate designed the cross-sectional study, registering the protocol on Open Science Framework and recruited eight countries from the COSI investigators to take part. MB prepared the SPSS file with the data cleaned in accordance with the WHO COSI data management framework. The candidate analysed the data in SPSS and wrote the first draft of the manuscript. All authors provided comments on early drafts and approved the final version of the manuscript, which was submitted for publication in October 2025.

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I gratefully acknowledge the use of illustrations from the CooC7 and CooC11 cooking competence measures tool (Dean et al., 2021), kindly provided by Dr Fiona Lavelle. These illustrations appear between chapters and are drawn from the CooC7 and CooC11 tools which inspired research projects in this thesis.

Dean, M., Issartel, J., Benson, T., McCloat, A., Mooney, E., McKernan, C., Dunne, L., Brennan, S. F., Moore, S. E., McCarthy, D., Woodside, J. V., & Lavelle, F. (2021). CooC11 and CooC7: the development and validation of age appropriate children's perceived cooking competence measures. The International Journal of Behavioral Nutrition and Physical Activity, 18(1), 20–20. https://doi.org/10.1186/s12966-021-01089-9

Abstract

Background: Healthy diets are associated with lower obesity prevalence and better health outcomes throughout the lifecycle. Learning cooking skills and food literacy in childhood can help to increase the intake of fruit and vegetables, which are associated with better nutrition. The availability of high calorie but nutrient poor fast food has increased in the last 20 years, which leads to a concern that young people are not learning adequate food preparation skills to eat healthy nutritious foods. This thesis examined the impact of food preparation and cooking skills in children and the associations with fruit and vegetable intake, food literacy and obesity risk.

Methods: A systematic literature review and meta-analysis was conducted to explore the impact of school-based cooking classes on food literacy, cooking skills and vegetable intake in children aged 5 – 12 years. A cluster randomised controlled trial (cRCT) "Cooking in Yorkshire" was conducted in 26 schools in North Yorkshire, UK to evaluate the PhunkyFoods primary school intervention on food literacy, cooking skills and fruit and vegetable intake. In Europe, cooking skills and obesity risk were examined using the World Health Organization (WHO) Childhood Obesity Surveillance Initiative (COSI).

Results: Meta-analysis indicated small positive effects of cooking lessons on cooking self-efficacy (0.39 units; 95% CI 0.05–0.54) and vegetable intake (0.25 units; 95% CI 0.05–0.45), with the largest effects in programmes exceeding six hours. The PhunkyFoods intervention showed no significant effects on food literacy, cooking skills, or fruit and vegetable intake compared with control. Girls scored 2.8 points higher than boys in cooking skills (95% CI 0.88–4.82; p = 0.005). In European children aged 6-9 years, peeling was associated with 15% reduced odds of having obesity.

Conclusion: Children's cooking programmes can produce small improvements in cooking self-efficacy and vegetable intake, particularly when exceeding six hours of instruction. Lesson plans should prioritise food preparation skills with vegetables, especially peeling. Education and health policymakers should review and strengthen primary school curricula to ensure these skills receive sufficient priority and ongoing monitoring as part of strategies to address childhood obesity.

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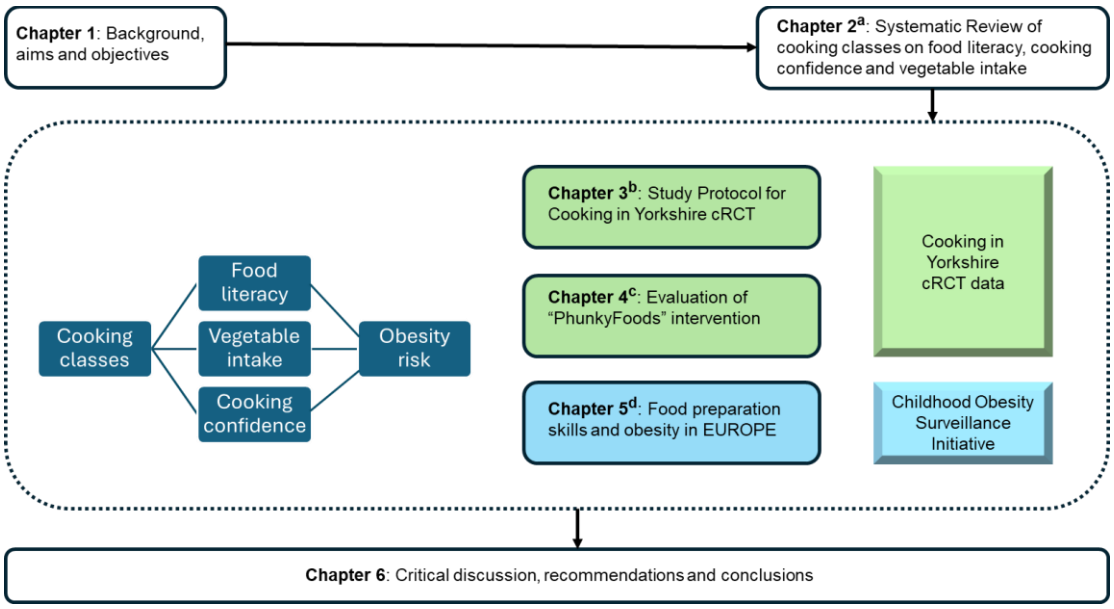
List of Abbreviations

%FSM	Percentage eligibility for Free School Meals
ANCOVA	Analysis of Covariance
ASA	Amateur Swimming Association
BCTs	Behaviour Change Techniques
BMI	Body Mass Index
CADET	Child and Adolescent Dietary Evaluation Tool
CI	Confidence Interval
CINHAL	Cumulative Index to Nursing and Allied Health Literature
COSI	Childhood Obesity Surveillance Initiative
CPD	Continuous Professional Development
cRCT	Cluster Randomised Controlled Trial
DAG	Directed Acyclic Graph
EASO	European Association for the study of obesity
ECOG	European Childhood Obesity Group
EDCs	Education Development Coordinators
EEF	Education Endowment Foundation
ERIC	Education Resources Information Center
IMD	Index of Multiple Deprivation
ISBNPA	International Society for Behavioural Nutrition and Physical Activity
ISRCTN	International Standard Randomised Controlled Trial Number
LSOA	Lower Super Output Area
NCMP	National Child Measurement Programme
NHS	National Health Service
NNS	National Nutrition Surveys
PICOS	Participant, Intervention, Comparator, Outcome and Study design

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
ROB-2	Risk of Bias 2 Tool
SD	Standard Deviation
SLT	Senior Leadership Team
SPIRIT	Standard Protocol Items Recommendations for Trials
SPSS	Statistical Package for the Social Sciences
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
TFLAC	Tool for Food Literacy Assessment in Children
TFLAC-UK	Tool for Food Literacy Assessment in Children for United Kingdom
UK	United Kingdom
WCRF	World Cancer Research Fund
WHO	World Health Organization

Thesis Outline



a. Vaughan K, Cade J.E., Hetherington M.M., Webster J and Evans, C.E.L. The impact of school-based cooking classes on vegetable intake, cooking skills and food literacy of children aged 4-12 years: A systematic review of the evidence 2001-2021. Appetite. 2024; 195 https://doi.org/10.1016/j.appet.2024.107238

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Chapter 1 Background, aims and objectives

This chapter provides an introduction of key themes and concepts which will help the reader to navigate the thesis. These include healthy diets in children, childhood obesity, nutrition education (school curriculum and interventions), food literacy, cooking skills and the food environment. Finally, the objectives and research questions are outlined.

Healthy diets in children

It is widely acknowledged that healthy diets in children are associated with better physical health outcomes (Collese et al., 2017; Dalwood et al., 2020). High quality diet patterns, containing whole foods such as fresh fruit and vegetables, are linked with better mental health in adolescents (Oddy et al., 2009; McMartin et al., 2012). Studies have shown that poor dietary patterns and childhood obesity are associated with cardiovascular disease (Umer et al., 2017; Linkon et al., 2023). WHO recommendations are that children and adults should eat at least 400g of fruit and vegetables per day, excluding potatoes, sweet potatoes and other starchy roots in order to provide an adequate intake of micronutrients and dietary fibre (World Health Organization, 2020b). In the first two years of a child's life, nutrition is particularly important both for cognitive development and healthy growth, but also it can help to build healthy eating habits. It is recommended that total fat intake is less than 30% of total energy consumption to prevent unhealth weight gain and that saturated fat is no more than 10% of daily intake. High sodium intake contributes to high blood pressure, which can then lead to an increased risk of heart disease and stroke (World Health Organization, 2025). In both adults and children, the intake of free sugars should be less than 10% of total energy intake. This can be achieved by limiting the consumption of foods and drinks which contain high amounts of sugar, for example sugary snack foods and flavoured and fizzy drinks.

National Nutrition Surveys (NNS) are commonly used to monitor trends in consumption and to inform health promotion programmes, although not all of these include energy and nutrient intakes in children (Rippin et al., 2018; Alkhaldy et al., 2024). In a recent 2024 review of 41 NNS in 4 continents, Alkhaldy et al. found that only 26 of these were ongoing and that more

standardization in methods is needed to make advances in precision and informative data about dietary intake in populations (Alkhaldy et al., 2024).

Despite widely established knowledge of healthy diets, many children are not eating enough fruits and vegetables and are regularly consuming sugary drinks. In the USA, research has shown that in 20 states, half of children aged 1-5 do not eat daily vegetables. Hamner et al. reported that more than half of children in this age group drank sugary drinks at least once a week in 40 states (Hamner HC, 2023). In 2020, research by McCarty et al. on national diet surveys of fruit and vegetable consumption in European children showed that intake was below the WHO recommendation of 400g with the exception of Denmark (McCarthy et al., 2020). In Australia, fewer children aged 2–17 years met the fruit and vegetable recommendations in 2022 compared to 2017–18 and only one in twenty (4.6%) met the vegetable recommendation (Australian Bureau of Statistics, 2022).

The WHO recognises that unhealthy diets are a key driver of overweight, obesity and diet-related NCDs and estimates this to be responsible for 11 million deaths every year (World Health Organization, 2022b). As a result, the WHO Childhood Obesity Surveillance Initiative (COSI) survey collects information on diet as one of the determinants of overweight and obesity. This includes the consumption frequency of fresh fruit and vegetables as well as frequency of sugary drinks consumption (WHO, 2017). The 5th round report from COSI survey showed that less than half (43%) of children aged 6-9 years consumed fresh fruit daily in the 27 countries included, and only a third (34%) ate vegetables daily. In Malta, over 30% of children never ate vegetables or ate them less than once a week. See Figure 1. The only two countries where more than half the children ate vegetables every day (57%) were Portugal and Denmark (World Health Organization, 2022b). In North Macedonia around 40% of children aged 6-9 years consumed soft drinks more than three days a week and only 29% less than once a week. By contrast in Estonia, the percentage of children consuming soft drinks more than three days a week was only 3% and 80% consumed these less than once a week. Differences between countries for fresh fruit and vegetables consumption and soft drink consumption may be influenced by government nutrition policies and actions across food environments, food systems and behaviour change communication

(World Cancer Research Fund, 2023a). Malta was rated “fair” or “poor” on eight out of the ten policy areas, whereas Denmark was rated “moderate”, “good” or “excellent” on four out of the ten policy areas, including “excellent” for public awareness about food and nutrition (World Cancer Research Fund, 2023b; World Cancer Research Fund, 2023c).

Figure 1 Frequency of vegetable consumption (daily versus never or less than once a week) among 6-9 year olds (%) Source: COSI Round 5 report WHO

Childhood Obesity

The COSI survey has collected obesity data on children aged 6 – 9 years since 2007, with 13 countries in the first round and has increased this to 45 countries in the 5th round in 2018-2020. The 5th round report showed that 29% of children aged 7-9 years in the countries who participated were found to be living with overweight, including obesity (World Health Organization, 2022b). There were large differences in prevalence of overweight in children, ranging from 6% in Tajikistan to 43% in Cyprus and the rate of obesity prevalence ranged from 1% in Tajikistan to 19% in Cyprus.

Worldwide, research has shown that the combined burden of underweight and obesity has increased in most countries Data from seven national school surveys showed that children and adolescents aged 7-18 years with obesity in China has risen steadily from 0.1% in 1985 to 8.25% in 2019 and

projects indicate that the prevalence will continue to rise in 2025 (Song et al., 2024).

The EASO obesity taxonomy was launched in 2024, providing a common language for definitions, causes, prevention, screening, diagnosis, treatment and health consequences aligning language used for policy-prioritised non-communicable chronic relapsing disease (Bowman-Busato et al., 2024). The taxonomy model outlines contextual definitions on obesity for this thesis. Within the theme of obesity prevention, health promotion is the process of enabling and supporting people and populations to maximise their health and quality of life. An example of a health promotion activity to prevent childhood obesity is cooking lessons and nutrition education in schools.

Nutrition Education Worldwide

The wider context of school food, nutrition education and nutrition policies is influenced by many factors which vary across countries and continents, including values, resources, human rights, acceptability and feasibility (World Health Organization, 2021b). The WHO launched the Nutrition-Friendly Schools Initiative (NFSI) in 2006 to provide a framework for ensuring that schools address the burden of nutrition-related ill health (World Health Organization, 2020a). The framework contains 26 criteria within five categories: school nutrition policies; awareness and capacity building of the school community; nutrition and health promoting curricula; supportive school environment for good nutrition and supportive school nutrition and health services. Table 1 shows 4 of these criteria for the category nutrition and health promoting curricula.

Table 1 Developing a nutrition and health-promoting school curriculum

Essential Criteria	
3.1	Culturally-appropriate and effective nutrition education
3.2	Age, sex and culturally-appropriate physical education curriculum
3.3	Healthy living and life-skills education curriculum
3.4	Regular monitoring of school curriculum relevant to NFSI, and evaluation of impact of how well the education meets the objectives

Source: WHO Nutrition Action in Schools: A review of evidence related to the Nutrition-friendly schools initiative 2021

The WHO review of NFSI in 2021 identified ten meta-analyses and 28 reviews examined various aspects of nutrition education in schools (World Health Organization, 2020a). Key findings were that there were benefits of integrating nutrition education into the formal curriculum and that curriculum-based approaches were only effective alongside other teaching strategies (Knai et al., 2006; Howerton et al., 2007; Dudley et al., 2015). The most effective nutrition education programmes were behaviourally-focused, at least 6 months and intensity delivered by trained staff and integrated into the curriculum (Price et al., 2017; Murimi, M. W. et al., 2018). Effective approaches were suggested to include experiential learning such as cooking classes and school gardening, since they make learning more meaningful and relevant (Murimi, Mary W et al., 2018; Bailey et al., 2019).

International provision of nutrition education varies widely, reflecting differences in national policy frameworks, curriculum structures, cultural priorities and school food systems (Smith et al., 2022; UNESCO, 2023; World Cancer Research Fund, 2023a). Policy-mapping tools such as the World Cancer Research Fund NOURISHING framework provide one perspective by benching the quality of nutrition policy across 30 European countries. This framework has three domains: food environments, food system and behaviour change communication (World Cancer Research Fund, 2023a). The 'G' component—'giving nutrition education and skills'—assesses nutrition education, training for educators and health professionals, cooking skills, school-based food growing and training for caterers. Norway was the only country rated as having a good nutrition education curriculum in schools, and Northern Ireland was the only country rated as excellent for cooking skills (World Cancer Research Fund, 2023d; World Cancer Research Fund, 2023e).

Curriculum-based analysis offers a complementary and narrower perspective by focussing in on nutrition education in schools. Smith et al. compared how 11 countries integrate food education within primary school curricula, examining nutrition knowledge, food literacy, cooking skills and experiential learning (Smith et al., 2022). Their analysis highlights substantial variation in both the scope and pedagogical approach to food education. The authors highlighted that when food education is designed under health, domestic and design material (for example in design and technology), this

makes the learning about design with food knowledge as a supplementary outcome. Instead, food education is best addressed with food knowledge and cooking skills are the primary learning outcome, as in Norway (Smith et al., 2022). Interestingly, Norway's food education policies scored better against a detailed food literacy framework than through the NOURISHING policy index, highlighting the importance of considering these different perspectives for analysis (Smith et al., 2022; World Cancer Research Fund, 2023e).

Countries such as Finland and Japan are frequently identified as exemplars. Finland embeds practical cooking, meal planning and food systems learning within its compulsory Home Economics curriculum (Kuusipal, 2023; Food and Agriculture Organization of the United Nations, 2025). Japan's Shokuiku framework provides a comprehensive, culturally embedded approach to food education delivered through classroom teaching, school meals and dedicated diet and nutrition teachers (Miyoshi et al., 2012; Shiobara et al., 2016; Smith et al., 2022; Research Consortium for School Health and Nutrition, 2023).

There is a growing view that children can and should learn food preparation and cooking skills at an early age for skill retention, cooking confidence and diet quality (Lavelle et al., 2016; Dimbleby, 2021). Dean at al. developed a framework for understanding the difficulty of food preparation and at what age children can acquire these important life skills as a foundation for building cooking confidence and healthy eating behaviours (Dean et al., 2021b). However, schools participating in cooking classes may lack resources to deliver practical nutrition education which includes food preparation skills. It is therefore not surprising that schools in many countries may prioritise food knowledge over practical food preparation skills in the curriculum (Smith et al., 2022; UNESCO, 2023).

Nutrition Education in the UK

In the UK, a teacher survey from 2016 by the Jamie Oliver Food Foundation showed that only 1 in 3 primary school teachers placed a significant emphasis on practical skills and cooking techniques in food lessons and less than half of primary school teachers said that pupils practice food and cooking skills more than twice a year at school (Jamie Oliver FOOD Foundation, 2017).

In 2022, the UK government introduced a rating system to capture good practice in four categories of their Healthy School Award Scheme: food education (25 points), school food standards (25 points), time spent on physical education in school 35 points) and active travel (15 points). The food education category asks schools to answer questions to determine if healthy eating is a curriculum priority, if the school provides extra-curricular cooking clubs, if pupils assist catering staff in preparing food, if the school food grows on-site for school meals and if there is professional development for teachers on food (Department for Education, 2022). However, in practise this scheme is not applied consistently across different regions of the UK. Schools are required to participate in an online teacher survey to access the healthy schools rating scheme and responses given are calculated to determine a rating of bronze, silver or gold (Healthy Schools Cambridgeshire & Peterborough). The national healthy schools award rating scheme does not require schools to provide evidence to substantiate claims made against the categories, and so instead many local authorities have decided to implement their own healthy school awards which requires robust evidence assessment by public health workers to obtain an award (Healthy Schools, 2024). The result of this is that there is no standard system of monitoring food education in the UK.

Food Literacy

To understand the importance of food literacy, it is useful to begin with a definition of health literacy, which is a related concept. The WHO defines health literacy as “representing the personal knowledge and competencies that accumulate through daily activities, social interactions and across generations. Personal knowledge and competencies are mediated by the organizational structures and availability of resources that enable people to access, understand, appraise, and use information and services in ways that promote and maintain good health and well-being for themselves and those around them” (World Health Organization, 2024a). In the United States of America, the WHO states that health literacy is a stronger predictor of an individual’s health status than other variables such as education level, income or employment status. It is believed that improving health literacy enables populations to improve their own health and engage with health promotion activities.

Food literacy is closely related to health literacy. It refers to the understanding and skills necessary to make informed food choices that positively impact on health and nutrition, the environment and the economy within our modern complex food systems (Food Literacy Center, 2019; Baker et al., 2020; Ares et al., 2023). This concept includes knowledge of nutrition, food preparation, global food system and the environmental and economic impacts of food choices. For policy analysis of food literacy, Smith et al. developed a framework for evaluating policies in 11 countries. Their food literacy framework included three broad categories: confidence and empowerment with food, joy and meaning through food and equity and sustainability for food systems (Smith et al., 2022).

Research tools have been developed to measure the concept of food literacy in children and young adults. One such food literacy instrument in Denmark designed by Stjernqvist et al. (Stjernqvist et al., 2021) draws on the work of Benn's food literacy model (Benn, 2014), which includes five core competencies: knowledge and understanding; every day practical life skills around food (growing and cooking); sensory experiences around smelling and tasking food; ethical considerations in relation to self and others around food choices; and citizenship and action in relation to environmental impact of food choices. Amin et al. developed a food literacy tool for use with young children in the United States of America that has five domains: cooking skills; cooking knowledge; food systems knowledge, nutrition knowledge; and self-efficacy regarding eating (Amin et al., 2019). The author has adapted this tool for use in the UK, described in Chapter 3 and which is shown in full at Appendix C. Table 2 below shows the scoring for this food literacy tool.

Table 2 Food Literacy tool scoring by Sara Amin (2019)

Food Literacy Domain	Topics Assessed	Question # (Points)	Total Points
Cooking skills	Ability to complete cooking tasks	#1-3 (3 pts)	3
Cooking knowledge	Kitchen tools	#4-6 (3 pts)	6
	Food safety	#7-9 (3 pts)	
Nutrition knowledge	Selecting healthy foods	#10 a-c, 11-12, 21-22 (7 pts)	15
	Food and your body	#23 (1 pt)	
	Eatwell plate/food groups	#24-30 (7 pts)	
Food Systems knowledge	Supply chain	#20 a-e (5 pts) #13-16 (4 pts)	12
	Food production (animal and plant-based sources)	#17-19 (3 pts)	
	Plant parts		
Self-efficacy around eating	Level of confidence in trying healthful foods	#31-34 (4 pts)	4
TOTAL			**40**

Research has shown that there is an association between food literacy, dietary intake and obesity prevalence. For example, a cross-sectional study in China, showed that nutrition literacy was inversely associated with overweight / obesity among adolescents (Li et al., 2022). In Denmark, Mullertz et al. found a positive association between overall food literacy and intake of vegetables (Mullertz et al., 2024). Research in Iran showed a relationship between food literacy and obesity and social economic status predicted academic performance partially mediated by food literacy (Doustmohammadian et al., 2022). However, these research examples are cross-sectional and lack causal inference and may not be applicable in the UK. Intervention based studies in the UK are needed to address the research gap.

Food Education Programmes in the UK

Whilst nutrition education and food literacy provide the conceptual foundations for understanding how children acquire knowledge and skills related to food, these components are typically delivered in practice through structured food education programmes that combine curriculum-based learning with practical cooking and experiential activities.

A range of established food education programmes operate across the UK to support schools in delivering both nutrition education and practical food literacy. These include Food for Life, which promotes a whole-school approach through cooking, gardening and farm-to-school activities; the Jamie Oliver Ministry of Food, which provides hands-on cooking skills training; and the Adopt a School programme, which delivers sensory food education through trained chefs (Jamie Oliver Group, 2025; Royal Academy of Culinary Arts, 2025; Soil Association, 2025). Within this landscape, PhunkyFoods and NourishEd offer structured, curriculum-aligned resources designed specifically for primary schools, combining practical cooking activities with broader food literacy education (Cockroft, 2021; School Health UK, 2025). Both programmes provide lesson plans, teacher support and facilitated sessions that help address gaps in school capacity for delivering practical food education. Their sustained presence in UK schools and emphasis on experiential learning make them representative examples of established, scalable approaches to food education.

Evaluating existing established programs is crucial for understanding their long-term effectiveness and sustainability. Unlike one-off interventions, which often aim to test specific hypotheses or theories without a plan for integration into school curricular, established programs have already demonstrated a degree of success and acceptance (Kidder et al., 2024).

Cooking skills and interventions

One important element of food literacy is practical food preparation and cooking skills. In 2021, Dean et al. developed effective guidelines for designing age-appropriate cooking lessons (Dean et al., 2021b). The researchers deconstructed and mapped 32 cooking skills to different development skills, for example washing fruit and vegetables, stirring and mixing, mashing, weighing, cutting, tearing, using a rolling pin, using scissors and using a grater. These

were tabulated with fine motor skills, gross motor skills and food hygiene and safety awareness requirements. Motor skill categories (crude hand movements, radial palmer grasp) were used to group each cooking skill into age ranges to support curriculum planning in schools.

Research tools have been developed to measure the concept of cooking skills, which has also been described as perceived capacity to cook, cooking self-efficacy, self-efficacy to cook, cooking experience score and cooking attitudes in intervention studies which include cooking lessons (Bisset et al., 2008; Cunningham-Sabo and Lohse, 2014; Ensaff et al., 2017; Davis et al., 2021; Dean et al., 2021a; Maiz et al., 2021; Yoshii et al., 2021). The CooC7 and CooC11 tools were designed by Dean et al. in 2021 to measure perceived cooking confidence in younger children aged 6-7 years and older children aged 8 – 12 years (Dean et al., 2021a). The tool for younger children (CooC7) measures seven food preparation skills: weighing, grating, mashing, washing, chopping, peeling and measuring. The tool for older children includes all the skills in CooC7 with an additional four food preparation skills: peeling, using a tin opener, using the oven, using a stove.

In preparation for round 6 of the COSI survey, the thesis author worked with colleagues at the WHO Regional Office for Europe to add new questions about food preparation skills practised by children aged 6 – 9 years. This is shown at Appendix D1. The new additional questions were based on the useful guidelines developed by Dean et al. and specifically, the cooking skills listed in the validated tool CooC7 for this age group. The food preparation questions were optional for countries to adopt and are shown in the COSI survey Round 6 implementation procedures (O12, O20 and O21 on pages 16 and 32) (World Health Organization, 2021a). 18 out of 37 countries elected to add in these additional food preparation skills questions for children aged 6 – 9 years.

Skill acquisition in children

Children acquire skills through observation, practice and reinforcement, gradually building competence as they repeat tasks. Social learning theory helps to explain the psychology that underpins this process, emphasising how children learn behaviours by watching and imitating others, especially peers and role models such as parents and teachers (Bandura, Albert and Walters, 1977).

Social cognitive theory develops this concept further, with self-efficacy beliefs operating within social systems (Bandura, A., 1997). This is especially relevant for nutrition education, since children acquire food skills in a multifaceted causal structure in which their perceived cooking competence operates together with goal expectations and facilitators within the home and school learning environments (Bandura, Albert, 2004). Table 3 below provides some definitions for the psychological constructs that are commonly used to describe cooking skill acquisition in children.

Table 3 Psychological constructs relating to skill development

Term	Definition
Confidence	A broad belief in oneself.
Perceived Competence	Task-specific self-assessment of ability.
Self-Efficacy	The belief in one's ability to carry out actions to achieve desired outcomes.

Food Environments

Dietary intake, nutrition education and obesity prevalence are all influenced by food environments and how children interact within food systems. This includes the availability and affordability of food options, food marketing, food labelling and how both children and families make decisions about how and what they eat. There is an increasing awareness of the need to transform environments using persuasion, nudging techniques and government policy to improve the quality of diets (Evans, 2022). For children, the home and school environments are both significant factors influencing nutrition education and dietary intake, and these vary widely across countries.

A descriptive summary of school food policies in 30 European countries found that the importance of school food to child health and development was supported by voluntary guidelines or mandatory regulations on what foods and drinks may and should be served in school settings (Stefan Storcksdieck genannt Bonsmann, 2014; Storcksdieck Genannt Bonsmann, 2014). The purpose of guidelines and legislation is primarily to improve child nutrition, learn healthy habits and to prevent obesity. However, a major criticism of the school food policies reviewed by the European Commission was that only half of these

had monitoring and evaluation in place to measure compliance of schools or dietary intake of children.

In the UK, England government introduced school food standards regulations in 2015 to improve the nutritional quality of food for children in schools during breakfast, break-times and lunches (Education England, 2014). However, recent evidence suggests that this had had little impact on the quality of food provided or the dietary intake of children in secondary schools and that monitoring of schools and caterers is required to ensure compliance (Pallan et al., 2024).

Food environments are changing all over the world. In Latin America and the Caribbean there are major shifts in the intake of low nutrient dense foods and sugary drinks and this has been attributed to changes in supply chains with the rapid rise in supermarkets and fast food chains (Popkin and Reardon, 2018). There is also considerably growing concern about the marketing of unhealthy foods to children. Evidence has shown that food marketing promotes intake of foods high in saturated fatty acids, trans-fatty acids, free sugars or salt (World health Organization, 2022a).

Many campaigns are now focussed on classifying foods that should be restricted from marketing to children and young people (World Health Organization, 2023). One example is the BiteBack youth activist movement in the UK, which was set up in 2019 to challenge a food system which markets unhealthy foods to children (BITEBACK, 2019). Boyland's research has shown that even brief exposure to junk food marketing significantly increases children's calorie intake (Boyland, 2025). This work has informed UK policy discussions on restricting unhealthy food advertising (NHS England, 2025). The UK government is working with supermarkets and plans to implement a new healthy food standard to promote healthier food and drink (GOV.UK, 2025).

Rationale for the study

Whilst there is a good understanding of the importance of nutrient rich healthy diets for children to achieve optimum growth in childhood and better health in adulthood, the reality is that poor diets in children prevail and obesity prevalence continues to rise in many parts of the world (World Health Organization, 2024b). There is a need to better understand what types of

nutrition education are most effective in building cooking confidence and food preparation skills in children and to better understand the relationship between cooking skills, food literacy and obesity in children aged 4 – 12 years.

Research objective and questions

This thesis investigates associations between nutrition education, cooking skills, and obesity prevalence in children aged 4–12 years. The three components of the research address this aim at different levels of scope: the literature review spans the full 4–12 age range, the PhunkyFoods evaluation examines programme outcomes in children aged 7–9 years, and the WHO COSI cross-sectional study analyses data for children aged 6–9 years.

Although the PhunkyFoods programme is delivered across whole primary school populations in the UK, the evaluation research focused on children aged 7–9 years to enable a pragmatic cluster-based design in which one class per school could be included within the available time and resources. Similarly, the WHO COSI dataset is collected for children aged 6–9 years across Europe, which defines the age range available for this component.

Together, these design choices allow each strand to contribute evidence relevant to the overarching focus on early and middle childhood. The research questions and methods are shown in Table 4.

Table 4 Thesis research questions and methods

1. What is the impact of cooking classes on dietary habits, cooking skills and food literacy of children in primary schools?	Children aged 4 – 12 years	Systematic Review and Meta-analysis
2. What is the impact of the PhunkyFoods intervention on food literacy and cooking skills of children aged 7 – 9 in primary schools in Yorkshire, UK?	Children aged 7 – 9 years	Cluster Randomised Controlled Trial
3. Is there an association between food preparation skills practised at school and at home with childhood obesity prevalence in countries in the EU?	Children aged 6 – 9 years	Cross-sectional Study

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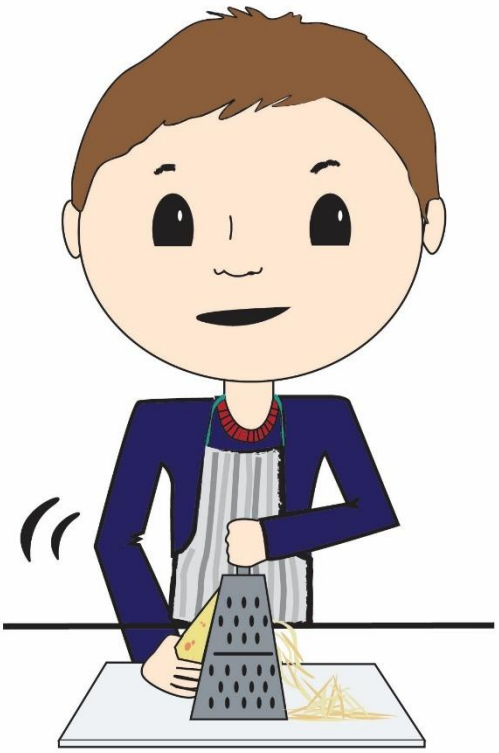


Chapter 2 Systematic Literature Review and Meta-analysis The impact of school-based cooking classes on vegetable intake, cooking skills and food literacy of children aged 4 to 12 years: A Systematic Review of the Evidence 2001-2021.

Karen L. Vaughan[1], Janet E. Cade[1], Marion M. Hetherington[1], James Webster[1], and Charlotte E.L. Evans[1]

Abstract

Background: Many children consume a poor quality diet with only a third of children aged 6-9 years eating vegetables daily. A high quality diet is important for good health in childhood; however, the prevalence of children living with obesity has doubled from 10% to 23% during primary school in the UK. Cooking lessons have the potential to improve diet quality and reduce obesity prevalence in childhood, both of which are associated with improved cardiometabolic outcomes in adulthood. The aim of this systematic review is to investigate the impact of school-based cooking classes on cooking skills, food literacy and vegetable intake of children aged 4 to 12 years.

Methods: We conducted a systematic review of OVID Medline, OVID Embase, EBSCO CINHAL and EBSCO ERIC for comparative studies that evaluated outcomes of children receiving cooking classes compared to a control group. Interventions included contained food preparation or a cooking activities and took place on school premises. Risk of bias was assessed using ROB2 and ROBINS-I. Outcomes were pooled in a meta-analysis using a random-effects model using standardised mean differences or reviewed using narrative synthesis. Certainty of evidence was assessed using GRADE.

Results: We included 21 studies, (6 randomised). Meta-analysis showed a small positive effect on cooking self-efficacy of 0.39 units (95% CI 0.05 to 0.54), and a small positive effect on vegetable intake of 0.25 units (95% CI 0.05 to 0.45). Programmes with more than 6 hours of cooking showed the greatest effects.

Conclusions: Children's cooking programmes result in small improvements in cooking efficacy and vegetable intake, particularly those with more than 6 hours

of classes. It is recommended that future interventions use consistent measurement for children's food literacy and cooking confidence.

Review registration: PROSPERO CRD42021284138

Keywords: Cooking classes, Primary schools, Cooking confidence, Cooking self-efficacy, Dietary intake, Food literacy.

Introduction

The World Health Organization (WHO) Regional Office for Europe Data Dashboard shows that obesity continues to rise (World Health Organization). Overall findings from the fifth round of the WHO Childhood Obesity Surveillance Initiative (COSI) report showed that 29% of children aged 7-9 years were living with overweight (including obesity) from the data collection 2018-2020 (World Health Organization, 2022). National data from the National Child Measurement Programme shows that the prevalence of children living with obesity more than doubles from 10% of children at the start of primary school to around 23% at the end of primary school in the UK (NHS digital, 2022). There is an urgent need for interventions that reverse this trend. Body weight change is associated with an imbalance between energy content of food consumed and energy expended by the body (Hall et al., 2012). Excess energy intake from foods and drinks which are high in sugars contributes to unhealthy weight gain, overweight and obesity (World Health Organization, 2020c). People living with obesity and overweight have higher risk of cardiovascular disease (Umer et al., 2017; Dimbleby, 2021).

The World Health Organization reports that daily vegetable consumption for children aged 6-9 years is only a third (35%) across 27 countries, and 11% never ate vegetables or did so less than once a week (World Health Organization, 2022). Fruit and vegetable consumption has been highlighted as important for obesity prevention (World Health Organization, 2002; World Health Organization, 2020b) and therefore policies and interventions that promote increasing intake in children to improve diet quality are highly relevant for public health.

Policy analysis undertaken by Smith et al. in 2022 has shown that all eleven of the countries included in their study had a dedicated food curriculum in primary schools to address food literacy. These were either practical (for example Home Economics) or health oriented (for example Health and Physical Education) (Smith et al., 2022). A framework used to evaluate 'Food Preparation Skills' contribution to food literacy within the curriculum revealed that Iceland, Norway, Slovenia and Scotland scored highest at 70% -100%, compared to Ireland and England which scored below 20%. The policy analysis found that whilst countries often have a mandatory food curriculum, 'there is no consensus in primary food education' about what this constitutes and if it includes cooking lessons (Smith et al., 2022).

Previous reviews have shown a link between broad, multi-component nutrition education programmes in primary schools and improved dietary intake for children (Hersch et al., 2014; Charlton et al., 2021; Lavelle, 2023). Interventions that last a year or longer are more likely to have a positive impact on anthropometric outcomes in children (World Health Organization, 2002; Chaudhary et al., 2020; World Health Organization, 2020a). Hasan and colleagues provided an analytic framework to conceptualise the potential link between culinary interventions (cooking classes), intermediate outcomes (behavioural, cardiometabolic, anthropometric, quality of life, dietary intake) and final outcomes (mortality and morbidity) for both adults and children (Hasan et al., 2019).

It is hoped that interventions that involve participatory cooking classes in primary schools will increase cooking skills, cooking confidence, and improve vegetable intake. However, it is not clear from the existing evidence if cooking interventions that take place in primary schools improve cooking confidence, food literacy and dietary habits of children since reviews in this research area indicate high risk of bias in studies included (Hersch et al., 2014; Hasan et al., 2019; Chaudhary et al., 2020; Charlton et al., 2021) and few studies use an adequate sample size (Lavelle, 2023). Our search from January 2001 to December 2021 is in response to this issue, and updates a prior review by Hersch et al. from 2014 using a similar search strategy (Hersch et al., 2014). It was hoped that recent Consort guidelines for RCTs would lead to higher quality studies.

To update the evidence base, we performed a systematic review and meta-analysis of the available literature on participatory cooking classes based in primary schools to investigate the impact on cooking confidence, food literacy and dietary intake. The studies included were randomised controlled trials (RCT), cluster RCTs or quasi-experimental design such as non-randomised trials.

Method

The reporting of this systematic review complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021) and follows a prospectively registered protocol (Vaughan, 2021).

Data sources and search Strategy

A search was conducted in OVID Medline, OVID Embase, EBSCO CINHAL and EBSCO ERIC using two search concepts: 1) 'cooking' or 'food preparation' or 'food literacy' or 'food technology' mapped to subject headings and key word search; 2) 'primary school' or 'elementary school' mapped to subject headings and key word search. There were no English language limits on the searches. The full search strategy is shown in Appendix A. Table 5 shows the Participant, intervention, comparator, outcome and study design (PICOS) criteria for inclusion of studies for the review. For interventions, we described the practical elements that must be a component (practical food preparation, cooking activity or both). For outcomes, we included a wide number of outcomes that could potentially be of interest, including cooking skills, cooking self-efficacy, food literacy and others. The search strategy undertaken in January 2022 identified 1,195 citations. Two additional studies were identified from existing literature reviews (Bennett et al., 2021; Charlton et al., 2021).

Table 5 Participants, intervention, comparator, outcome and study design (PICOS) criteria for inclusion of studies for review

PICOS criterion	Inclusion criteria
Participants	School children aged 4 – 12 years old
Interventions	Practical classes in school setting that included children involved in food preparation (e.g. mashing, peeling, grating, mashing, measuring, weighing, mixing) or cooking activity (cooking on a hob or in the oven) or both food preparation and cooking activity.
Comparisons	Control group or multi-arm trial
Outcomes	Cooking skills / cooking self-efficacy / cooking competency, Food literacy, Dietary habits / fruit and vegetable intake / food preferences
Study Design	RCT, cluster RCT and quasi experimental design

Study selection

Studies were included if the domain being studied was nutrition education with a specific focus on cooking skills and food literacy. The participant population was school children aged 4 – 12 years. The search strategy undertaken in January 2022 identified 1,195 citations.

The intervention exposure had three inclusion criteria: 1) includes food preparation (e.g. washing, peeling, grating, mashing, measuring, weighing, mixing) or cooking activity (cooking on a hob or in the oven) or both food preparation and cooking; 2) takes place at least partially on the school premises; 3) takes place during the school day or as an after school activity. Intervention exclusion criterion were: 1) tasting fruit and vegetables only but no food preparation or cooking activity; 2) cooking or food preparation classes taking place totally off the school premises. Studies were not restricted if they had multiple components in additional to cooking and food preparation activities, nor where they restricted on length of study or hours of intervention. Study designs included randomised controlled trials (RCTs), cluster randomised controlled trials (cluster RCTs), and quasi-experimental (non-randomised trials).

Primary outcomes were: 1) cooking skills / cooking self-efficacy / cooking competency; 2) food literacy; 3) dietary habits / fruit intake / vegetable intake / food preferences. Secondary outcomes also included were childhood obesity / BMI / BMI z-score / weight change but are not the focus of this paper.

We did not include editorials, systematic reviews, letters or conference abstracts. Studies were screened by two independent reviewers using the screenatron feature in the software SR Accelerator (Bond University, 2022) . The level of agreement between review authors ranged from 0.406 to 0.705 (Cohen's Kappa) for initial title and abstract screening and from 0.342 to 0.583 (Cohen's Kappa) for full text screening. All discrepancies were considered by a third reviewer and resolved using the disputatron feature from SR Accelerator. Discussion between reviewers revealed that disagreements were most often due to the intervention criteria, specifically whether it took place in a school and if children were directly involved in the food preparation or cooking activities. An agreed list of reject codes was used to label each study at the full text review stage.

Data extraction and risk of Bias assessment

We pilot tested data extraction using an Excel spreadsheet. The following information was extracted for a summary sheet: author / year / country; title of article, study design, sample size, duration of intervention, cooking hours, cooking components, other components, type of outcome. Columns for broad outcome categories were: cooking skills / cooking self-efficacy / cooking competency; food literacy; dietary habits / vegetable intake / food preferences; and BMI z-score. Additional sheets were used to collect data on mean scores, standard deviations, change scores for intervention and control groups, grouping studies together by outcome type. Cochrane Risk of Bias 2 tool in Excel was used to assess the risk of bias in RCTs (Sterne et al., 2019) and ROBINS-I tool for non-randomised trials (Sterne et al., 2016). Data extraction and quality assessment was completed by KV and checked by JW.

Dietary intake outcome was more complex to extract, having many potential components. We narrowed our focus for synthesis by looking specifically at intake of vegetables across studies as increasing vegetable intake was an aim of many of the programmes.

Outcome measures

We evaluated three types of outcomes: cooking confidence, food literacy and vegetable intake. For cooking confidence, we looked at outcomes described in studies as either cooking self-efficacy, self-efficacy to cook and/or cooking attitudes. Food literacy was assessed where studies measured the impact of an intervention on knowledge of food and healthy lifestyles included knowledge of healthy diet. Units for the analysis of vegetable intake were 'veg servings per day', 'vegetable consumption', vegetable intake score' or 'number of days vegetables eaten at supper' and therefore random-effects meta-analysis was used to address the variation in outcome scales used by different studies (Borenstien, 2021)

Data synthesis and analysis

For outcomes where there was three or more similar studies to allow for a meta-analysis, we used a random-effects model in RevMan 5.4 to pool the mean differences across studies (The Cochrane Collaboration, 2020; Borenstien, 2021). Where there were too few studies reporting a similar outcome with sufficient details, we presented the results using a narrative description.

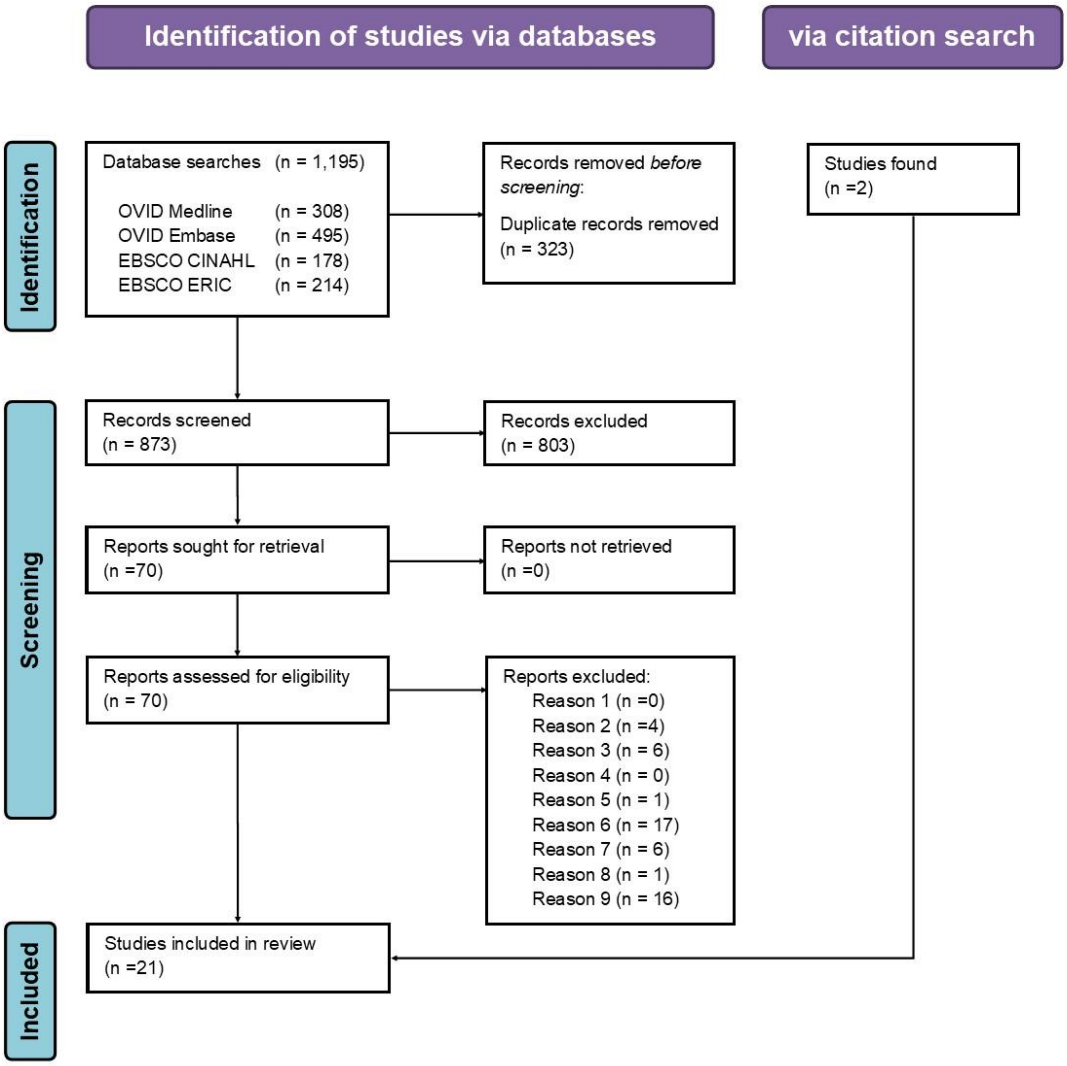
Results

Study characteristics

A total of 21 studies met the inclusion criteria shown in Figure 2.

Description of the interventions

Interventions ranged in duration from 1 week to 104 weeks (2 years), with cooking activity range from 1 hour to 115 hours. Of the 21 studies included, 6 were randomised controlled trials and 15 were non-randomised controlled trials. The location of interventions included Australia, Canada, Japan, Netherlands, Spain, UK and USA. The total number of participants in all studies was 12,542 and for individual studies this ranged from 100 (Zahr and Sibeko, 2017) to 3,135 (Davis et al., 2021).



Note on reason codes:
Reason 1 – Literature Review; Reason 2 – Duplicate; Reason 3 – Study Design; Reason 4 – Domain studied; Reason 5 – Participant Population; Reason 6 – Intervention Criteria; Reason 7 – Comparator Criteria; Reason 8 – Outcome Criteria; Reason 9 – Abstract Conference Paper

Figure 2 Flow chart depicting the process of study selection

The Cooking with Kids programme was a 10-week programme delivered in the spring and included three, 2-hour cooking lessons. Recipes used in the cooking lessons were Chinese-American fried rice with vegetables; east Indian lentils with carrot and raisin pilaf; and potatoes persillade with cabbage (Cunningham-Sabo and Lohse, 2013). The EgizuSUK Project was a 3-week intervention with 1 hour of cooking. In the first workshop participants were asked to choose a recipe, thinking about how difficult it might be; the second workshop involved shopping for ingredients; and in the third workshop children used the recipe to cook a meal (Maiz et al., 2021). The Texas Sprouts programme was a larger study and involved 11 hours of cooking. There were 18 lessons that were 60 minutes in length and each one included either a garden taste lesson or a cooking lesson (Davis et al., 2021). In the 'Taste Lessons' study in Netherlands, a 5-week intervention, there were three trial arms: taste lessons vegetable menu group (which included 1 hour of cooking), taste lessons group and a control group (Battjes-Fries et al., 2016). Table 6 provides further detailed information on all of the included studies' characteristics.

Table 6 Study Characteristics

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
1	**Adab P**, Pallan MJ, Cade J, Ekelund U, Barrett T, Daley A, et al. **2014** *England, UK*	Preventing childhood obesity, phase II feasibility study focusing on South Asians: BEACHeS	quasi-experimental	574	269	305	6.48	To increase healthy cooking skills and confidence and influence dietary behaviour	52	na	6 invervention components including a 5-week courses on healthy cooking	Physical activities in and out of school. Course run by premier league football	BMI z-score, childhood obesity, body image questionnaires, Diet (CADET)
2	**Adab P**, Pallan MJ, Lancashire ER, Hemming K, Frew E, Barrett T, et al. **2018** *England, UK*	Effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6 and 7 year olds: cluster randomised controlled trial (WAVES study)	cluster RCT	1392	660	732	6.3	Aim 2: improve children's dietary intake	52	3	1) 3 x Cooking skills workshops	2) Villa Vitality - 6 weeks	BMI z-score, childhood obesity, Diet (CADET)
3	**Alexander AG**, Grant WL, Pedrino KJ, Lyons PE. **2014** *California, USA*	A Prospective Multifactorial Intervention on Subpopulations of Predominately Hispanic Children at High Risk for Obesity	quasi-experimental	561	272	289	na	To measure the responses to these interventions as a function of the degree of body habitus, as indicated by BMI subgroups.	26	26	2 x 30-min cooking classes per week	physical activities, health camps, chef in the classroom, parent groups.	BMI

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
4	**Battjes-Fries MC**, Haveman-Nies A, van Dongen EJ, et al **2008** *Netherlands*	Effectiveness of Taste Lessons with and without additional experiential learning activities on children's willingness to taste vegetables	quasi-experimental	1010	702	308	10.3	To assess the effectiveness of Taste Lessons with and without additional learning activities on children's willingness to taste unfamiliar vegetables.	na	1	1 cooking lesson (additional activity)	5 Taste Lessons and 4 additional activities: veg quiz, excursion, homework, cooking lesson.	Willingness to taste vegetables, Vegetable consumption, food neophobia (Child Food Neophobia Scale)
5	**Bisset S**L, Potvin L, Daniel M, Paquette M **2008** *Montreal, Canada*	Assessing the Impact of the Primary School-based Nutrition Intervention Petits cuistots – parents en réseaux	quasi-experimental	388	209	179	4.5	To evaluate Petits Cuistots programme on 1) knowledge, attitude, capacity and experience of nutrition and cookery. 2) parental involvement.	52	12	8 x Nutritional Workshops delivered for 1.5 hours.		*Knowledge of nutrition*, Attitude to food, *Experience of Food preparation*, **cooking skills / competence (capacity)**.
6	**Caraher M**, Seeley A, Wu M, Lloyd S **2013** *England, UK*	When chefs adopt a school?: an evaluation of a cooking intervention in English primary schools.	quasi-experimental	169	86	83	6	To measure the impact of chefs in schools on food preparation skills, food consumption and cooking confidence.	6	na	Two sessions with a chef	none	Cooking confidence, vegetable consumption, food confidence

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
7	**Chen Q**, Goto K, Wolff C, Bianco-Simeral S, Gruneisen K, Gray K **2014** *California, USA*	Cooking up diversity. Impact of a multicomponent, multicultural, experiential intervention on food and cooking behaviors among elementary-school students from low-income ethnically diverse families	quasi-experimental	1204	604	600	6	To evaluate the impact of a pilot intervention promoting ethnic produce through classroom food demonstrations, tastings and home cooking activities.	16	na	Monthly demonstrations of cooking recipes with tasting sessions followed by home cooking activity.	Family component - food kits to take home and cook recipes at home.	Food preferences, vegetable consumption, cooking at home survey
8	**Cunningham-Sabo** L, Lohuse, B, **2013**, *Colorado, USA*	Cooking with Kids Positively Affects fourth Graders' Vegetable Preferences and Attitudes and Self-Efficacy for Food and Cooking	RCT	257	137	120	na	To evalute the impact of the Cooking with Kids (CWK) food education programme.	10	12	6 x 2-hour cooking lessons delivered by a food educator	3 tasting lessons with multi-sensory exploration of citrus, pears and salad greens.	Vegetable preference, cooking attitudes, cooking self-efficacy.
9	**Davis JN**, Ventura EE, Cook LT **2011** *Los Angeles, USA*	LA Sprouts: A Gardening, Nutrition, and Cooking Intervention for Latino Youth Improves Diet and Reduces Obesity	quasi-experimental	104	34	70	9.8	To evaluate 12-week LA Sprouts on dietary intake and obesity risk.	12	9	12 x 45minute cooking / nutrition instruction.	12 x 90 minute sessions which included 2 elements: 1) gardening instruction 2) nutrition / cooking instruction (both for 45 mins)	BMI, body fat %, Dietary intake

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
10	**Davis JN**, Asigbee FM, Landry MJ **2021** *Texas, USA*	School-based gardening, cooking and nutrition intervention increased vegetable intake but did not reduce BMI: Texas sprouts - a cluster randomized controlled trial	cluster RCT	3135	1412	1723	9.22	To evalute 1-year Texas Sprouts on dietary intake, obesity outcomes and blood pressure on school children.	39	11	11 x 1-hour cooking lessons	Gardening lessons, teaching garden, lessons in nutrition and 9 parent lessons.	BMI, waist circumference and body fat %, *blood pressure* and dietary intake.
11	**Ensaff H**, Crawford R, Barker ME, Russell JM **2017** *England, UK*	Preparing and sharing food: a quantitative analysis of a primary school-based food intervention	quasi-experimental	325	154	171	na	Impact of school-based Jamie Oliver Kitchen Garden Project.	39	28	90-minute cooking sessions, fortnightly delivered over an academic year.	none	Cooking knowledge/experience, food awareness, food enjoyment, food neophobia and food fusiness.
12	**Gibbs L**, Johnson B, Block K, et al. **2013** *Australia*	Expanding Children's Food Experiences: The Impact of a School-Based Kitchen Garden Program	quasi-experimental	764	475	289	na	To evalute the Stephanie Alexander Kitchen Garden Programme.	104	115	90 minute cooking classes, weekly for 2 years.		Willingness to try new foods, food literacy.
13	**Hovland JA**, Carraway-Stage VG, Cela A **2013** *North Carolina, USA*	Food-Based Science Curriculum Increases 4th Graders Multidisciplinary Science Knowledge	quasi-experimental	641	380	261	na	To evaluate the FoodMASTER initiative on food-related science knowledge.	39	29	24 x 45-minute Foodscience lessons lessons during the academic year.	teachers received training before the intervention started.	Food Literacy (science knowledge about food)

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Inter venti on	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
14	**Jaenke R**L, Collins CE, Morgan PJ **2012** *Australia*	The Impact of a School Garden and Cooking Program on Boys' and Girls' Fruit and Vegetable Preferences, Taste Rating, and Intake	quasi-experimental	127	70	57	na	To examine gender differences in the impacct of a school garden and nutrition curriculum on FV intake, willingness to taste and taste ratings.	10	na	Garden programme involved 45-minutes for 4 x times a week, over 10 weeks (cooking and gardening).	Nutrition education component, parent newsletters, homework with cooking activities.	Food preverences (F&V), F&V intake.
15	**Landry M**J, Markowitz AK, **2019** *Texas, USA*	Cooking and Gardening Behaviors and Improvements in Dietary Intake in Hispanic/Latino Youth	RCT	290	160	130	9.2	To assess the changes in cooking and gardening behaviours with changes in dietary intake and obesity of LA Sprouts.	12	9	12 x 45minute cooking / nutrition instruction.	12 x 90 minute sessions which included 2 elements: 1) gardening instruction 2) nutrition / cooking instruction (both for 45 mins)	BMI z-scores, 41-item Block Kids Food Screener (food intake), self-efficacy to cook fruits and vegetables, Motivation for health behaving.
16	**Maiz E**, Urkia-Susin I, Urdaneta E, **2021** *Spain*	Child Involvement in Choosing a Recipe, Purchasing Ingredients, and Cooking at School Increases Willingness to Try New Foods and Reduces Food Neophobia	quasi-experimental	202	103	99	na	To investigate effect of involving children in cooking on their lunch food choice at school.	3	1	3 x workshops (last one including cooking a recipe)	There were two groups: Nutrition Education (NE) and Hands-on (HO). HO had the cooking-related activities.	BMI, Veg preferences, KidMed mediterranean diet, Spanish Child Food Neophobis Scale, Cooking Self-efficacy.

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
17	**Parmer SM**, Salisbury-Glennon J, Shannon D **2009** *Alabama, USA*	School Gardens: An Experiential Learning Approach for a Nutrition Education Program to Increase Fruit and Vegetable Knowledge, Preference, and Consumption among Second-grade Students	quasi-experimental	115	76	39	na	To examine effects of school garden on children's F&V knowledge, preference and consumption.	28	14	For the NE and G group - later stages involved cooking. NE+G included 1 hour gardening every two weeks.	Nutrition only group; nutrition education and gardening; control group.	Nutrition Knowledge, F&V preferences, F&V consumption at lunchtime.
18	**Sahota P**, Christian M, Day R, Cocks K. **2019** *England, UK*	The feasibility and acceptability of a primary school-based programme targeting diet and physical activity: the PhunkyFoods Programme	cluster RCT	311	168	143	7.25	Feasibility study to evaluate the PhunkyFoods programme and impact on nutrition knowledge, physical activity knowledge and behaviours.	26	na	Complex menu of components including D&T lesson plans, which involve food preparation skills.	Complex menue of components about health eating and healthy living for delivery in schools.	Healty Lifestyle Knowledge (HLKQ), Diet and Lifestyle behaviour (SNAP), Body Shape Perception Scale (BSPS), BMI.
19	**Wolfe WS**, Dollahite J **2021** *New York, USA*	Evaluation of the Choose Health: Food, Fun, and Fitness 3rd- to 6th-Grade Curriculum: Changes in Obesity-Related Behaviors	quasi-experimental	561	561	561	na	Evalute CHFFF intervention - which aims to decrease childhood obesity and chronic disease risk.	6	6	Each lesson includes 2 recipes and at least one tasted in class.		a 22-item diet survey including: Veg intake, Fruit intake, fast food intake, fast food intent to consume.

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
20	**Yoshii E**, Akamatsu R **2021** *Tokyo, Japan*	Impact of a school-based cooking programme on home cooking participation in Japan	quasi-experimental	312	170	142	na	To evaluate the impact of school-based cooking programmes on cooking activities at home.	3	2.25	3 x 45-minute lessons: 1 lesson peeling an apple, 1 lesson cooking a recipe, 1 lesson peeling an apple (review)	cooking homework and parent newsletters.	Children's cooking attitudes, self-efficacy and participation in cooking at home.
21	**Zahr R**, Sibeko L **2017** *Massachusetts, USA*	Influence of a School-Based Cooking Course on Students' Food Preferences, Cooking Skills, and Confidence	quasi-experimental	100	68	32	na	To evaluate influence of Project CHEF (Cook Healthy Edible Food) on students food preferences, cooking skills and confidence.	1	15	3 hours day of preparing food and cooking recipes for a week.	There was some elements of food literacy instruction within the practical sessions.	Liking new foods, preferences for new foods, cooking skills and cooking confidence.

Effect on cooking self-efficacy

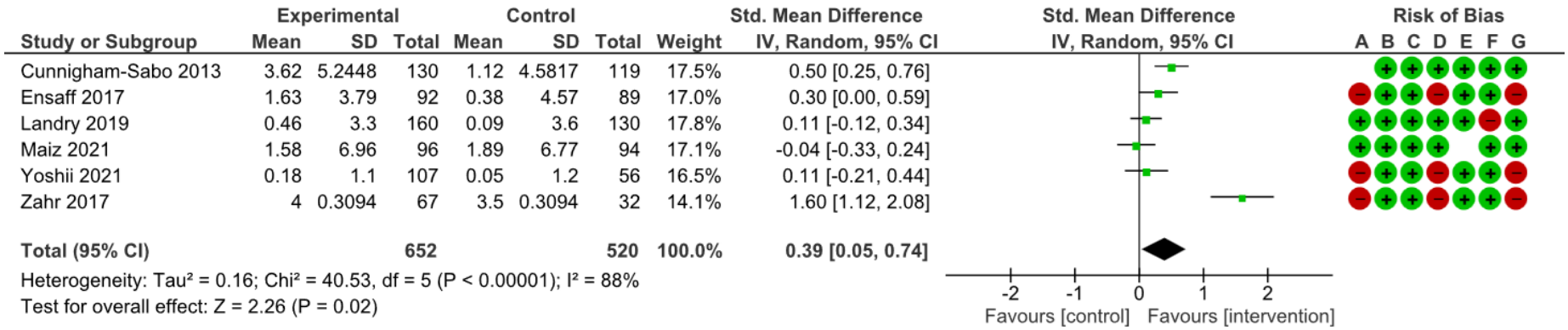
Eight studies investigated outcomes related to cooking skills, cooking attitudes and cooking self-efficacy. Some measured 'attitudes towards cooking' (Landry et al., 2019; Maiz et al., 2021; Yoshii et al., 2021) and other studies described outcomes as either 'cooking self-efficacy' or 'self-efficacy to cook (Cunningham-Sabo and Lohse, 2013; Landry et al., 2019; Maiz et al., 2021). One study measured a variety of specific outcomes (cut vegetables and fruit, measure ingredients, use a knife) but without a pooled estimate for cooking self-efficacy (Zahr and Sibeko, 2017). Six studies were included in a random effects meta-analysis using standardised mean differences to investigate the overall effect on cooking self-efficacy. The authors used standardised mean differences to account for the different measurement tools used in the studies, and random effects meta-analysis (rather than fixed effect) to allow for variation in the interventions (Deeks, 2023). The results showed a small positive effect on cooking self-efficacy of 0.39 units (95% CI 0.05 to 0.54) favouring the intervention. Heterogeneity for the analysis was very high; $I^2 = 88\%$, ($P < 0.001$). The forest plot showing effects for cooking self-efficacy is shown in Figure 3.

Effect on food literacy

Three studies were included in the analysis on food literacy outcomes, however the concept was interpreted differently for each intervention. The Hovland study from North Carolina, USA measured food-based science knowledge (Hovland et al., 2013). For the Parmer study in Alabama, USA we took a pooled average of 4 scores; MyPyramid food groups; nutrient-food association, nutrient-job association; and food and vegetable identification (Parmer et al., 2009). The Sahota study in England, UK used Healthy Lifestyle Knowledge scores (Sahota et al., 2019). Whilst all these studies showed a positive raw mean difference between the control arms favouring the intervention, it was not appropriate to undertake a meta-analysis due to the differences in intervention components and measurement of the outcomes relating to food literacy. Table 7 shows the intervention components for the three studies, outcome measurement and raw scores for impact.

Table 7 Food Literacy impact for three studies in North Carolina, Alabama and England

Study	Intervention components related to food and cooking	Food Literacy measurement	Raw mean difference between intervention and control arms
Hovland JA, Carraway-Stage VG, Cela A 2013 North Carolina, USA	24 x 45-minute food science lessons during the academic year.	Food based science knowledge 13-question multiple choice exam.	1.21 favouring intervention (no 95% CI reported)
Parmer SM, Salisbury-Glennon J, Shannon D 2009 Alabama, USA	14-hour programme. For the Nutrition Education and Gardening group - later stages involved cooking.	Nutrition knowledge survey 16-items (food groups, nutrient knowledge, fruit and vegetable identification)	1.37 favouring intervention (no 95% CI reported)
Sahota P, Christian M, Day R, Cocks K. 2019 England, UK	18-month healthy lifestyles programme including lesson plans, which involved food preparation skills.	Healthy Lifestyle Knowledge Scores (including nutrition knowledge and food)	0.8 favouring intervention (95% CI -4.3, 2.7)



Risk of bias legend

(**A**) Random sequence generation (selection bias)
(**B**) Allocation concealment (selection bias)
(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

Figure 3 Forest Plot showing effect on cooking self-efficacy in children aged 4 – 12 years

Effect on vegetable intake

Sixteen studies included some data on dietary habits with outcomes ranging from fruit intake (servings), vegetable intake (servings), vegetable intake score, fruit intake score, vegetable servings per day, fruit servings per day, pooled average for eating vegetables, 24-hour fruit and vegetable intake and number of days per week vegetables eaten at supper. We extracted the data on the vegetable intake outcomes only for analysis. The authors used standardised mean differences to account for the different measurement tools used in the studies, and random effects meta-analysis (rather than fixed effect) to allow for variation in the interventions (Deeks, 2023). We included seven studies for a meta-analysis to investigate the effect of cooking interventions on vegetable intake. The random effects meta-analysis calculating standardised mean difference showed a small effect on vegetable intake of 0.25 units (95% CI 0.05 to 0.45). Heterogeneity was high; $I^2 = 87\%$, ($P < 0.001$). The forest plot showing effects on vegetable intake is shown in Figure 4.

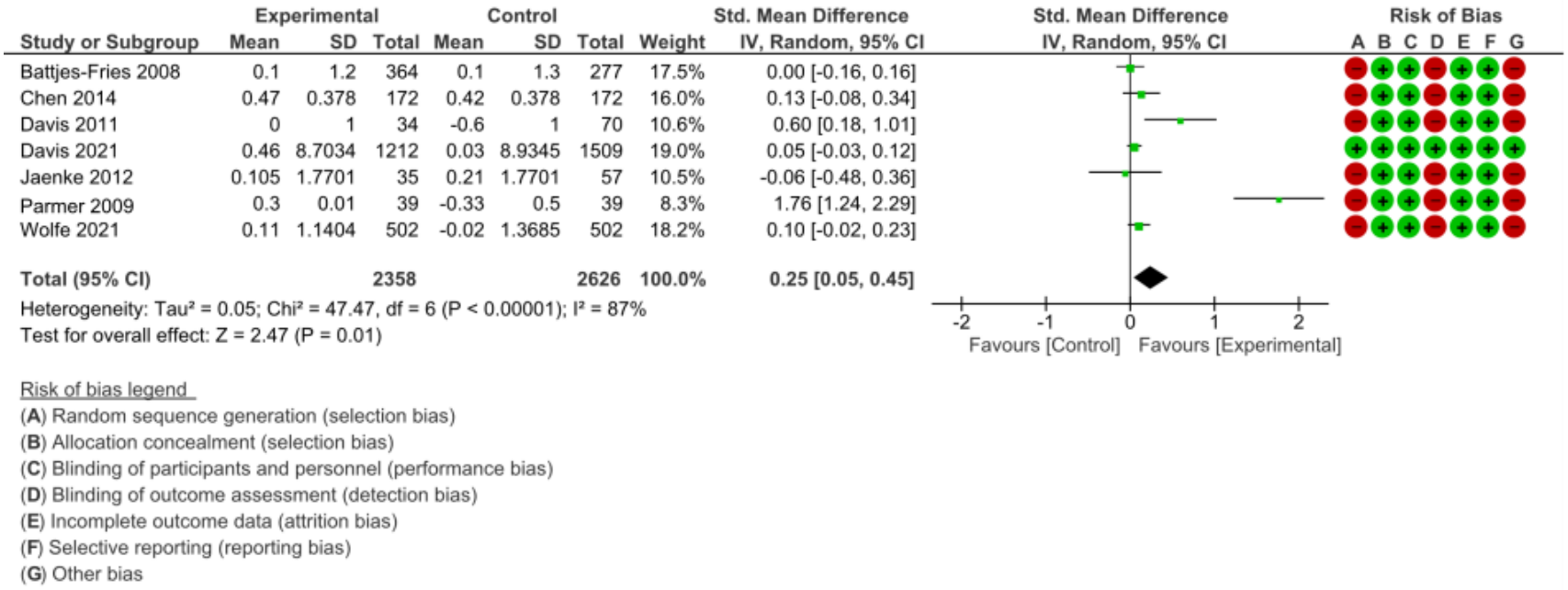


Figure 4 Forest Plot showing effect on vegetable intake in children aged 4 – 12 years

Summary of evidence

The overall summary of evidence table completed using GRADEpro software shows that the certainty of evidence was very low for cooking self-efficacy and vegetable intake outcomes (Schunemann, 2013). For the outcome cooking self-efficacy, the certainty of evidence is very low due to different measures for cooking self-efficacy and the confidence interval overlapping the line of no effect. For the outcome vegetable intake, the certainty of evidence is very low due to different measures of vegetable intake and there is only one RCT study that assessed this outcome. Of the six other non-randomised studies that measured the outcome vegetable intake, 5 of these were assessed as having serious risk of bias. Table 8 shows the certainty of assessment judgments across risk of bias, inconsistency, indirectness, imprecision with effect sizes for randomised trials and non-randomised trials (observational studies).

Table 8 Summary of evidence table completed using GRADEpro Software

Certainty assessment							№ of patients		Effect	Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	cooking classes for children	comparison	Absolute (95% CI)	
Cooking Self-efficacy										
3	randomised trials	not serious	very serious[a]	not serious	serious[b]	none	386	343	- SMD **0.19 SD higher** (-0.12 lower to 0.51 higher)	⨁◯◯◯ Very low
3	observational studies	serious[c]	very serious[a]	not serious	serious[b]	none	266	177	- SMD **0.65 SD higher** (-0.11 lower to 1.41 higher)	⨁◯◯◯ Very low
Vegetable intake										
1	randomised trials	not serious	very serious[d]	not serious	serious[e]	none	1212	1509	- MD **0.43 higher** (-0.24 lower to 1.1 higher)	⨁◯◯◯ Very low
6	observational studies	very serious[f]	very serious[d]	not serious	not serious	none	1146	1117	- SMD **0.34 SD higher** (0.05 higher to 0.64 higher)	⨁◯◯◯ Very low

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

Explanations

a. The heterogeneity is high due to different measures for cooking self-efficacy.

b. Confidence interval overlapped line of no effect.

c. Two of the studies had moderate risk of bias and 1 study had serious risk of bias.

d. The heterogeneity is high due to different measures for vegetable intake.

e. There is only 1 RCT study that assessed vegetable intake. The other 6 studies were non-randomised controlled trials.

f. Of the 6 non-randomised studies measuring the outcome vegetable intake, 5 of these were assessed as having serious risk of bias.

Risk of Bias

Six RCTs were assessed using the Cochrane Risk of Bias 2 for clusters tool (Sterne et al., 2019). Two of the studies, Waves intervention and Texas Sprouts intervention, showed low risk of bias (Adab et al., 2018; Davis et al., 2021). Four of the studies showed some concerns. For example, the Cooking with Kids study did state that four schools were randomly assigned to an intervention (2 schools) or a comparison group (2 schools) but there was no description of how this was done and there was no flow diagram. A high risk of bias on reported results was identified for the Landry study as a previous paper on the same study measured outcomes in a different way, signalling that the methodology for measuring the outcome changed after the data was collected and it is not explained (Davis et al., 2015; Landry et al., 2019). For the Sahota and Maiz studies, some concerns related to the reported result as there was no protocol document available and so not possible to check if the data analysed was in accordance with a pre-specified plan (Sahota et al., 2019; Maiz et al., 2021). The RCT studies are shown in Figure 5.

Fifteen studies were assessed using the ROBINS-I tool for non-randomised intervention studies (Sterne et al., 2016). Of these studies, 7 were assessed as having moderate risk of bias, 7 with serious risk of bias and one study with critical risk of bias. Serious risk of bias was most often due to confounding factors not being addressed. Where studies identified confounding factors such as socioeconomic differences across schools and sought to ensure these were balanced across the trial arms, the study was assessed as having low risk of bias. Two studies were assessed as having serious and critical risk of bias due to missing data. For example, the Bisset study did not describe what data was missing and how this was addressed (Bisset et al., 2008) and the Caraher study only reported data from one of the trial arms (Caraher et al., 2013).

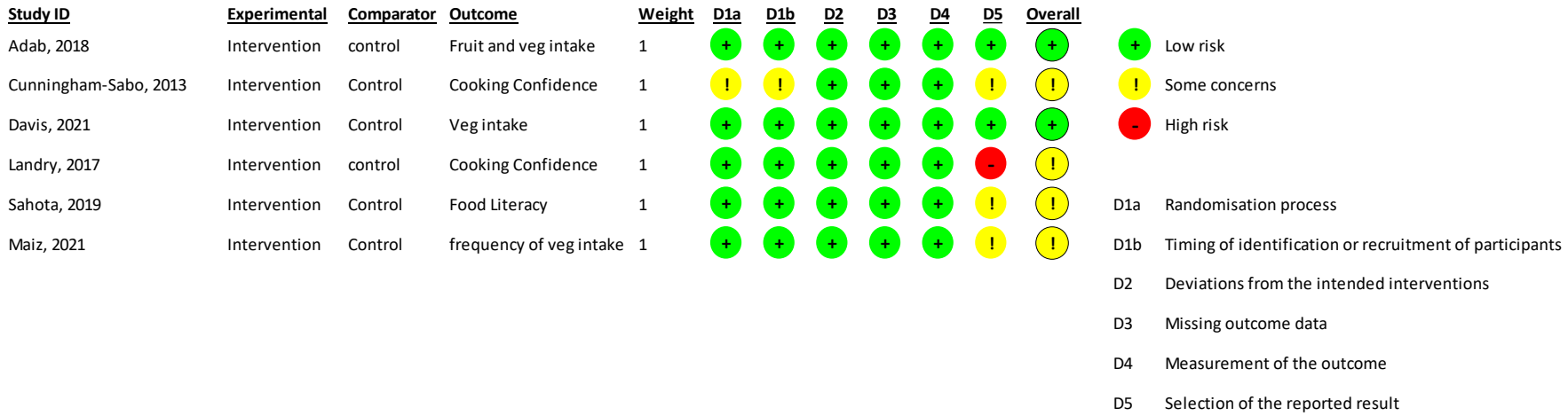


Figure 5 Risk of Bias assessments for cluster RCTs.

The main risk of bias in non-randomised studies is due to confounding and measurement of outcome domains. The bias relating to confounding could have been addressed through the randomisation process. However, it is interesting to note that all studies had moderate or critical risk of bias in the measurement of outcomes, which is due to the signalling questions in the ROBINS-I tool, judging this as at least moderate if the trial is not blinded to assessors. In contrast, whilst the Rob-2 tool for RCTs asks a similar question about whether the assessors are aware that the trial is taking place, the algorithm result can still obtain a low risk of bias judgment for this domain even when not blinded. The studies assessed using the ROBINS-I risk of bias tool are shown in Table 9.

Table 9 Risk of bias in non-randomised controlled trial studies

Study	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall Bias
Adab 2014	Low	Low	Low	Moderate	Low	Moderate	Low	Moderate
Alexander 2014	Serious	Low	Low	Moderate	NI	Moderate	Low	Serious
Battjes-Fries, 2008	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Bisset, 2008	Low	Low	Moderate	Low	Serious	Moderate	Moderate	Serious
Caraher, 2013	Serious	Low	Low	Low	Critical	Critical	Critical	Critical
Chen, 2014	Moderate	Low	Low	Low	Low	Moderate	Low	Moderate
Davis, 2011	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Ensaff, 2017	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Gibbs, 2013	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Hovland, 2013	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Jaenke, 2012	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Parmer, 2009	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Wolfe, 2021	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Yoshii, 2021	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Zahr, 2017	Low	Low	Low	Low	Low	Moderate	Low	Moderate

Discussion

The findings support the importance that cooking plays for improving and food literacy and diet quality. Results indicated that cooking programmes increased vegetable intake, cooking confidence and food literacy, although increases were only small. Diet quality is important for children's health as vegetable intakes are generally low, and this is thought to be an intermediate outcome leading to improved health (World Health Organization, 2002; Upton et al., 2012; Hasan et al., 2019; Nekitsing and Hetherington, 2022). This is the first meta-analysis on this topic. The evidence presented here is important to improve the promotion of school-based food education which specifically includes the teaching of food preparation skills and cooking lessons for children (World Health Organization, 2020a; Dimbleby, 2021).

However, there are concerns about the research design and quality of studies in this field. A recent critical review which also looked at cooking interventions (but with wider inclusion and different outcome criteria assessing psychosocial and wellbeing outcomes) expressed concerns about the quality of studies, with only two of 38 studies having a positive quality assessment rating (Lavelle, 2023).

The main challenge with comparing the effects of studies was the variety of measures for outcomes and lack of comparable data. Heterogeneity was high for cooking self-efficacy, likely reflecting the different contexts such as length of intervention and the style of questions in different measuring tools for this outcome. For example, the Cunningham-Sabo Cooking with Kids survey included 8 items on cooking self-efficacy from Lohse et al. (Lohse et al., 2011; Cunningham-Sabo and Lohse, 2013) and scored this ranging from 8 – 40. The Mais study also used an 8-item scale on cooking self-efficacy but with score ranges from 6 to 3 (Maiz et al., 2021). In contrast, the study from Japan by Yoshii et al. used a cooking self-efficacy scoring system of 1 – 4 (Borenstien, 2021). The LA Sprouts study by Landry et al. used a 14-item item scale which included attitudes, self-efficacy and motivation to cook questions and a total cooking behaviours score (Landry et al., 2019). Standardised mean differences were used, which is a common approach for combining outcomes from studies with different scales to standardize the outcomes.

The individual effects sizes and summary effects for outcomes are small. One likely reason could be the dosage (number of cooking hours) across interventions. There was a huge variation in the cooking programmes. For example, the 6 studies where we examined cooking confidence showed a bigger impact with the dose of the intervention. The two studies with the smallest dose of cooking hours (1 hour and 2.25 hours) these showed the smallest raw mean differences between the intervention and control arms (-.031 and 0.13) (Maiz et al., 2021; Yoshii et al., 2021). The studies with the largest dose of cooking hours (15 hours and 28 hours) showed larger raw mean differences between the intervention and control arms (0.5 and 1.3) (Ensaff et al., 2017; Zahr and Sibeko, 2017). The exception to this is the Cunningham-Sabo study, which had just 6 hours of cooking dosage but with the largest non-standardised mean difference between the intervention and control arms of 2.5 (Cunningham-Sabo and Lohse, 2013). It is possible that the Ensaff and Zahr studies having much larger dose of cooking hours compared to the other studies might account for the majority of the between-study heterogeneity in the meta-analysis.

There are other reasons why interventions might vary in impact which are related to theoretical underpinnings of the programme designs. Behaviour change techniques (BCTs) have been commonly advocated in healthy lifestyle interventions so that the mechanisms for effective components are understood and built into the design (Michie et al., 2011; Marques et al., 2023) . Hollywood and colleagues recommend that BCT CALO-RE taxonomy to inform the design and delivery of cooking interventions (Hollywood et al., 2018). It has also been proposed that there is a need for best practice reporting guidance so standardise processes of applying behaviour change theory and detail reported in publications (Chakraborty et al., 2022; Lavelle, 2023). However, the process of coding interventions is a highly skilled task requiring familiarity with BCT labels and complex interpretative judgements (Wood et al., 2015). It is possible see from the study intervention descriptions that most cooking lessons in schools are likely to include BCT's such as 'instruction on how to perform the behaviour' [BCT label 4.1] 'demonstration of the behaviour' [BCT label 6.1] and 'behaviour practice/rehearsal' [BCT label 8.1] when teaching children how to prepare food and cook recipes. However, it is less clear from descriptions

whether other BCTs such as ‘identification of self as a role model’ [BCT label 13.1], ‘framing/re-framing’ [BCT label 13.2] and ‘verbal persuasion about capability’ [BCT label 15.1] are part of interventions (Michie et al., 2013). None of the studies examined provided clarity on the BCTs used within the intervention components and so it is not possible to evaluate whether some studies had a higher impact on outcomes because of theoretical underpinnings of programme design.

Practical implications

Schools participating in cooking interventions may have additional practical challenges such as lack of equipment, safety issues with managing hot items in the classrooms, particularly for this age group where resources are limited for this curriculum (Frerichs et al., 2015; Day et al., 2019; World Health Organization, 2020a). There may also be some reluctance to teach practical food skills to younger children, although it has been shown that children can learn age appropriate food preparation skills starting in primary and infant schools (Dean et al., 2021b). It is therefore not surprising that schools in many countries have been found to prioritise food knowledge curriculum over practical food skills learning (Smith et al., 2022).

To develop a higher certainty of evidence findings, there is a need for more high quality randomised controlled trials evaluating cooking interventions in schools. Future trials could consider using the Tool for Food Literacy Assessment in Children (TFLAC) by Amin et al. which contains numerical values for food systems knowledge, cooking skills, cooking knowledge, nutrition knowledge and self-efficacy (Amin et al., 2019). This tool was developed by a panel of food and nutrition experts in three phases for content validity and has been adapted for use in the UK (Vaughan et al., 2022). For measuring cooking competence, future trials could consider using the tools developed by Dean et al. in 2021; CooC11 and CooC7 are two measures of cooking competence developed and reviewed by an expert panel, based on new recommendations about children’s developmental skills and are relevant for this specific age group (Dean et al., 2021a; Dean et al., 2021b). We propose that these measurement tools stand up well to scrutiny using the Risk of Bias 2 assessment questions on outcome domain (Sterne et al., 2019) and have been used with children of this age group in cooking interventions (Amin et al., 2019;

Dean et al., 2021a; Dean et al., 2022; Vaughan et al., 2022). The Cook-ED model and matrix could also provide further guidance for researchers for designing cooking interventions (Asher et al., 2020; Asher et al., 2022).

Limitations and strengths

The strength of the review is that 21 studies were selected using SR accelerator software with two independent reviewers and a third reviewer to resolve disputes. These studies were then examined for risk of bias, summary effects for vegetable intake and cooking confidence outcomes and the GRADE approach was used to evaluate the certainty of evidence for these outcomes. A strength of combining randomised and non-randomised studies in the meta-analysis is smaller subgroups, although the limitation of this approach is increased heterogeneity.

The limitations of the review are a low number of high quality cluster randomised controlled trial studies, serious inconsistency in the type of interventions, and serious concerns about imprecision of the effects. Therefore, the overall certainty of evidence is low, as shown in Table 8. Further high-quality studies evaluating cooking interventions in schools are needed to increase the certainty of evidence. Future reviews might also include the search term 'culinary' and branch terms since this is now increasingly used for cooking interventions. There is a need for funding prioritisation for this research area.

Conclusions

Whilst a small number of trials showed small pooled effects for increased vegetable intake and increased cooking confidence, more high quality randomised evaluations are needed to increase the certainty of evidence. Future trials should consider detailing behaviour change techniques of interventions so that more can be understood about what works and in what circumstances for complex multi-component interventions (Skivington et al., 2021; Lavelle, 2023). Consistent use of outcome tools for vegetable intake, Food Literacy and cooking competence will improve the consistency and precision of meta-analysis and therefore the certainty of evidence.

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Authors' contributions

KV conceived the study and completed the first draft of the paper. KV prepared the search strategy and completed the initial title and abstract screening and full text screening from the results. CE, JC and MH contributed to the initial title and abstract screening and full text screening. KV and JW completed the data extraction. KV, CE, JC and MH participated in the risk of bias assessments. KV and JW completed the GRADE assessments. KV created all the tables and figures. CE, JC and JW commented on the first draft. KV made edits and provided a second draft. CE, JC, and MH commented on the second draft. KV made edits and created the final version. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

N/A

Consent for publication

N/A

Competing interests

All the authors declare that they have no competing interests.

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Chapter 3 Trial Protocol for the PhunkyFoods intervention on food literacy and cooking skills of children aged 7 – 9 years: a cluster randomised controlled trial in Yorkshire Primary Schools UK

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Abstract

Background: Childhood obesity rates more than double during primary school in England. Acquiring competent cooking skills is a key part of children's education that can lead to improved knowledge of a healthy lifestyle and dietary behaviours. Evaluation of the impact of 'PhunkyFoods', a school-based food and nutrition education programme, will assess food literacy, cooking skills and dietary behaviour in primary-school children.

Methods: A cluster randomized controlled trial will be undertaken in 28 primary schools in North Yorkshire, UK, including a total population of children aged 7-9 years (n = 420). The trial has two arms: (a) intervention group receiving PhunkyFoods programme (n=210), (b) the wait-list control group receiving the usual school curriculum (n = 210).

The intervention 'PhunkyFoods' will be delivered by Purely Nutrition Ltd. Participating school staff are supported with training, policy development and access to resources to improve the delivery of nutrition education. Children participate through whole school assemblies, classroom activities, and after school clubs about food preparation, cooking healthy meals and healthy living.

Schools, parents and children have access to healthy meal recipes through the PhunkyFoods website.

The primary outcomes are differences in food literacy and cooking skills scores between control and intervention arms after 12 months of the intervention and adjusted for baseline values. The secondary outcome is differences in fruit and vegetable intake between the arms after 12 months (adjusted for baseline). Treatment effects will be examined using mixed ANOVA and regression analysis. Primary analyses will adjust for baseline food literacy and cooking skills scores and secondary analysis will adjust for pre-specified baseline school and child level covariates.

Discussion: The PhunkyFoods programme is a flexible menu of options for schools to choose from, making this a highly complex intervention. Following Medical Research Council guidance, research perspectives will focus on effectiveness and theory-based approaches: to what extent the intervention produces the intended outcomes in real world settings and what works in which circumstances.

Trial registration: ISRCTN, ISRCTN68114155, Prospectively registered 22/10/2021 https://doi.org/10.1186/ISRCTN68114155

Keywords: Cluster-RCT, Food Literacy, Cooking skills, Complex Intervention, Childhood Obesity Prevention, Primary Schools, Protocol.

Note: the numbers in curly brackets in this protocol refer to SPIRIT checklist item numbers. The order of the items has been modified to group similar items (see https://uk01.l.antigena.com/l/No6NZkdmCCqK54rxvBrmWWdkRMJMZezCpgvwMZggQBsXfTE5JxwRkvfLlKx0U70lwk7cMxP4G-JXA9DRXoSHskRP35mvo0zLdHo13fmjz3NUC2JsGZx7J2EDnMtOmO38H5Albd3MRNSKY9lc58ocvVAIu9e8SKQUoh9njrlxFgTyLFNTJYXVHyGkSTxrbtVR3WJgqPGboeXzZpCi3bHGJTQ6-boK)

Administrative Information

Title {1}	Evaluation of the PhunkyFoods intervention on food literacy and cooking skills of children aged 7 – 9 years: a cluster randomised controlled trial in Yorkshire Primary Schools UK Cooking In Yorkshire / PhunkyFoods Cluster-RCT
Trial registration {2a and 2b}.	ISRCTN68114155
Protocol version {3}	Issue date: 14th January 2022 Protocol number: 01 Author: KV, JaC, MaH, JeC, HR, MiH, CE
Funding {4}	The PhunkyFoods programme in North Yorkshire is funded by Nestlé For Healthier Kids and delivered by Purely Nutrition Ltd. The lead researcher is supported by the University of Leeds as part of a PhD project. This study has been produced with financial assistance within the context of the WHO European Office for the prevention and control of Prevention and Control of Non-communicable Diseases.

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Name and contact information for the trial sponsor {5b}	c/o Prof. Jason Halford G.02 Psychology Building University of Leeds Leeds LS2 9JT England, United Kingdom +44 (0)113 343 6678 J.Halford@leeds.ac.uk
Role of sponsor {5c}	Purely Nutrition staff will have some role in data collection activities across the 28 school sites, working with the University of Leeds research team staff. Nestlé Healthy Kids and Purely Nutrition will not have any role in study design, management, analysis and interpretation of data, writing of report or decision to submit the report for publication. The ultimate authority over all the research activities resides with the University of Leeds.

Introduction

Background and rationale {6a}

Childhood obesity in the UK

Childhood obesity rates typically double during primary school in England and prevalence at age 4-5 years in reception classes has increased to 14% in 2020/21 (NHS digital, 2021). Good nutrition and maintaining a healthy weight in childhood helps to prevent obesity and diet-related ill health later in life (Umer et al., 2017). Knowledge about nutrition and cooking healthy meals helps people to live healthier lives (Hersch et al., 2014; Chaudhary et al., 2020; World Health Organization, 2020).

School-based nutrition programmes: existing knowledge

A systematic literature review of successful primary school-based nutrition programmes has highlighted the value of experiential curriculum strategies to develop food literacy and cooking skills in children. Programmes are more likely to be successful if they have multiple strategies, parental involvement and focus specifically on vegetable intake (Charlton et al., 2020).

The PhunkyFoods programme aims to help early years settings and primary schools to deliver a whole-settings approach to healthy lifestyles and to engage with all pupils, and their families, in promoting tangible health behaviour change in a fun, lively and positive manner. The cooking skills elements of the PhunkyFoods programme delivered in schools is supplemented with additional components such as online videos demonstrating knife and other cooking skills (PhunkyFoods, 2020).

The feasibility study undertaken in 2019 by Sahota and colleagues (Sahota et al., 2019) identified key outcomes of the programme but was not powered to detect definitive effectiveness. However, results did show the potential of the programme to increase knowledge of healthy lifestyle and dietary behaviours.

This research will build on the previous feasibility trial by implementing recommendations for enrolment and baseline data collection with a fully powered phase 3 trial design. The trial will investigate the impact of the PhunkyFoods programme on dietary behaviour, nutrition knowledge and

cooking skills for primary aged children aged 7 - 9 years. This age group was chosen as relevant for study as this population is also targeted by the World Health Organization Child Obesity Surveillance Initiative (COSI) as an important area for research. This UK trial will provide supplementary contextual data to complement the current COSI survey 2021-2023, which includes new questions about children's food preparation and cooking skills in this age group (World Health Organization, 2021a).

Objectives {7}

The main aim is to assess the impact of the PhunkyFoods healthy lifestyles intervention programme, (developed and refined by Purely Nutrition), on food literacy, cooking skills and fruit and vegetable intake of children using usual practice in primary schools as the comparator. Intervention effects will be examined at 12 months. Cost-effectiveness of the intervention will be assessed from a societal perspective. In addition, differences in outcomes will be explored by model fidelity in each school setting, other healthy living initiatives in the local area and socioeconomic status using percentage eligibility for free school meals (%FSM) and the index of multiple deprivation (IMD) as covariables.

The PhunkyFoods programme is a flexible menu of options for schools to select from, making this a highly complex intervention. Following Medical Research Council guidance on the evaluation of complex interventions, research perspectives will focus on effectiveness and theory-based approaches: the overall objective of the study is to explore to what extent the intervention produces the intended outcomes in real world settings and what works in which circumstances (Skivington et al., 2021).

The research hypotheses are:

1) The PhunkyFoods intervention group will show higher food literacy and cooking skills than the control group measured by mean scores;

2) The PhunkyFoods intervention group will show higher intake of fruit and vegetables than the control group measured by mean scores;

3) Schools in the intervention arm that choose more 'active ingredients' (intervention components) from the flexible menu of options will have better outcomes than those schools that choose less 'active ingredients';

4) The covariates, %FSM and IMD, will have a mediating impact on outcomes for schools in the intervention arm.

Trial design {8}

The PhunkyFoods evaluation design is a parallel, cluster randomized controlled trial, with two arms and with 1:1 allocation ratio. The intervention arm will receive the PhunkyFoods programme starting in May 2022 and the wait-list control arm will receive the PhunkyFoods programme after the final research data collection, with training from May 2023 (superiority trial). If the trial is not able to recruit 28 schools within the recruitment period, then the research team will consider an unequal allocation ratio with a smaller number of schools in the control group or widening the geographical recruitment area. The impact of this is discussed in the section on sample size.

Methods: Participants, interventions and outcomes

Study setting {9}

All state mainstream primary schools in Harrogate (n = 74) and Selby (n = 40) areas of North Yorkshire are eligible for inclusion and will be invited to express an interest in the study. Schools will be approached until the required sample size of (n = 28) schools is achieved.

Eligibility criteria {10}

Exclusion criteria: schools with fewer than 20 pupils in the relevant year groups (year 3 and/or year 4). Schools that are unable to commit to the two data collection points in March 2022 and March 2023 for the identified class of children will also be excluded from the study.

Who will provide informed consent? {26a}

Informed consent will be requested at three stages:

1) **School Consent:** Headteachers will be provided with an information sheet and consent form for the Study. Details of the PhunkyFoods Programme and the Research Study will be explained via a 30-minute School Briefing session on Microsoft Teams by the lead researcher (KV). If they decide to participate and the school meets the eligibility criteria, informed consent

for the school to participate will be signed by the Headteacher and a class identified to participate in the study.

2) **Parent Consent:** Once the school consent has been obtained, a Parent Information Sheet will be sent out for all the parents / carers for children in the identified class with an opt-out clause. If parents do not want their child to participate in the Research Study, they can either email or ring the school. This information will then be passed to the research team to update the recruitment flow diagram. Parents will be given 2 weeks if they wish to withdraw their child from the research study. This will mean that all children will still participate, and no child will be excluded from the PhunkyFoods programme activities. This includes the data collection activities; however, their data will not be used for the purposes of research if the parent opted out.

3) **Child Assent:** The two data collection surveys for children will have a consent tick box on the front page. The lead researcher will explain that no individual child will be identified from the study and information will not be used beyond the research team. Children who are happy for the surveys to be used in the research study will be asked to tick the consent box on the front page of the surveys. At the beginning of the research activity, the researcher will explain to children about the work of the University on Food Science and Nutrition and ask them to complete the surveys as part of the study.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

N/A - no biological specimens are collected as part of this trial.

Interventions

Explanation for the choice of comparators {6b}

The control group schools will receive their usual existing school curriculum for food science as delivered in the Food Technology schemes of work, without any support from the PhunkyFoods Programme. This may include specific nutritional components, designed and delivered by the school. In the UK, the

Department for Public Health sets out the topics that should be covered in Food Technology lessons for primary schools (Public Health England, 2015) but in reality, this is likely to look different across school settings. We will ensure we collect relevant information on what schools are currently doing in relation to food knowledge and skills and include this information in the analysis as an additional independent variable if deemed appropriate.

Intervention description {11a}

The PhunkyFoods Programme is a flexible menu of 8 'active ingredients', which schools can select from. The Education Endowment Foundation (EEF) uses the term 'active ingredients' to describe intervention components in a school intervention (Education Endowment Foundation, 2019). The PhunkyFoods Logic Model in Appendix B1 shows the behaviour theory for the PhunkyFoods programme and implementation planning.

The PhunkyFoods programme has a detailed Delivery Manual with implementation guidance and resources for Engagement & Development Coordinators (EDCs) to deliver each of the 8 active ingredients in partnership with schools (Cockroft, 2020):

Active ingredient 1: Whole setting staff training in the PhunkyFoods Programme with additional Continuous Professional Development (CPD) opportunities available for schools to opt into. Examples of CPD opportunities include; National Level 2 Award in Nutrition and Health of School Aged Children; Food Prep in the Classroom; and Setting Up and Running a Cook Club.

Active ingredient 2: Whole Setting Audit (Health Check) and action planning support around the Whole School Approach to Health. This consists of an initial meeting with a member of the Senior Leadership Team (SLT) to work through the Health Check document, then co-production of an action plan for development priorities agreed.

Active ingredient 3: Policy evaluation and updating of Whole School Food and Packed Lunch policies.

Active ingredient 4: Whole School Activities such as assemblies, pupil workshops on a range of topics relating to Phunky FOOD. Examples include:

Eatwell, Strive for 5, Drain your Drinks, Bag-A-Breakfast, Top Teeth, A Healthy Lunch, Snack Attack, Food Waste, Phunky FIT (Get Active) and Phunky MINDS (Resilience, Feelings, Relationships, Anti-Bullying).

Active ingredient 5: Experiential curriculum / classroom-based Activities. Examples include: Design and Technology Scheme of Work; Personal Health and Social Education Scheme of Work; Topic Based Activities; Planning, Preparation and Assessment solutions (healthy eating and physical activity); Phunky15 (physical activity); and Mindful Moments.

Active ingredient 6: Extra-curricular Activities. Examples include: Breakfast Club; Cookery Club; Gardening Club; and After-schools Club.

Active ingredient 7: Student-Led Activities. The Phunky AMBASSADORS programme involves mentoring students to deliver key healthy lifestyle messages through peer-to-peer learning.

Active ingredient 8: Parent Engagement Activities. Examples include: Parent/Child Cook Clubs; Parent Workshops; Parent Stay and Play Sessions; Parent Health Promotion Events; and Parent Communication Material (newsletter text; email snippets; display assets).

Criteria for discontinuing or modifying allocated interventions {11b}
Participating schools in the intervention arm will be given the freedom to choose from the flexible menu of active ingredients in the programme and work at the pace that is right for the individual school setting. In line with the PhunkyFoods Logic Model (Appendix 1), schools will be encouraged to participate in active ingredients 1 and 2 within the first 3 months as part of the model fidelity. Whilst the programme pace is led by schools, the EDCs will support and encourage participating schools to consider active ingredient 3 by 6 months of the programme and will highlight opportunities to select 'Active Ingredients' 4 – 8 after 6 months. This flexibility is indicative of the complexity of the trial; and hence the theory-based approach to research perspectives and hypotheses which aim to understand the interplay of mechanisms and context in evaluating complex interventions (Skivington et al., 2021).

Strategies to improve adherence to interventions {11c}

The PhunkyFoods programme is run by Purely Nutrition. All EDCs are employed by Purely Nutrition and supported with training and guidance on how to implement the programme according to the Programme Manual (Cockroft, 2020) and the Logic Model, whilst providing the flexibility for schools to work at the pace that is right for their setting. The study will collect data on of how many components each school delivers and this will be included as part of the analysis.

Relevant concomitant care permitted or prohibited during the trial {11d}

N/A - no concomitant care permitted or prohibited as part of this trial.

Provisions for post-trial care {30}

N/A - no provisions for ancillary and post-trial care as part of this trial.

Outcomes {12}

At the time of trial registration, it was thought that the outcome measures would be measured at baseline (T1) and then at 8 months post-intervention delivery (T2), identifying September as the start time of the intervention. However, in recognition that the training phase of the programme delivered in May – July includes active ingredients 1 and 2, it is felt more appropriate to include this phase in the time period from baseline to final value. Therefore, the outcomes will be measured at baseline (T1) and then 12 months (T2) after the intervention starts, including the initial training for teachers. See Figure 6.

Primary outcome measures

1. **Food literacy** will be measured by the Tool for Food Literacy Assessment in Children (TFLAC - UK) at baseline (T1) and at 12 months after intervention delivery (T2). The Food Literacy outcome is composite, and contains numerical values for food systems knowledge, cooking skills, cooking knowledge, nutrition knowledge and self-efficacy. The original questionnaire developed by Amin et al. (Amin et al., 2019) Tool for Food Literacy Assessment in Children (TFLAC) was developed by a panel of food and nutrition experts in three phases for content validity, with test-retest reliability and internal consistency assessed amongst children (n = 706) aged 9 – 11 years. Food literacy domain-specific Cronbach alpha values were: food systems knowledge (0.80); cooking skills (0.94); cooking knowledge (0.63); nutrition knowledge (0.83) and self-efficacy regarding eating (0.98) and intraclass correlation coefficients were 0.64−0.70 (P< .001). Reliability was generally good, though the cooking knowledge subscale (α = 0.63, ICC = 0.64–0.70) warrants cautious interpretation.

   The TFLAC was adapted for use in the UK by consulting with EDCs at PhunkyFoods during an away day on 10th September 2021. Terminology was changed from US English words to equivalent UK English words and then further checks on the survey language were undertaken by the authors of this protocol. Example changes included ‘measuring cup’ to ‘measuring jug’ and ‘oven mitt’ to ‘oven glove’. No other changes were made to the content, structure, order, or phrasing of questions in the survey design that could have an impact on internal consistency.

2. **Cooking skills** will be measured by the CooC11 child survey by Dean et al. (Dean et al., 2021a) at baseline (T1) and at 12 months after intervention delivery (T2). CooC11 and CooC7 are two measures of cooking competence developed and reviewed by an expert panel, based on new recommendations about children's developmental skills and are relevant for this specific age group (Dean et al., 2021a; Dean et al., 2021b). The internal consistency reliability of CooC11 was good, with Cronbach score of 0.86, and temporal stability rating ICC of 0.91. The measure was shown to be responsive to change in the cooking camp intervention with differences in pre-cooking camp mean (SD) of 21.75 (7.89) to post camp mean of 26.13 (8.89) (Dean et al., 2021a).

Secondary outcome measures

1. **Total fruit and vegetable intake** will be measured using a shortened version of the Child Assessment of Diet Evaluation Tool (CADET) (Christian et al., 2015) at baseline (T1) and at 12 months after intervention delivery (T2). The CADET is a 24-hour food diary that measures the nutritional intake of children and has been validated for use with children aged 3-11 years (Cade et al., 2006; Christian et al., 2015). A sample of children (n = 67) completed the diary with a mean age of 9.3 years in the validation study (Christian et al., 2015). The proposed CADET fruit and veg survey uses a sub-section of CADET, which assesses dietary information on fruit and vegetables only. This shortened version was chosen by the authors to make it easier for parents to complete and for the potential of a shorter version to increase survey return rate.

Participant timeline {13}

Figure 6 Schedule of enrolment, intervention and assessments

		STUDY PERIOD							
		Enrolment		Allocation	Post allocation				Close-out
TIMEPOINT		$-t_2$	$-t_1$	0	t_1	t_2	t_3	t_4	t_x
		Dec 21 – March 22	March 22	April 22	May - July 22	Sept 22	March 23	Jun 23	Sept 23
ENROLMENT:									
Expressions of interest		X							
Eligibility screen		X							
Informed consent (schools)		X							
Informed consent (caregivers)		X							
Cluster allocation				X					
INTERVENTIONS:									
PhunkyFoods					training ←		→ intervention		
Control group (normal teaching)					←		→		
ASSESSMENTS:									
Baseline	Cooking Skills (CooC11)		X						
	Food Literacy (TFLAC)		X						
	Fruit and Veg (CADET)		X						
Outcome	Cooking Skills (CooC11)						X		
	Food Literacy (TFLAC)						X		
	Fruit and Veg (CADET)						X		
Other variables	% FSM	X							
	IMD	X							
	Number of pupils in school	X							
	Number of active ingredients selected					X			

Sample Size {14}

The study by Dean and colleagues in 2019, based on 469 participants and using CooC11 to assess cooking competence, showed a significant increase ($p<0.01$) in cooking competence at follow up after the camp-based intervention compared with results at baseline (Dean et al., 2021a). The results of CooC11 at baseline (mean (SD)) were, 21.75 (7.89) and at follow up 26.13 (8.89). The

difference in cooking competence scores were therefore approximately 5 units, the equivalent of a moderate effect size (cohen's d= 0.52).

A power calculation was undertaken using STATA, approximately based on this moderate effect size of the Dean study. To detect this effect size with 90% power using a two-level model with individuals clustered within schools (as whole schools rather than individual children were recruited), 13 clusters were required in each arm. The calculation incorporated several assumptions: an average of 15 participating children per school; a conservative intraclass correlation coefficient of 0.20 to allow for the possibility that children within the same school may be more similar to each other than children in other schools; and adjustment for baseline scores, assuming a moderate correlation between baseline and follow-up measures (r = 0.5), consistent with the planned ANCOVA analysis. Although the true ICC for cooking-related outcomes is likely to be lower, limited evidence in this area necessitated a conservative estimate. Due to the reasonable possibility that schools may drop out of the study we aim to recruit 14 schools per arm (28 schools in total).

Recruitment {15}

Eligible schools will be recruited through email, social media, newsletters and follow up telephone calls. Networks such as North Yorkshire County Council, Huntington Research School, Red Kite Teaching School Alliance will be used to help promote the project in newsletters and social media. Those schools that express an interest in the project will be sent a 'Cooking in Yorkshire' Poster, a Headteacher Information Sheet with details about the study, aims and methodology, and invited to a 30-minute online school briefing to discuss the project and research design.

Once schools that have received a briefing about the project understand the randomised controlled trial design and data collection elements of the study, they will be asked to sign the Headteacher Consent Form and allocate one class for the research project. Parental and Child consent procedures will then take place and have already been outlined early. A flowchart for the trial procedure is shown at Figure 7.

Assignment of interventions: allocation

Sequence generation {16a}

A computer-generated randomisation sequence will be used to allocate schools into the intervention and wait-list control arms of the trial. Block randomisation will be used to ensure equivalence between intervention and waitlist-control schools. Furthermore, schools will be stratified according to region (e.g. Selby or Harrogate) and whether they are above or below the England median for free school meals eligibility (Education Statistics Service, 2024). The randomisation will be conducted immediately after T1 baseline data is collected.

Concealment mechanism {16b}

A computer-generated randomisation sequence will be used to allocate schools into the intervention and wait-list control arms of the trial. The research team will not be fully blinded to the group allocation. Schools will be informed of which group they have been allocated to and therefore the schools will not be blind to their allocation.

Implementation {16c}

The lead researcher (KV) will enrol participants onto the study and allocate them a unique ID number. One member of the research team (CE), blinded to the schools, will generate the allocation sequence using the school ID numbers but not the school names. The lead researcher (KV) will then inform schools which group they have been allocated to.

Assignment of interventions: Blinding

Who will be blinded {17a}

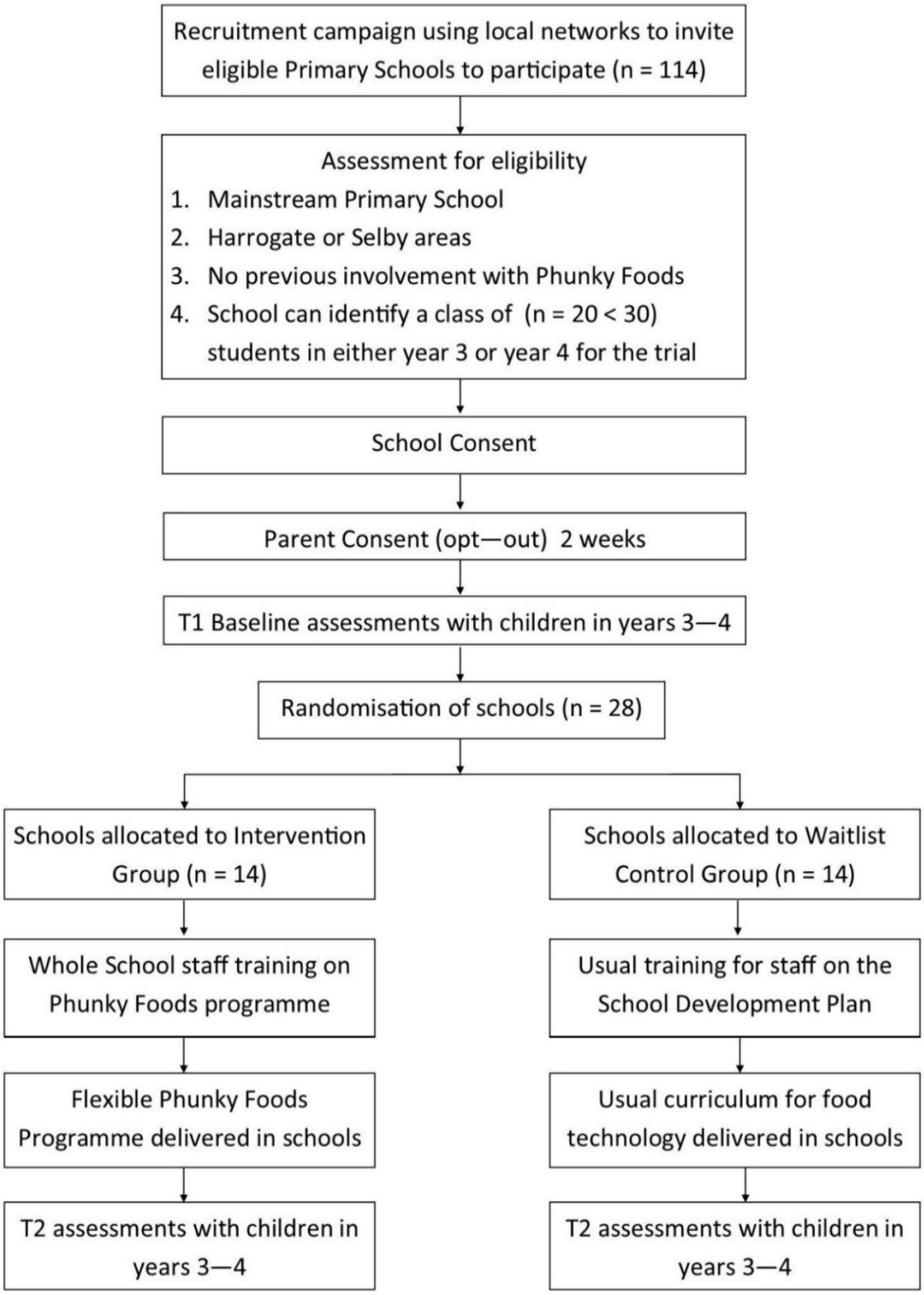
There will be full blinding at T1 baseline data collection by trial participants, schools and the research team, since randomisation will take place after data is collected. This is a pragmatic trial evaluating effectiveness of a food skills-based intervention and therefore it is not possible for trial participants, schools or parents to be blinded after assignment to the intervention groups. We plan for the blinding of outcome assessors at T2 by using additional research team members from the University of Leeds to undertake data collection in the participating schools. This will be dependent on access to further funding being

sought. It will not be possible for the data analyst to be blinded, since this work is in support of a PhD thesis by the main author of the study.

Procedure for unblinding if needed {17b}

N/A - no procedure for unblinding as part of this trial as participants are not blinded to allocated group.

Figure 7 Flowchart of trial procedures



Note on Figure 7. Children who are in years 3 -4 at UK Primary schools in Yorkshire are aged 7 – 9 years.

Data collection and management

Plans for assessment and collection of outcomes {18a}

Data collection will be via paper surveys at two timepoints; baseline (T1) and 12 months post intervention (T2). The two child surveys on Food Literacy and Cooking Skills will be conducted on the school premises in a whole class setting. The fruit and veg diet diary (CADET) will be sent home to parents in paper format, asking them to complete it and send it back to the school.

Plans to promote participant retention and complete follow-up {18b}

Short articles about the research project will be sent out in School Newsletters in the half-term before data collection with a photograph of the main researcher (KV) to make the message more personal. It is hoped that this personal approach will encourage the completion of the CADET fruit and veg survey by parents.

Data management {19}

All paper-based data will be collected by the lead researcher and held in locked filing cabinets in a locked office. There will need to be some training undertaken for the coding work on diaries and questionnaires to ensure a consistent approach across the research team. For data entry, a 5% sample will be checked by another member of the research team to monitor error rates. The data will be inputted into MS EXCEL by the lead researcher (KV), exported to SPSS and STATA for analysis and saved on the University of Leeds SAN (Storage Area Network); which comprises enterprise-level disk storage and file servers located in physically secure data centres with appropriate fire suppression equipment. The electronic data will be accessible only by the Research Team.

Confidentiality {27}

Individual participants will be given an anonymous unique identity number. All participating schools and families will be informed that the data provided will be treated confidentially. It will be explained that the research team are the only people who will look at the data and that the published reports of results will not identify any individuals either before, during or after the trial.

Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular analysis in this trial/future use {33}

N/A - no biological specimens are collected as part of this trial.

Statistical methods

Statistical methods for primary and secondary outcomes {20a}

Baseline demographic characteristics for the participating schools will be summarised using means and 95% confidence intervals for continuous variables and frequencies and percentages for categorical variables. Contextual data such as %FSM eligibility, IMD and Public Health England data from National Child Measurement Programme (NCMP) (NHS digital, 2021) will be provided at school and Lower Super Output Area (LSOA) (NHS Digital) levels respectively in a summary table.

Primary analysis on the effectiveness of the intervention on outcome data for the trial arms will be compared using two-way mixed analysis of variance (ANOVA) and multivariable regression models. The statistical analyses will be conducted using the following: food literacy score, cooking skills score and fruit and vegetable intake score as the dependent variables; time (T1 and T2) as the repeated measures independent variable; and treatment (intervention / control) as the independent groups variable. Effect size coefficients will be reported with measures of variation as well as Cohen's d to determine relative size of the effectiveness. We have identified the key outcomes on which we are basing our evaluation and any additional results will be interpreted cautiously and with the awareness that multiple testing is an issue. To reduce this risk we will consider using statistical significance at the 1% level.

Interim analyses {21b}

N/A – no interim analyses are planned as part of this trial.

Methods for additional analyses (e.g., subgroup analyses) {20b}

Secondary analysis will use a theory-based approach to explore the interplay of mechanisms and context (Skivington et al., 2021), including model fidelity. This will involve adjusting for pre-specified baseline school and child level covariates to investigate the impact of the intervention arm for individual clusters. Multiple regression will be used with the number of intervention

components as a predictor variable. In addition, %FSM and IMD will be used in a linear model as predictor variables. The study will have low power to detect all but the largest differences in subgroups.

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

Missing data will be reported and associations between outcomes considered. A sensitivity analysis will be undertaken if deemed appropriate, depending on the extent of the missing data.

Plans to give access to the full protocol, participant level-data and statistical code {31c}

As stated in the Information Sheets for Headteachers and Parents, no individual participant level data will be available outside of the research team. The datasets analysed during the current study and statistical code are available from the corresponding author on reasonable request, as is the full protocol.

Oversight and monitoring

Composition of the coordinating centre and trial steering committee {5d}

Once recruitment is underway, a Trial Steering Group will be set up comprising representation from: the University of Leeds, Purely Nutrition Ltd., North Yorkshire County Council and Primary Schools in Harrogate or Selby. The Trial Steering Group will meet online, at a minimum, 4 times during the trial: an initial meeting to discuss the role of the group, two weeks before both data collection time points and at the end of the Trial for a close-out endpoint discussion and final feedback.

The coordinating centre Research Team at the University of Leeds will provide oversight of the whole trial design, day-to-day management of the trial, data management processes, analysis, report writing and decisions on publications. The coordinating centre Research Team will meet every 8 weeks throughout the trial to monitor progress, data collection, consider risks and address any issues raised by the Trial Steering Group members.

Composition of the data monitoring committee, its role and reporting structure {21a}

The coordinating centre research team (KV, CE, JeC and MaH) will provide the function of data monitoring, including the oversight of the data management processes and quality control. This work will take place as part of the formal PhD supervision processes at the University of Leeds, the sponsor of the study. The lead researcher (KV) will report to the Trial Steering Group on data monitoring issues on behalf of the coordinating centre research team.

Adverse event reporting and harms {22}

Adverse events (for example, any minor mishaps or injuries that occur due to food preparation or food cooking activities) will be identified in discussion with Purely Nutrition Ltd., recorded in a secure place and reported in a timely fashion to the Steering Group.

Frequency and plans for auditing trial conduct {23}

The principal researcher (KV) from the Research Team will undertake 4 audit visits to schools in the intervention arm during the delivery phase to observe the activities, consider trial conduct and consider model fidelity issues. This will not be independent from the sponsoring organisation. Schools will be chosen at random from the participating cluster sites and then dates arranged by liaison with the PhunkyFoods representative on the Trial Steering Group.

Plans for communicating important protocol amendments to relevant parties (e.g., trial participants, ethical committees) {25}

Any important protocol amendments will be decided by the Coordinating Centre Research Team and communicated to relevant stakeholders, for example the University Ethics Committee, Trial Steering Group, trial participants, the trial registry (ISRCTN) and journals.

Dissemination plans {31a}

The Research Team intends to disseminate the trial results through publication in an open access relevant academic journal. Participants did not provide consent for their data to be shared.

Discussion

The World Health Organization (WHO) Regional Office for Europe Data Dashboard shows that obesity continues to rise at an alarming rate (World Health Organization). The global target of halting the rise of obesity is going in the wrong direction in the WHO European Region and so effective interventions to improve diet quality are needed. Overall findings from the fourth round of the WHO COSI report showed that almost 1 in 3 children aged 6-9 are living with overweight or obesity. The highest prevalence of childhood overweight and obesity were observed in Cyprus, Spain, Greece and Italy, where over 40% of boys aged 6-9 years and over 30% of girls aged 6-9 years were living with overweight (including obesity) (World Health Organization, 2021b). The PhunkyFoods intervention could be a UK case study example that could inform similar interventions in other Member States.

Given the complex nature of the intervention and the contextual factors, it will not be possible to examine the efficacy of the PhunkyFoods programme as an experimental setting. Instead, the research perspective focuses on effectiveness and theory-based approaches. The cluster randomised controlled trial design and plans for secondary analysis will allow for some investigation and discussion into what works in what circumstances and why.

The additional level of complexity for this study is the flexibility in which schools choose from the active ingredients in the Logic Model. Whilst this reflects the real-world context of the study, it also limits the statistical power for cluster comparison between settings since the intervention will likely look very different in each school. It is hoped that the secondary analysis using complex regression, using the number of active ingredients, %FSM and %IMD as predictor variables, combined with observations from the audit visits, will enable some discussion about the effectiveness of particular settings.

Trial status

Protocol version 1, 14 January 2022. Recruitment of participants began 01/12/2021 and will end on 31/3/2022.

Abbreviations

ANOVA: Analysis of Variance; CADET: Child Assessment Diet Evaluation Tool; COSI: Child Obesity Surveillance Initiative; EDCs: Education and Development Coordinators; EEF: Education Endowment Foundation; FSM: Free School Meals; IMD: Index of Multiple Deprivation; LSOA; Lower Super Output Area (a geographic hierarchy designed to improve the reporting of small area statistics in England and Wales); NCMP: National Child Measurement Programme; TFLAC: Tool for Food Literacy Assessment in Children; WHO: World Health Organization.

Acknowledgements

The Engagement & Development Coordinators commented on the practical aspects of delivery and tested the research instruments at a PhunkyFoods away day for staff in September 2021.

Authors' contributions {31b}

KV is the Chief Investigator; she conceived the study, led the proposal and wrote the first draft. CE is the primary PhD supervisor of KV and contributed to the design of the cluster RCT study and sample size calculation. KV, CE, MaH and JaC are all involved in the design of the trial including methods for sampling, data collection and reporting of the trial findings. JeC is the creator of the PhunkyFoods intervention and provided edits to the second draft. HR provided comments and edits to the first and second drafts and MiH provided comments on the second draft. All authors read, commented and approved the final manuscript.

Funding {4}

The PhunkyFoods Programme in the North Yorkshire region is funded through sponsorship from the Nestlé For Healthier Kids Programme. Purely Nutrition staff will be providing support time in attending the Trial Steering Group meetings. The lead researcher (KV) is supported by the University of Leeds as part of a PhD project. This study has been produced with financial assistance within the context of the WHO European Office for the Prevention and Control of Non-communicable Diseases. The Nestlé for Healthier Kids Programme is not involved in any part of the study design, data collection, analysis or interpretation of data. Purely Nutrition staff are involved in some elements of

data collection but will not be involved in data analysis, interpretation of data or writing of trial evaluation manuscripts. The WHO European Office for Prevention and Control of Non-communicable Diseases may be involved in the reporting and sharing of trial results.

Availability of data and materials {29}

The final trial data for this protocol can be supplied on request to the Research Team at the University of Leeds. The research materials (information sheets, consent forms, surveys) will be available upon request to KV by emailing a request to mc17kv@leeds.ac.uk

Ethics approval and consent to participate {24}

Ethics approval was granted on 30/09/2021, by the School of Business, Environment and Social Sciences Committee at the University of Leeds (The Secretariat, University of Leeds, LS2 9NL, UK; +44 (0)113 343 2876; researchethics@leeds.ac.uk), ref: AREA 21-011.

Consent for publication {32}

No identifying images or other personal or clinical details of participants are presented here or will be presented in reports of the trial results. Informed consent materials are attached as supplementary materials.

Competing interests {28}

The authors declare that they have no competing interests.

Authors' information (optional)

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[2] WHO European Office for Prevention and Control of Noncommunicable Diseases (NCD Office)

[3]Purely Nutrition Ltd.

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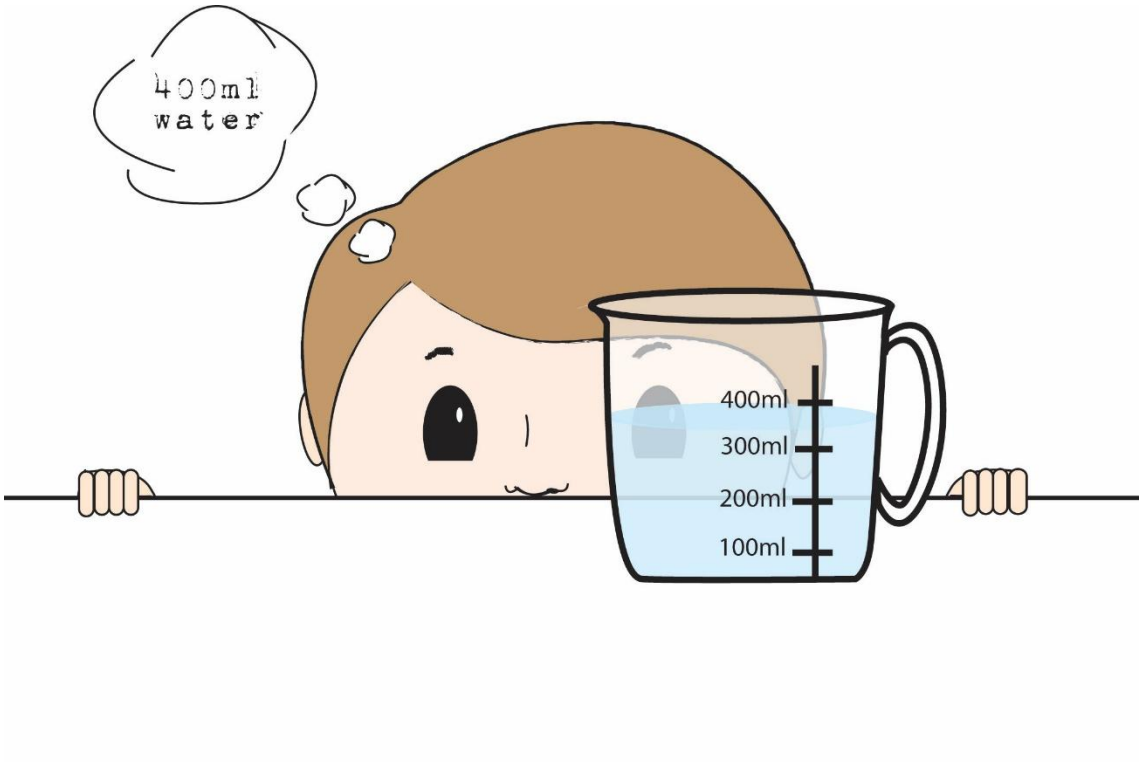
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Chapter 4 Evaluation of the "PhunkyFoods" intervention: a cluster randomized controlled trial in the UK.

Karen L. Vaughan[1], Janet E. Cade[1], Marion M. Hetherington[1], and Charlotte E.L. Evans[1]

Abstract

Objective: We evaluated the impact of an established nutrition education intervention, 'PhunkyFoods' on food literacy, cooking skills, and fruit and vegetable intake in primary school aged children.

Design: A pre-registered cluster randomised controlled trial was used; the intervention group received the 'PhunkyFoods' programme and the wait-list control group received the usual school curriculum. Primary outcomes measured were differences in food literacy and cooking skills scores between the intervention and control arms after 12 months adjusted for baseline values.

Setting: The trial was undertaken in 26 primary schools in North Yorkshire, UK.

Participants: 631 children aged 6 – 9 years participated (intervention n = 307, control n = 324) through assemblies, classroom activities and after-school clubs.

Results: There were no significant effects of the intervention compared to control on food literacy, cooking skills, vegetable intake or fruit intake. Adjusting for baseline, the Food Literacy Total Score was 1.13 points lower in the intervention group than the control (95% CI -2.87 to 0.62, p = 0.2). The Cooking Skills Total Score was 0.86 lower in the intervention group compared to the control (95% CI = -5.17 to 3.45, p = 0.69). Girls scored 2.8 points higher than boys in cooking skills across the sample (95% CI = 0.88 to 4.82, p < 0.01).

Conclusion: The intervention did not result in improved food literacy or cooking skills, though sex effects on these outcomes were observed. More practical food preparation hours are needed in primary schools to improve likelihood of an effect on outcomes.

Trial registration ISRCTN, ISRCTN68114155, prospective registration on 22/10/2021

Key Words: Cluster-RCT, Food Literacy, Cooking skills, Complex Intervention, Fruit and Vegetable Intake, Healthy Eating.

Background

Acquiring competent food preparation and cooking skills is an important part of children's education that can lead to improved healthy lifestyles and dietary behaviours (World Health Organization, 2020a; Dimbleby, 2021). Studies have shown that school-based cooking interventions which have experiential learning activities have the potential to increase food literacy knowledge, cooking skills and fruit and vegetable intake (Hasan et al., 2019; Charlton et al., 2021; Vaughan et al., 2024). Recent research has shown an association between food literacy and vegetable intake in adolescents (Mullertz et al., 2024). Experiential learning with sufficient hours of practical food preparation activities can increase vital skills such as chopping, weighing, mashing, measuring and cooking on the hob (Charlton et al., 2021; Dean et al., 2021b). It is through learning these practical food preparation techniques that primary school aged children can show improved cooking self-efficacy and also small but significant changes in food intake, especially vegetable intake (Vaughan et al., 2024). Previous research has found that child learners of cooking skills have better outcomes than teen learners or adult learners, suggesting that if these skills are learned at a younger age, then individuals are more likely to identify themselves as cooks (Lavelle et al., 2016).

Since children spend so much time in school each week, this is a useful place to acquire the skills and knowledge related to healthy diets and healthy lifestyles. The Nutrition-Friendly Schools Initiative was set up in 2006 outlining 26 essential criteria within five components, including nutrition and health promoting curricula although there are no essential criteria specifically related to developing food preparation skills in children (World Health Organization, 2020a). Policy analysis of the food curriculum in eleven countries undertaken by Smith et al. in 2022 describes approaches as either practical (Home Economics) or health oriented (Health and Physical Education). The authors developed a framework to evaluate 'Food Preparation Skills' in each country,

assessing the contribution to food literacy within the curriculum (Smith et al., 2022). Their analysis revealed that whilst countries often have a mandatory food curriculum (and would therefore meet the essential criteria for a 'Nutrition-Friendly School' as defined by the WHO), there is still 'no consensus in primary food education' about what this includes and more specifically, if it includes the teaching of food preparation skills such as chopping, grating and mashing (Smith et al., 2022). These are essential life skills that can be learned in stages through the early school years, to improve children's habits and diets, since using food preparation techniques to cook a meal from scratch usually involves eating more fresh fruit and vegetables (Mills et al., 2017; Wolfson et al., 2020; Dean et al., 2021b).

The importance of interventions designed to improve the food education curriculum in schools is a priority for public health. Good nutrition and maintaining a healthy weight in childhood helps to prevent obesity and diet-related ill health later in life (Umer et al., 2017; World Health Organization, 2020a; World Health Organization, 2022). However, data from the National Child Measurement Programme in the UK shows that the prevalence of children living with obesity more than doubles from 9% at the start of school to around 22% age 11 years (NHS Digital, 2023) and so better nutrition education is needed to improve food skills and food literacy in childhood.

This research is the first fully powered efficacy cRCT (cluster Randomized Controlled Trial) to evaluate the impact of a lifestyle intervention programme on food literacy, cooking skills and fruit and vegetable intake for primary-aged children aged 7-9 years in the UK. PhunkyFoods is an established multicomponent intervention which has been delivered in the UK for over 20 years and the design has evolved using the COM-B model of behaviour change (Michie et al., 2011). Research perspectives in this evaluation focus on effectiveness and theory-based approaches to increase knowledge and understanding of what works (Skivington et al., 2021).

Objectives

A cluster randomization approach was chosen for the practical reasons of recruiting schools and is more ecologically valid to conduct interventions with schools. The main aim of the cRCT was to assess the impact of the

PhunkyFoods healthy lifestyle intervention programme on food literacy, cooking skills and fruit and vegetable intake of children comparing against the usual practice in primary schools. For the fourth hypothesis, we originally included Index of Multiple Deprivation (IMD) is a potential mediator in the trial protocol. However, this was removed on reflection, since it was felt that percentage eligibility for free school meals (%FSM) was a better indicator for deprivation and both were not needed. The research hypotheses as outlined in the trial protocol are as follows (Vaughan et al., 2022):

1) The PhunkyFoods intervention group will show higher food literacy and cooking skills than the control group measured by mean scores.
2) The PhunkyFoods intervention group will show higher intake of fruit and vegetables than the control group measured by mean scores.
3) Schools in the intervention arm that choose more 'active ingredients' (intervention components) from the flexible menu of PhunkyFoods options will have better outcomes than those schools that choose less 'active ingredients.'
4) The school level measure of deprivation (%FSM) will have a mediating impact on the outcomes for schools in the intervention arm.

Methods

Trial design

The study was a parallel, cRCT, with two arms and with a 1:1 allocation ratio. The unit of cluster was the school. The intervention arm received the PhunkyFoods programme, with introductory training from May 2022, and the wait-list control arm received the PhunkyFoods programme after the final research data collection was completed, with introductory training from May 2023. This was a superiority trial, designed to test if the intervention was more effective than the control. The trial was registered prospectively with ISRCTN (ISRCTN68114155) in October 2021 and the study protocol was published in 2022 (Vaughan et al., 2022). The study was informed by a feasibility pilot study from 2019 (Sahota et al., 2019). The authors followed the CONSORT reporting guidelines for cluster randomised trials (Campbell et al., 2012).

Sampling and participants

School recruitment

Power calculations determined that 13 clusters (schools) were needed in each arm to detect a moderate effect size with 90% power, based on a previous study by Dean et al., 2021 (Dean et al., 2021a). This calculation assumed that a mean of 15 children would be included in each school, and therefore 195 would be needed in each arm. Only one class per school participated in the research. Due to the clustered nature of the 2-level model where individual children are clustered in schools, a conservative estimate of 20% variation at the school level was assumed.

Recruitment was from December 2021 to March 2022. Inclusion criteria for eligible primary schools in Harrogate or Selby in the North of England included having at least one class with 20 or more students aged between 7 – 9 years. Seventy-four eligible schools were invited to participate in the study using invite letters, adverts in North Yorkshire Council communications, Huntington Research school newsletters and social media. Follow up contacts were made to schools using telephone calls and emails to headteachers. Headteachers that expressed an interest were invited to attend a short 20-minute online school briefing to inform them about the PhunkyFoods programme and the requirements of the research project. Eligibility criteria were amended in February 2022 to allow three rural schools to participate with smaller numbers of children (n = 9, n = 11, n = 14) to improve recruitment numbers. The online school briefings were delivered by the lead researcher (KV) with support from a member of the PhunkyFoods team. Schools were offered one full year of fully funded PhunkyFoods intervention at their school if they participated in the research project. It was explained that some participating schools would receive the intervention in the first year (intervention group) and that some schools would receive the intervention in the second year (wait-list control group). A the PhunkyFoods programme has been well established in the UK and has been running for 20 years, this likely impacted on recruitment success.

Participant recruitment

Once the headteacher of the school had signed a school consent form, we requested a 15-minute telephone meeting to complete the enrolment to the project. This meeting was to identify the research class (participants) and main contact person for the school. After the research class was identified, a parent information letter was sent to the parents of the research class with an option to opt out of the study.

Intervention

The intervention contains a flexible menu of eight 'active ingredients' (programme optional components), which are detailed in the PhunkyFoods Logic Model in Figure 8. PhunkyFoods has a detailed Delivery Manual with implementation guidance and resources for Education and Development Coordinators (EDCs) to deliver each of the eight active ingredients in partnership with schools. The initial introduction and training for school staff about the PhunkyFoods intervention took place from April to July 2022. The delivery period of the intervention to children was from September 2022 and this was for 5 to 7 months until follow-up.

It was expected that all schools would demonstrate a willingness to engage in the programme by completing the first two 'active ingredients' of staff training in the summer term of 2022. The first involved whole setting staff training in the PhunkyFoods Programme with additional Continuous Professional Development (CPD) opportunities available for schools to opt into. Examples of CPD opportunities proposed included; the English Northern Council for Further Education (NCFE) National Level 2 Award in Nutrition and Health of School Aged Children (Purely Nutrition, 2024a); Food Preparation in the Classroom; and Setting Up and Running a Cook Club. Following the staff training was a health check on policy involving a whole setting audit and action planning support. This consisted of an initial meeting with a member of the Senior Leadership Team (SLT) to work through the Health Check document, then co-production of an action plan for development priorities agreed.

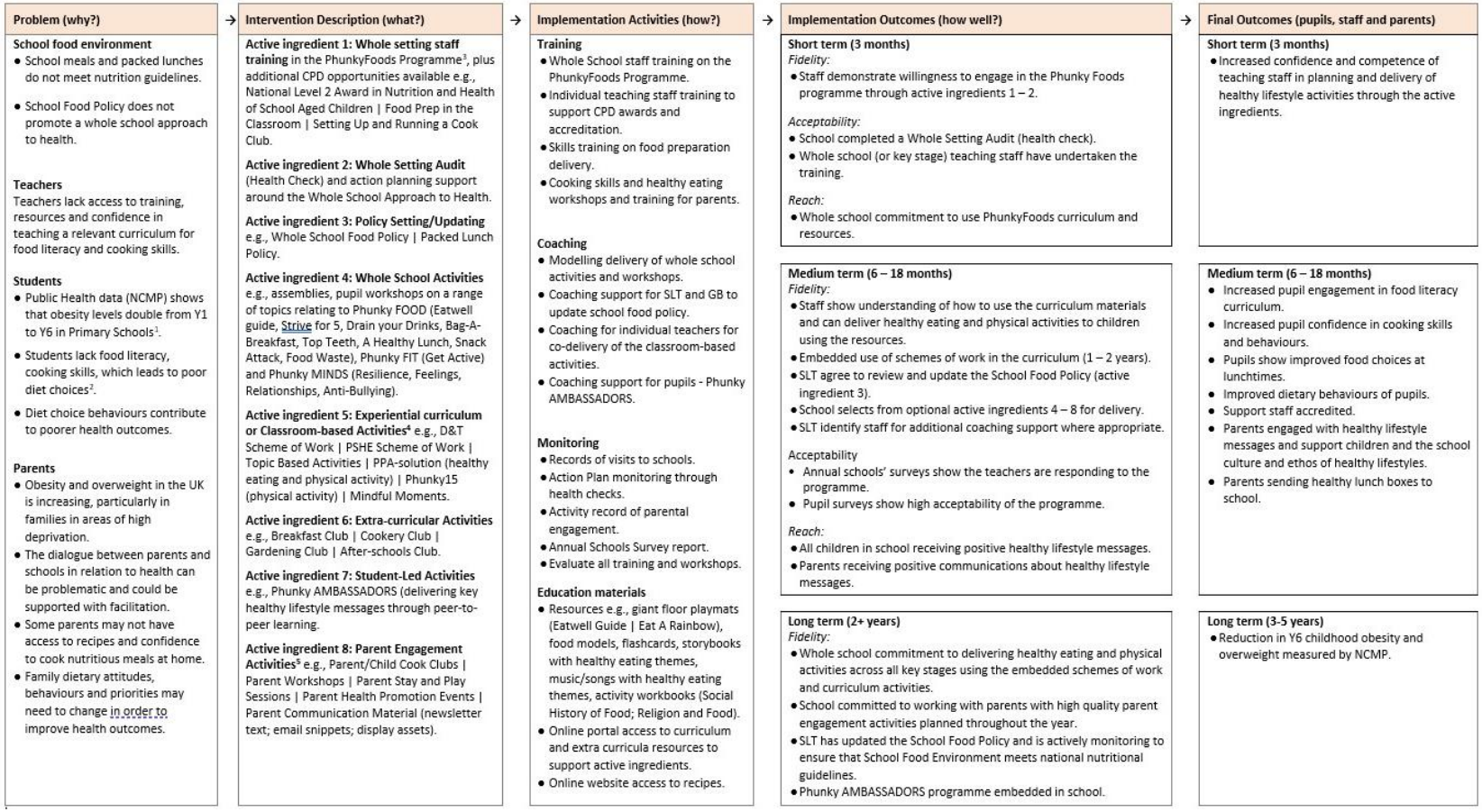


Figure 8 Logic Model for PhunkyFoods Intervention[1] NHS DIGITAL. 2020. *National Child Measurement Programme, England 2019/20 School Year* [Online]. Available: https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/2019-20-school-year [Accessed]. [2] DIMBLEBY, H. 2021. National Food Strategy: The Plan. UK. [3] SAHOTA, P., CHRISTIAN, M., DAY, R. & COCKS, K. 2019. The feasibility and acceptability of a primary school-based programme targeting diet and physical activity: the PhunkyFoods Programme. *Pilot Feasibility Stud,* 5, 152. [4] CHARLTON, K., COMERFORD, T., DEAVIN, N. & WALTON, K. 2020. Characteristics of successful primary school-based experiential nutrition programmes: a systematic literature review. *Public Health Nutr*, 1-21. [5]AXFORD, N., BERRY, V., LLOYD, J., MOORE, D., ROGERS, M., HURST, A., BLOCKLEY, K., DURKIN, AND MINTON, J. 2019. How Can Schools Support Parents' Engagement in their Children's Learning? Evidence from Research and Practice. London: Education Endowment Foundation

Activities with pupils started from September 2022. The Phunky Ambassadors programme involved mentoring pupils to deliver key healthy lifestyle messages through peer-to-peer learning. The PhunkyFoods intervention has a vast collection of resources available for schools to access, some of which are available to all on the website, and more curriculum planning resources for members using a school login (Purely Nutrition, 2024b). Whole school assemblies were delivered by the pupils on the Phunky Ambassadors programme in year 5, aged 9 – 10 years. Classroom activities were delivered to smaller groups of children and most often involved the Phunky Ambassadors. Schools were also invited to start up a cooking club, after-school cook club and parent engagement programme.

Outcome measurements

Primary outcome measures were Food Literacy and Cooking Skills. Food Literacy measured by the Tool for Food Literacy Assessment in Children (TFLAC-UK) at baseline and at 12 months. The original questionnaire was developed by Amin et al. in 2019 (Amin et al., 2019) and the UK version is available at Appendix C1. Food Literacy is scored from 0 to 40, with 40 being the highest score indicating better food literacy. Cooking Skills were measured by CooC11 at baseline and at 12 months (Dean et al., 2021a). Cooking skills is scored from 0 to 55, with 55 being the highest score indicating better cooking skills. The survey is available at Appendix C2.

Secondary outcome measures were fruit intake and vegetable intake measured using a shortened version of the Child Assessment of Diet Evaluation Tool (CADET) at baseline and at 12 months (Cade et al., 2006). The food diary is available at Appendix C3. This tool is intended to be used retrospectively as a tick list record for all foods consumed over a 24-hour period. In this case, we just selected fruits and vegetables from the larger tool which aimed to collect data on all foods consumed during a day. In total, the consumption of 13 fruits and 18 vegetables and pulses was asked in five mealtimes (breakfast at home, lunch at school, before tea, evening meal, after tea). The dietary information was analysed on the website ‘nutritools’ (Medical Research Council, 2024)

using the Food Questionnaire Creator pages. The portion sizes used in CADET vary by age (3 to 11 years) and gender and are based on National Diet and Health Survey mean weighted consumption data (Public Health England, 2014).

Dose, reach and fidelity of intervention

The PhunkyFoods programme is a flexible menu of component ingredients, where schools can choose how much they want to engage. Whilst the Logic Model shows how fidelity to the intervention components can lead to improved health outcomes, the practical approach to delivery is deliberately flexible to encourage signup from schools. This aspect of real-world research poses a methodological challenge, in that not all the clusters (schools) get the same treatment in the intervention. To address this aspect, information was collected from each of the intervention clusters on how much of the programme they engaged with by the Education and Development Coordinators (EDCs) employed by Purely Nutrition Ltd, who had delivered the programme. A single EDCs assigned an overall engagement score from 0 – 14 for the schools that they worked with, based on their experience and knowledge of which components the school engaged with. Scores for each component were 0 – 2, depending on how many activities were delivered and if they were led by the EDC or the school. This is shown in Table 12.

Randomisation

The allocation to trial arms was undertaken using a computer-generated randomisation sequence. Block randomisation was used to ensure equivalence between the intervention and control schools for geographical area (Selby or Harrogate), size of school (above or below the median school size) and above or below the median for % free school meals eligibility. The lead researcher (KV) enrolled participants and allocated unique ID numbers. After baseline data collection, one member of the research team (CE), who was blinded to the names of schools enrolled, generated the allocation sequence. The lead researcher then informed schools which trial arm they were in.

Data collection

Data collection events were standardised across all schools and completed at two time points. Data were collected at baseline and follow up (March 2022 and March 2023 respectively) during school hours. Only one visit per school was allocated and so children absent on the day of collection were not included. During the data collection visits children completed the Food Literacy Survey (40 minutes) and the Cooking Skills Survey (15 minutes). These were completed as a whole class activity, with a member of the research team reading out each question to the class. For the CADET food diaries, one member of the research team introduced the research tool to the class, checking their understanding of a diary by asking the pupils questions, and then reading out the instructions on how to complete it. Children were asked to take the tool home and to bring the completed CADET food diary back to school the next day. The research team then collected the returned CADET food diaries over the following three weeks, sometimes returning to schools more than once to collect as many food diaries as possible.

Statistical methods

The statistical analysis plan has been published previously as part of the trial protocol (Vaughan et al., 2022). In summary, the primary and secondary analysis for the evaluation of PhunkyFoods intervention focused on two research perspectives (effectiveness and theory-based) identified in the framework for developing and evaluating complex interventions Medical Research Council guidance update (Skivington et al., 2021). Our analysis was conducted on an 'intention-to-treat' basis, in that all pupils with a recorded outcome at baseline and at follow-up were included. We used SPSS software (IBM SPSS Statistics for Windows, Version 29.0.2.0 Armonk, NY: IBM Corp, released 2024) and allowed for the design effect of cluster trials in schools with pre-post design using multi-level regression models, using child-level covariates at level 1 and school-level covariates at level 2 (Van Breukelen, 2023). Regression models were adjusted for clustering, baseline and covariates (Sex, % eligibility for Free School Meals and School Engagement Score).

Results

A total of 34 schools expressed an interest in starting the trial and attended one of the online school briefings. Of these, six were excluded due to geographical eligibility and one was excluded as it had previously had some involvement with the PhunkyFoods programme. Sixteen 20-minute online Schools Briefings were delivered between December 2021 and March 2022. In all, 27 schools completed baseline data collection but one school dropped out of the trial immediately after randomization due to lack of school capacity.

Of the participating North Yorkshire schools, 13 of these were in Harrogate and 13 were in Selby. Baseline characteristics of the schools and pupils are shown in Table 10. The median value for percentage of free school meals in both groups was 10.7% compared to the national median of 24.6% (Cribb, 2023). Whilst the control and intervention groups looked similar in their characteristics, the exception to this was sex. A chi-square test showed a significantly higher proportion of females in the control group (58%) compared to the intervention group (42%), $\chi^2 = 5.45$, $p = 0.02$.

The number of participants recruited and who completed baseline data collection was 704 (Figure 9). However, since one school dropped out immediately after baseline data collection, the number who completed the trial was 307 children assigned to the intervention arm (in 13 schools) and 324 children in the control arm (in 13 schools). At 12-month follow-up, 552 pupils were present, of which 275 were in the intervention arm and 277 in the control arm. The Food Literacy and Cooking Skills surveys were completed in the classroom with the researchers.

The CADET diaries were completed by participants partially in the lesson at school and the completed at home and returned to school the next day. We excluded 9 extreme cases from the CADET diary analysis by using SPSS to compute the following criteria: if the vegetable frequency variable was greater than 16 and / or the fruit frequency variable score was greater than 18. An inspection of the excluded extreme cases showed incorrect understanding of the survey, for example the participant ticked all the fruit and vegetable boxes for every meal. The number of CADET diaries included in the analysis was 110 for the intervention group and 94 in the control group. See figure 9.

Table 10 School and child characteristics for the intervention and control groups at baseline

	Control	Intervention	Total
School characteristics			
Schools	13	13	26
Geographical location of schools			
Harrogate	7	6	13
Selby	6	7	13
Size of school (number of students)			
Median (IQR)	195 (105 to 257)	170 (121 to 201)	192 (105 to 212)
Size of research class (number of students)			
Median (IQR)	29 (25 to 32)	24 (22 to 30)	27 (22 to 30)
School level % free school meals			
Median (IQR)	10.7 (6.2 to 21.5)	10.7 (7 to 18.5)	10.7 (6.5 to 21.5)
Child characteristics			
Number of participating pupils	324	307	631
Median age in years (IQR)	8.4 (8 to 9.1)	8.4 (7.9 to 8.9)	8.4 (7.9 to 9)
Sex			
male	141	172	313
female	183	135	318

Intervention Delivery

Appendix C4 shows detailed information on the number of schools that participated in each of the ‘active ingredients’ of programme along with some examples of activities delivered.

Food Literacy and cooking skills

The between treatment group difference for Food Literacy Total Score was -1.13 (95% CI -2.87 to 0.62, p = 0.2), using a mixed multi-level ANCOVA model with adjustment for baseline. Control group scored 1.13 more than the intervention group but this was not statistically significant. Food literacy domain-specific Cronbach alpha values were cooking skills 0.53, cooking knowledge 0.40, nutrition knowledge 0.67, food systems knowledge 0.35 and self-efficacy regarding eating 0.73. These lower reliability values suggest that the TFLAC, originally validated in older children (9–11 years), may perform more consistently in that age group than in our younger trial cohort (7–9 years), as differences in cognitive development, broader domain coverage, and less stable response styles likely reduced internal consistency. Food Literacy scores were calculated out of a total of 40 and were significantly higher at follow-up than baseline in both the control and intervention groups. At baseline, scores across all the Food Literacy Domains (cooking skills, cooking knowledge, nutrition knowledge, food systems knowledge and self-efficacy around eating) were similar for control and intervention groups. See Table 10.

The between treatment group difference for Cooking Skills Total Score was -0.86 (95% CI = -5.17 to 3.45, p = 0.69) using a mixed multi-level ANCOVA model with adjustment for baseline. The control group scored 0.86 more than the intervention group controlling for baseline but this was not statistically significant. The internal consistency reliability for cooking skills was high with a Cronbach's alpha score of 0.85. Cooking Skills Total Score was out of a total of 55 and was also significantly higher at follow-up than baseline in both the control and intervention groups. At baseline, the most frequent of the 11 surveyed skills used in the control and intervention groups were mixing, weighing and chopping.

Fruit and vegetable intake

Fruit and vegetable portion scores over 24-hours from the CADET diaries showed no statistically significant differences between treatment groups. The difference between the treatment groups was -52.36g for Vegetable Intake Portion Score (95% CI = -122.75 to 18.03, p = 0.14), using a mixed multi-level ANCOVA model with adjustment for baseline. The control group scored 52g

higher than the intervention group but the difference was not statistically significant. The difference between the treatment groups was -79.21g for Fruit Intake Portion Score (95% CI = -250.34 to 91.92, p = 0.34), using a mixed multi-level ANCOVA model with adjustment for baseline. The control group scored 80g higher than the intervention group but this was not statistically significant.

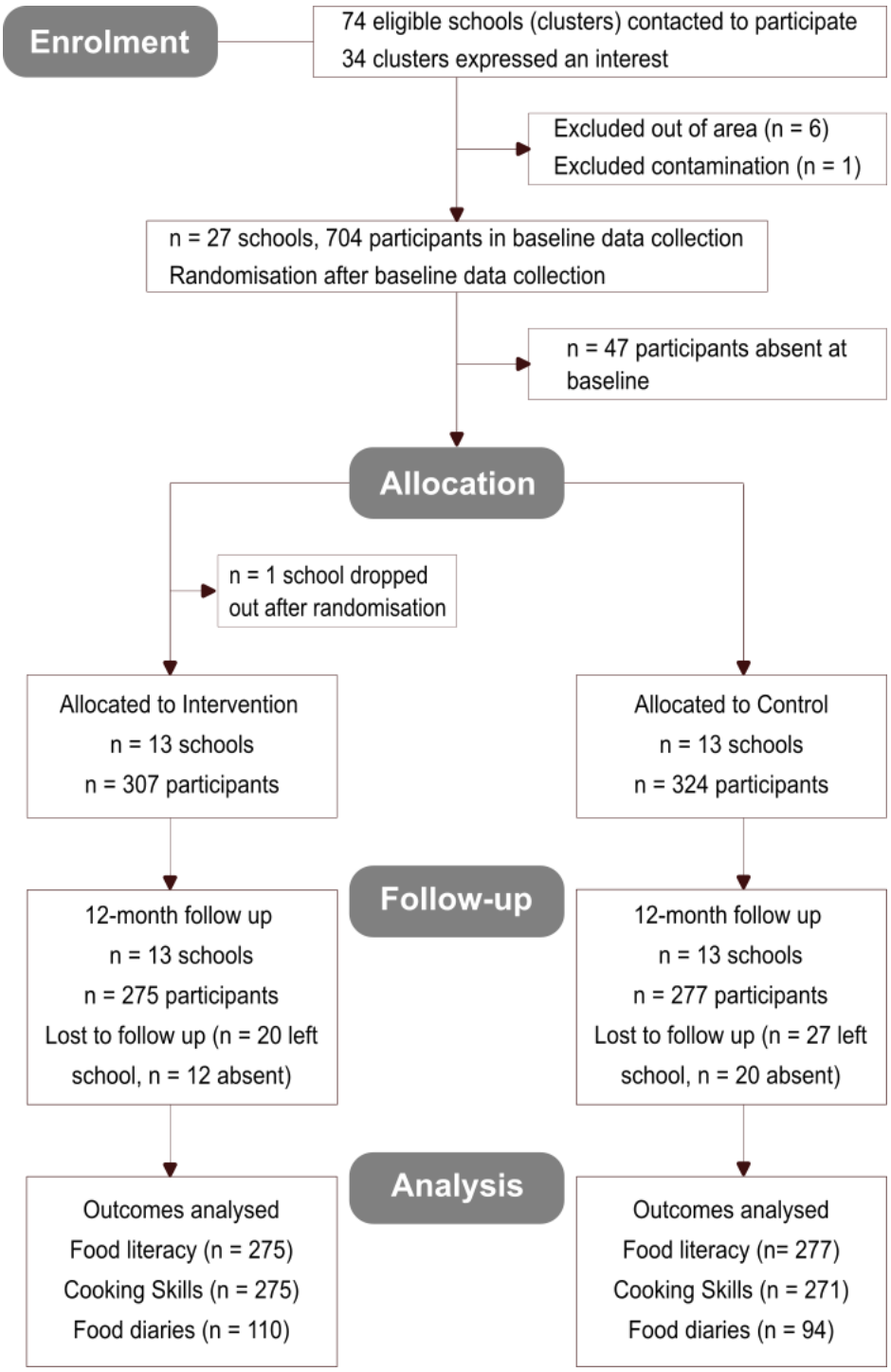


Figure 9 Consort Flow Diagram

Secondary analysis – mediating impact of covariates

The secondary analysis shows the mediating impact of school engagement level, a school level measure of deprivation (percent of pupils eligible for free school meals) and sex of participants.

Contrary to our hypothesis, the results showed no difference between schools who chose more 'active ingredients' from the flexible menu of options in the PhunkyFoods programme than those schools that chose less 'active ingredients.' In Table 12, the change in means from baseline to follow-up were colour coded to reflect if these were higher than the average change in means for the intervention group. School 10, with the highest engagement score of 13 out of a maximum of 14 showed a positive change of 3.0 for cooking skills and 2.8 for food literacy, which was higher than the intervention group average of 1.6 for cooking skills and 1.9 for food literacy. School 8 had an above average engagement score of 10 and had the greatest increase in cooking skills of 8.6 and an increase in food literacy of 3.9. However, school 18 had the lower score on engagement, with only 1 point for attending initial training and yet scored 4.9 higher in cooking skills from baseline to follow up. Interestingly, it was noted that one school had an average engagement score of 8, but both cooking skills and food literacy scores were lower at follow-up than at baseline. This school had 14 pupils who received the intervention, 13 of whom were boys.

To explore the mediating impact of % free school meals, the level of free school meals was grouped into high or low in relation to the median for the sample. The results showed that the intervention had a very small (-0.05) but statistically significant effect, with a greater impact on food literacy for schools with higher % of free school meals than the control group (95% CI = -.085 to -0.011, p = 0.013). See figure 10.

Due to sex differences between the intervention and control groups found in the baseline characteristics (Table 10), further exploratory analysis was conducted (this was additional to the pre-specified analysis). Using a multi-level regression model, the analysis showed a significant fixed effect of sex on food literacy scores, with girls scoring 1 point higher than boys (95% CI = 0.4 to 1.63, p = 0.001) across the total sample. See figure 10. There was a statistically significant, fixed effect of sex on cooking skills, with girls scoring 2.8 points higher than boys (95% CI = 0.88 to 4.82, p > 0.01).

Table 11 Differences in mean scores on Food Literacy, Cooking Skills, Vegetable Intake and Fruit Intake

Outcome	Intervention		Control		Between-group differences (1-0) minimally adjusted [d]				Between-group differences (1-0) fully adjusted [e]			
	Pre mean (SD) [a]	Post mean (SD) [a]	Pre mean (SD) [a]	Post mean (SD) [a]	EMM	95% CI	P-	ICC	EMM	95% CI	P-	ICC
Food Literacy Survey												
Cooking Skills	2.3 (0.6)	2.4 (0.6)	2.3 (0.6)	2.5 (0.5)	-0.03	-0.14 to 0.07	0.55	0.02	0.00 [f]	-0.19 to 0.19	0.98	0.00
Cooking Knowledge	4.7 (1.2)	5.1 (1.1)	4.8 (1.1)	5.2 (1)	-0.08	-0.31 to 0.14	0.46	0.04	-0.14	-0.64 to 0.36	0.58	0.04
Nutrition Knowledge	11 (2.5)	11.7 (2.4)	11.2 (2.5)	11.9 (2.3)	-0.08	-0.52 to 0.37	0.72	0.02	-0.62	-1.36 to 0.13	0.1	0.00
Food Systems	9.5 (2)	10.1 (2)	9.7 (2.3)	10.3 (1.9)	-0.13	-0.5 to 0.25	0.49	0.02	-0.51	-1.36 to 0.33	0.22	0.02
Self-efficacy	3.3 (1)	3.5 (0.8)	3.5 (0.8)	3.6 (0.7)	-0.06	-0.21 to 0.09	0.38	0.02	-0.01	-0.35 to 0.32	0.95	0.03
Food Literacy Total	30.9 (5.2)	32.8 (4.7)	31.5 (5.1)	33.5 (4.6)	-0.27	-1.12 to 0.59	0.53	0.04	-1.13	-2.87 to 0.62	0.2	0.03
Cooking Skills Survey												
Number of Skills	6.6 (3)	7 (2.9)	6.8 (3)	7.2 (2.9)	-0.12	-0.57 to 0.36	0.64	0.01	-0.22	-1.15 to 0.71	0.64	0.00
Cooking Skills Total	25.7 (14)	27.4 (13.7)	27.1 (14.7)	29 (14.3)	-0.89	-2.93 to 1.21	0.4	0.00	-0.86	-5.17 to 3.45	0.69	0.00
CADET Food Diaries												
Vegetable intake [c] (g)	187 (96)	175 (125)	213 (111)	195 (126)	-	-45.67 to 22.39	0.5	0.00	-	-122.75 to	0.14	0.00
Fruit intake [c] (g)	313 (217)	373 (273)	342 (257)	410 (312)	-	-106.88 to	0.54	0.00	-	-250.34 to	0.34	0.01

ICC, Intraclass Correlation Coefficient; *EMM,* Estimated marginal means

[a] Raw mean score (standard deviation)

[b] Primary outcome

[c] Secondary outcome

[d] EMM minimally adjusted for clustering and baseline

[e] EMM fully adjusted for clustering, baseline and covariates (Sex, % eligibility for Free School Meals, School Engagement Score)

[f] Value is less than 0.005

Table 12 Effects of school engagement on primary outcome scores for intervention schools

School	Staff training	Action plan	Policy updating	Whole school activities	Classroom activities	After School Cooking club	Student Led Ambassadors	Parent engagement	Engagement Score (out of 14)	Cooking Skills Total Score (out of 55) School Means 2022	Cooking Skills Total Score (out of 55) School Means 2023	Cooking Skills Total Score (out of 55) Change	Food Literacy Total Score (out of 40) School Means 2022	Food Literacy Total Score (out of 40) School Means 2023	Food Literacy Total Score (out of 40) Change
18	1								**1**	22.3	27.2	4.9	30.7	31.6	0.9
11				1	2		1		**4**	27.8	28.4	0.6	29.3	32.0	2.7
7	1	1		2	2		1		**7**	34.8	31.4	-3.4	33.9	36.1	2.2
22	1	1		1	1	1	1	1	**7**	25.6	28.6	3.1	32.8	31.6	-1.2
2	1	1		2	2		2		**8**	23.3	25.3	2.0	29.9	33.1	3.2
12	1	1		1	2	1	1	1	**8**	19.8	23.1	3.2	29.1	31.9	2.8
27	1	1		1	1	1	2	1	**8**	30.0	28.5	-1.5	34.0	32.3	-1.7
5	1	1		2	2	1	1	1	**10**	25.8	28.3	2.5	32.1	32.1	0.0
8	1	1	1	2	1		2	2	**10**	21.7	30.4	8.6	27.2	31.1	3.9
10	1	1	2	1	1	1	2	1	**10**	24.6	22.1	-2.5	29.5	32.3	2.8
20	1	1	2	2	1	1	1	2	**11**	23.8	25.0	1.3	28.2	32.6	4.5
24	1	1	1	2	2	2	1	2	**12**	29.0	28.7	-0.3	33.2	33.6	0.5
15	1	1	2	1	2	2	2	2	**13**	25.5	28.5	3.0	32.5	35.3	2.8
total intervention group means and change										25.8	27.5	**1.6**	30.9	32.7	**1.9**

School Engagement Score

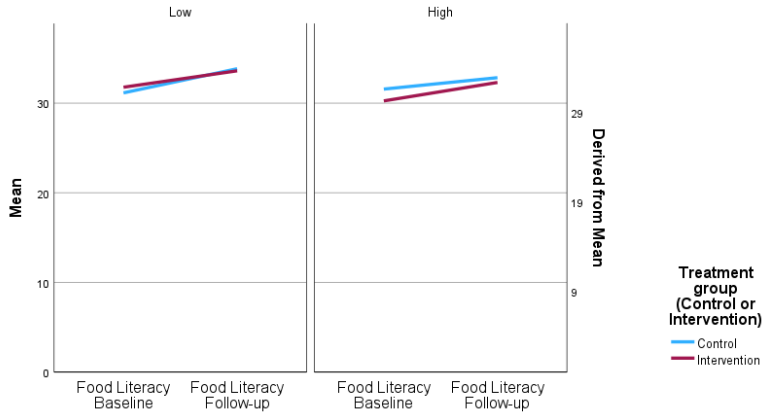
- 1 EDCs* led activity only
- 2 EDC and school led activity

School change compared to the mean change for the intervention group

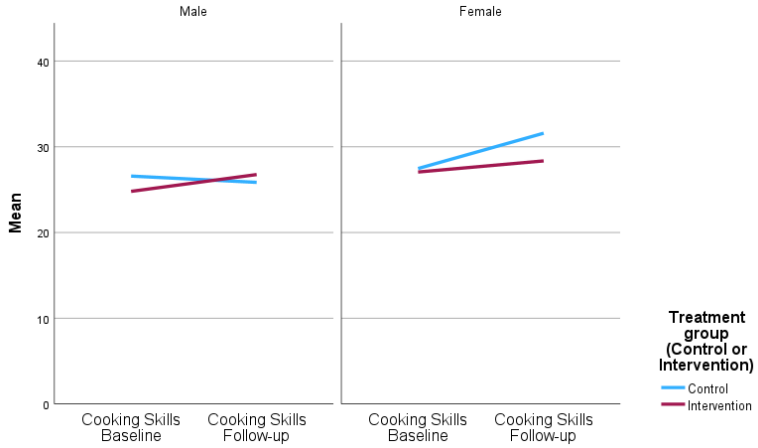
- > 400% lower
- 200 < 400% lower
- 0 < 200% lower
- 0 < 200% higher
- 200 < 400% higher
- > 400% higher

*EDC Education Development Coordinator

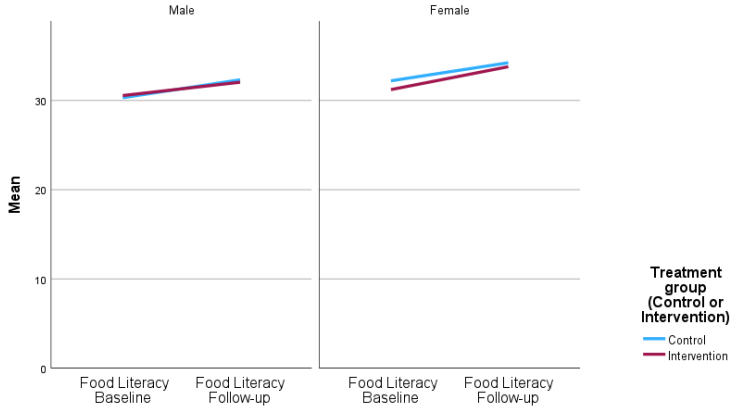
a) Interaction effects of % free school meal entitlement levels on Food Literacy Total Score



b) Interaction effects of sex on Cooking Skills Total Score



c) Interaction effects of sex on Food Literacy Total Score



d) Sex differences in Cooking Skills Total Score

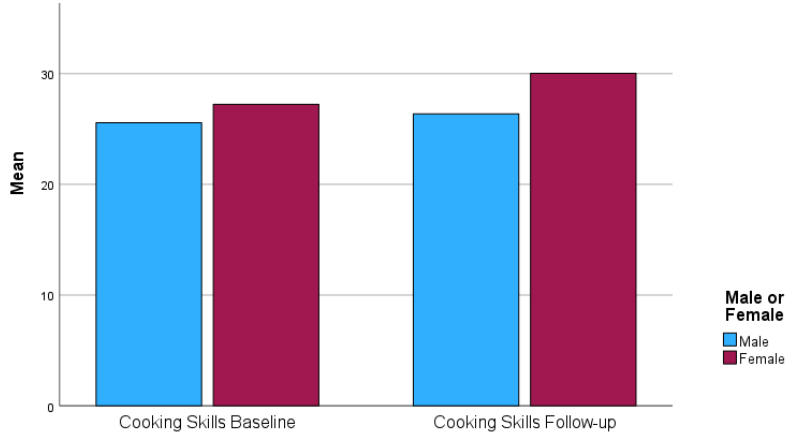


Figure 10 Secondary analysis: a) interaction effects of % free school meal entitlement levels on Food Literacy, b) interaction effects of sex on Cooking Skills c) interaction effects of sex on Food Literacy d) sex differences in Cooking Skills

Discussion

Overall, the results showed no substantial impact of the PhunkyFoods intervention on food literacy, cooking skills, fruit intake or vegetable intake. When examining individual school engagement, those schools with higher engagement in the intervention did not have greater improvements in food literacy or cooking skills than schools with lower engagement. Schools with a higher level of % free school meals showed a slightly higher but significant change in food literacy scores from baseline to follow-up in the intervention group compared with the control group.

Previous studies of cooking interventions have shown a positive impact on food literacy outcomes (Vaughan et al., 2024). In North Carolina, USA, Hovland et al., measured food literacy using food-based science knowledge questions (with a total score out of 13) and showed a raw mean difference of 1.21 favouring the intervention (no 95% CI reported) (Hovland et al., 2013). In Alabama, USA, Parmer et al. measured food literacy using a nutrition knowledge survey with 16 items (including food groups, nutrient knowledge, fruit and vegetable identification) and results showed a 1.37 raw mean difference (no 95% CI reported) favouring the intervention (Parmer et al., 2009). However, it is important to note the difference in length and dose of the food preparation and cooking 'treatment' of these interventions compared to the current study. The Hovland study included 24 x 45-minute food science lessons and the Parmer study was a 14-hour programme. In comparison, many of the PhunkyFoods intervention schools had just 4 hours of food preparation or cooking activities over 7-months. It is suggested that more intensive cooking interventions may be more effective.

Impact of lifestyle intervention programmes on cooking self-efficacy is often very small, even with longer intervention periods. A meta-analysis of six studies involving cooking lessons in primary schools showed a standardized mean difference of 0.39 (95% CI = 0.05,0.74) for cooking self-efficacy in children aged 4 – 12 years (Vaughan et al., 2024). The Project CHEF study in Vancouver, Canada showed a standardized mean difference of 1.6 (95% CI = 1.12 to 2.08) favouring the intervention and included 15 hours of cooking (Zahr and Sibeko, 2017). This study, evaluated by Zahr et al., showed the largest impact on cooking self-efficacy and it is relevant to note that the participating

students had four or five sessions (two and a half hours long) where children learned knife skills and made 11 recipes from scratch.

The limited effectiveness of previous cooking interventions on cooking self-efficacy, food literacy and vegetable intake suggest it is important to investigate what types of school-based approaches and improvements can be made (Hersch et al., 2014; Charlton et al., 2021; Vaughan et al., 2024). The design of the PhunkyFoods programme is intentionally flexible, in the hope that this will encourage schools to sign up and participate at a pace appropriate for the individual school context. The varying levels of engagement in the programme can be seen in Table 12, ranging from a score of 1 to a score of 13, out of a total 14. Feedback from schools who have participated in PhunkyFoods is extremely positive, indicating that this flexible approach meets their variable and changing capacity needs well (Nutrition, 2019). Nutrition education programmes whose mission is to work collaboratively with schools, arguably need to be flexible to foster long-term effective partnerships on policy and curriculum reform. From this perspective, complex interventions are not only understood from the number of different components, but also from the varying relationship dynamics and school contexts in each setting and how flexibility helps to develop trust and longer-term commitment for change.

There is a further flexibility within each component of the programme, which may further influence impact. One example is the after-school cook club component, which although was designed to be at least six weeks in duration, in reality lasted four weeks, due to difficulties in negotiating a commitment to the full six weeks. The cooking clubs usually only had between 6 – 12 pupils participating, and often this meant that only 50%, or less, of the research class were involved. In addition, some schools opted to have different families attending the after-school cook club each week, which extends the reach but dilutes the treatment effect for each participant even further. It is recommended that at last 6 hours of cooking is needed and for whole class groups rather than small after school clubs for some children.

The tension between model fidelity and flexibility in real-world complex interventions may account for why the trial results did not show an association between school engagement and outcomes. Implementation science theory concepts highlight these challenges, in particular the interplay of drivers such as

capability, opportunity and motivations of schools to engage and the reach, effectiveness and adoption of programme elements (Michie et al., 2011; West, 2019; JaKa et al., 2021).

Since there were more girls in the control group than the intervention group, and girls are known to have higher cooking skills than boys, the analysis of the data also explored the impact of sex differences. A recent study by Labbe (2023) involving primary school children showed that girls scored better in cooking skills, food knowledge and food skills in both the control and the intervention groups (Labbe et al., 2023). An evaluation of the 'Cooking With Kids' programme by Cunningham-Sabo et al. (2014) found that males made twice the gains in cooking self-efficacy compared with females (Cunningham-Sabo and Lohse, 2014). However, the analysis in the current study did not find an interaction effect between sex and treatment. Further analysis of the sex differences with the age variable confirmed that this effect was not due to the girls being older than boys.

It is likely that the number of food preparation and cooking hours for each research participant was insufficient to make an impact on cooking self-efficacy and fruit and vegetable intake. A recent systematic reviewed showed that 6 or more hours of cooking are needed to make a difference on cooking skills and vegetable intake (Vaughan et al., 2024). Of the seven schools that participated in the cooking club, it has already been noticed that one school had different children attending each week, and so the treatment dose was in total just 1 hour of cooking. Studies involving only 1 – 2 hours of cooking lessons have previously shown no impact on outcomes for the intervention group compared to the control group (Maiz et al., 2021; Yoshii et al., 2021).

We noted that the mean scores for vegetable and fruit intake, using the CADET shortened survey were much higher than other studies and exceeded the recommended combine 400g of fruit and vegetable guidelines by the World Health Organization (World Health Organization, 2020b) and contrast sharply with findings from the WHO COSI survey, which found that only 45% of children eat fruit daily and only 25% eat vegetables (World Health Organization, 2021). In comparison, a study using the whole CADET tool, Project Tomato in the UK showed baseline scores of 110g for vegetables and 195 g for fruit (Evans et al., 2013).

Strengths and limitations

The main strength of this study was the robust cluster randomised controlled trial design, which was informed by a previous feasibility trial to improve the timeline for data collection of baseline measures before randomisation and the sample size was properly powered to detect an effect. The study was supported by a steering group with members of North Yorkshire County Council and the Huntington Research school, who actively engaged with practical support around communication with schools and recruitment (Research Schools Network; Healthy Schools, 2024). This enabled us to recruit a sample of 26 schools that completed the trial and increased the power of the statistical analysis.

The main limitation of the study is the representativeness of the sample to the whole of the English population. The median eligibility for free school meals for the current study is 10.7% but the median for primary schools in England is 24.6%. Due to the flexible design of the intervention, model fidelity was very poor and we know that the delivery of the treatment will have varied considerably. Although we collected some information on school engagement, this was not extensive and was based on the assessment by EDCs on their perception of how much schools engaged, which is subjective and relies on memory. A more realistic measure of school engagement could have been to check the number of times that each intervention school accessed the school resources on the PhunkyFoods website, but this was not possible with resources available.

It is possible that the shortened format of the CADET food diary to assess fruit and vegetable intake may have inadvertently led to over-reporting. The CADET was validated for children aged 8 to 11 years against a weighed food method, maintaining its reliability and validity for nutrient analysis in children's diets (Christian et al., 2015). However, Christian et al., 2015 discussed that CADET diaries tend to record higher fruit and vegetable intakes compared to weighed records, likely due to participants overestimating portion sizes (Christian et al., 2015). Additionally, the National Diet and Health Survey age-related portion size data used for analysing CADET, despite being comprehensive, sometimes relies on relatively small sample sizes for specific foods, potentially leading to overestimations.

Social desirability bias is another likely factor influencing the high intake reports. The presence of researchers in classrooms to introduce and explain the diaries might have prompted children to report higher consumption of fruits and vegetables, aligning with perceived expectations. This bias is well-documented in dietary assessments where participants, particularly children, may alter their responses to conform to social norms or perceived preferences of the researchers (Baranowski et al., 2006).

A final limitation concerns the short duration and low dose of the intervention in this trial. The PhunkyFoods programme is designed to build relationships with schools for curriculum change with increased dose of the intervention components over time. It is possible that the intended outcomes of increased food literacy and cooking skills of children (as shown in the Logic Model) could have been achieved with a longer duration of 18 months or 2 years for the current trial.

Conclusions

Robust research evidence is important to understand how to improve cooking skills, food literacy and dietary intake in children, which can help to improve the design and impact of healthy lifestyle interventions in schools. This research strengthens the evidence on the effectiveness of cooking interventions in schools by adding to knowledge about what works and in what circumstances. The PhunkyFoods intervention is a flexible whole school approach to developing a health promoting school, and the dose of food preparation and cooking skills within the programme may not be sufficient to show an impact on the outcomes. It is possible that some of the PhunkyFoods components that are easier to deliver and more popular with schools are less effective on food literacy and cooking skills outcomes than the more practical food preparation components. It is recommended that the programme could consider how to increase the number of experiential food preparation and cooking hours and the number of children participating in these activities to help increase the likelihood of producing significant benefits to children sooner. Further research is needed to explore sex differences in cooking skills and food literacy, and if there is an association between cooking skills, food literacy and obesity in this age group in the UK and other countries.

Abbreviations

ANCOVA: Analysis of Covariance; CADET: Child Assessment Diet Evaluation Tool; COSI: Child Obesity Surveillance Initiative; CPD: Continuous Professional Development; D&T: Design and Technology curriculum; EDCs: Education and Development Coordinators; EEF: Education Endowment Foundation; FSM: Free School Meals; GB: Governing Board in schools; IMD: Index of Multiple Deprivation; LSOA: Lower Super Output Area (a geographic hierarchy designed to improve the reporting of small area statistics in England and Wales); NCMP: National Child Measurement Programme; PPA: Planning Preparation and Assessment time; SLT: Senior Leadership Team; TFLAC: Tool for Food Literacy Assessment in Children; WHO: World Health Organization.

Availability of data and materials

There is no intention to share the data with anyone outside the University at this stage although any requests will be considered by the Research Team.

Consent for publication

Schools provided informed consent for the children's data to be used for the purpose of this research study which includes the publication of findings. No identifying images or other personal or clinical details of participants are presented the trial results. Informed consent materials are attached as supplementary materials.

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Chapter 5 A cross-sectional study of food preparation skills and obesity risk in European children aged 6 – 9 years from eight countries – World Health Organization European Childhood Obesity Surveillance Initiative (COSI) 2022-2024.

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Abstract

Background: Preparing meals from raw ingredients has been linked to healthier diets, while developing cooking skills in childhood may foster lifelong healthy eating habits. In its 6th round (2021–2023), the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) added questions regarding food preparation skills.

Methods: Data from 19,736 participants across eight countries were analysed. Multilevel linear regression models examined the relationship between food preparation skills practiced at home and school and daily vegetable intake, accounting for individuals nested within schools. Logistic regression was used to assess associations between experience of these skills and obesity risk.

Minimally adjusted models included random intercepts for schools, while fully adjusted models also controlled for child sex and mother's education level.

Results: Increased experience of food preparation skills at home was associated with a small increase in daily fruit and vegetable intake; each one-point increment on the skills scale corresponded to a 0.09-point rise on a 5-point ordinal measure. Overall, food preparation experience at home was associated with a marginally higher odds of having obesity (OR = 1.02, 95% CI: 1.01, 1.03). Notably, experience of peeling skills was associated with lower odds of having obesity (OR = 0.84, 95% CI: 0.82, 0.86). Additionally, significant sex differences were observed: girls were more likely than boys to engage in tasks such as washing, mashing, peeling, and chopping, whereas boys more frequently reported involvement in weighing and measuring.

Conclusion: Experience of food preparation skills, especially those practiced at home, is modestly associated with increased dietary intake of fruit and vegetables. Although most food preparation skills were associated with a slight increase in obesity risk, exposure to peeling was linked to a 15% lower risk. The observed sex differences in food preparation skills underline the need for targeted educational strategies. Further research is needed to examine the association between children's participation in family food preparation and their body weight.

Study registration: Open Science Framework https://osf.io/nfd6m/ prospective registration on 12th December 2024.

Key Words: food preparation skills, childhood obesity, nutrition education, fruit and vegetable intake, public health nutrition.

Background

Based on evidence, it is understood that cooking meals from scratch using raw ingredients is linked to a healthy diet and that children can learn food preparation skills during childhood to provide healthy meals and build healthy eating habits (Hasan et al., 2019; World Health Organization, 2020; Dean et al., 2021). The World Health Organisation (WHO) Childhood Obesity Surveillance Initiative (COSI) has consistently shown sex and age differences for children's obesity prevalence and that there are large differences across countries in the European region (World Health Organization, 2022; World Health Organization, 2024b). In high-income countries, childhood obesity is often associated with lower socio-economic status and in low and middle-income countries higher socio-economic status is associated with increased obesity prevalence (Buoncristiano et al., 2021). Little is known about the factors that may help to explain some of these differences, though variability in education, food quality consumed and income may contribute to these inequalities (Buoncristiano et al., 2021; World Health Organization, 2021b).

There are no known studies that have investigated any association between food preparation skills and obesity prevalence in children aged 6 - 9 years. Mejean et al. (2018) found that women in France who prepared meals from scratch had 1.32 (95% CI = 1.08, 2.32) times the odds of not having obesity over a 5-year period compared to those who did not prepare meals from scratch. Pelonha et al. (2023) found that both sharing meal preparation responsibility and high self-efficacy in using fruits, vegetables and seasoning lower the odds of having overweight or obesity in undergraduate students in Brazil (da Costa Pelonha et al., 2023). Sharing meal preparation responsibility lower the odds of having overweight or obesity by 56% compared to preparing meals alone (adjusted odds ratio (AOR) = 0.44; 95% CI = 0.26, 0.74) and high self-efficacy in preparing fruits and vegetables lowered the odds by 68% (AOR = 0.32; 95% CI = 0.11, 0.95). Arslan et al. (2022) found that healthier eating behaviours were associated with higher food and cooking skills in adults with overweight or obesity (Arslan et al., 2023). For our study, we wanted to explore younger children who are helping with the preparation of family meals at home

in relation to fruit and vegetable intakes and association with risk of having obesity.

The WHO Regional Office for Europe established the COSI for routine monitoring of the policy response to the emerging obesity epidemic, to measure trends in overweight and obesity in children aged 6.0–9.9 years and to allow intercountry comparisons (World Health Organization. Regional Office for Europe, 2016). In 2021, additional questions about children's food preparation skills practised at school and at home were added to the COSI 6th Round of questions in the survey (World Health Organization, 2021a). The aim of the present study is to explore whether having stronger food preparation skills (practised in school through nutrition education and at home in the preparing of family meals) is associated with higher fruit and vegetable intake and lower risk of having obesity in children aged 6 - 9 years.

Objectives

The research objectives for the study were to answer the following questions:

1) Are higher levels of food preparation skills practiced at school associated with a lower risk of having obesity in children aged 6-9 years?
2) Are higher levels of food preparation skills practiced at home associated with a lower risk of having obesity in children aged 6-9 years?
3) Are higher levels of food preparation skills practiced at school associated with higher intake of fruit and vegetables in children aged 6-9 years?
4) Are higher levels of food preparation skills practiced at home associated with higher intake of fruit and vegetables in children aged 6-9 years?
5) Do attributes of the child, family and country moderate any associations?
6) Do girls have higher levels of food preparation skills practiced at home than boys?

The above research questions are based on the pre-registered study design at Open Science Framework on 12th December 2024 (Vaughan, 2024).

Methods

The analysis used data collected during the COSI round 6 survey and reporting of the results followed the guidance from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (von Elm et al., 2008).

The COSI survey data for round 6 was collected between 2022 and 2024, involving 37 countries from the WHO European region. The scope of the COSI survey is to include measurements from child participants aged 6 – 9 years. The WHO COSI protocol specifies that the effective sample size should be at least 2,800 children per target age group and that the total number of children approached should exceed these minimum thresholds (World Health Organization. Regional Office for Europe, 2016). Sampling design used in the COSI round 6 varied by country. The WHO Regional Office COSI team estimated sampling weights, using a standardized approach that accounted for the sampling design used in each country.

There are two mandatory components: the Child Record Form and the School Record Form. There is one optional component: the Family Record Form. Child participants were recruited according to the published methodology and implementation processes for COSI (Breda et al., 2021). Countries chose whether to undertake data collection online, paper or both. For paper versions, parents were provided with a sealed envelope to return it to school to minimise potential reporting bias. The full list of questions in the survey are available in the Data Collection Procedures for Round 6 (World Health Organization, 2021a).

In preparation for the round 6 data collection, additional new questions for countries about food preparation skills were added to the School Record Form (shown at Appendix 1) and the Family Record Form (shown at Appendix 2). The new food preparation skills were optional for countries to implement in their country surveys. Eighteen countries chose to add in the new food preparation skills questions to the School Record Form and the Family Record Form for round 6. The countries that included the additional optional questions about food preparation skills were subsequently invited to participate in the current study, with recruitment from September 2024 to December 2024. Nine

countries expressed an interest to participate but one did not meet the eligibility criteria as none of the optional data collected about food preparation skills was collected. The eight participating countries in the study were: Bulgaria, Denmark, Germany, Hungary, Kazakhstan, Lithuania, Republic of Moldova and Republic of North Macedonia. In two of these, only smaller geographical data collections were conducted: in Germany only the federal state of Bremen participated and in Kazakhstan data was collected only in the city of Almaty. Of the eight countries, four did not meet the minimum effective sample size specified in the WHO COSI protocol, two countries nearly achieved it, and two countries exceeded it.

Child Record Form

The child measurements were undertaken by trained examiners and followed the COSI protocol procedures (World Health Organization, 2021a). Before weighing, children removed shoes, socks and heavy clothing (coat, jacket) wallets, mobile phones, key chains, belts and other objects. Weight was measured in kilograms and recorded to the nearest 100g unit. Height was measured in centimetres and readings taken to the last completed 1mm. The BMI-for-age z-score was calculated to indicate how a child's Body Mass Index (BMI) compares to that of a reference population matched by age and sex (World Health Organization, 2025). From the child BMI-for-age z-score, we computed an additional binary variable having obesity or not using the WHO definition of greater than two standard deviations.

School Record Form

The school record form was completed by the school principal (headmaster or headmistress), or the teachers of the sampled classes. Information was documented on the location of the school, the number of children registered and measured per sampled class, those who refused to be measured and those who were absent on the measuring day. Nutrition Education information was collected as a categorical variable. Schools were asked: 'tell us what type of nutrition education your school provides' and had four options: 'healthy eating information', 'tasting of fresh fruit and vegetables', 'learning food preparation skills (e.g. weighing, grating, mashing, washing, chopping, peeling, measuring)'. We used three of these categories for descriptive statistics and selected the

option ‘learning food preparation skills’ as a binary predictor variable for inferential statistics.

Family Record Form

For fruit and vegetables daily intake, parents were asked: ‘Over a typical week, how many portions of fresh fruits and/or vegetables does your child eat on a typical day?’ and had 5 options to select (none, less than one portion per day, 1 to 2 portions per day, 3 to 4 portions a day, 5 or more portions per day). Parents were asked: ‘tell us about the food preparation activities that your child helps with at home’ and had seven items to select (weighing, grating, mashing, washing, chopping, peeling and measuring). Responses were binary; yes or no for each skill. See Appendices D3 and D5. Parents were asked: ‘what is the highest level of education that you or your spouse or partner has completed?’ and had 5 options from Primary education or less to Master’s or Doctoral level using combinations of levels on the International Standard Classification of Education (ISCED) framework (UNESCO Institute of Statistics, 2025).

Data analysis

To build the model, variables were selected from the COSI survey data that are related to the experience of interest (food preparation skills practised at home) and the outcome of child BMI for age z-score. This is based on previous work on the moderators, confounders and competing experience for mapping childhood obesity using the software package, Dagitty (Textor et al., 2016) . The authors created a causal inference map (supplementary material) to highlight the variables used from the COSI survey data to include in the statistical analysis plan (McGlashan et al., 2016; Textor et al., 2016; Jelenkovic et al., 2017; Zhu et al., 2023). These were included in the pre-registered study in Open Science Framework (Vaughan, 2024) . A list of the variables is available at Appendix 3.

There were substantial amounts of missing data for several variables that we initially intended to include as confounders in the model: Centred Group Mean of play at weekends (14.2% missing), Group Mean Earnings (46.0% missing), and M6 Minutes per week of physical education lessons (11.6% missing). Given the extent of missingness, particularly for earnings, these variables were not included in the final adjusted models. Full details of the

missingness patterns are provided in Appendix D6. Of all the potential variables in the COSI dataset that could be used to control for confounding, mother's education was the most complete. Independent predictor variables included nutrition education in schools (information, tasting fruit and vegetables, food preparation skills) and food skills practised at home (weighing, grating, mashing, washing, chopping, peeling, measuring). A Total Score Food Skills at Home (scored 0 – 7) was computed as a predictor for the outcome variable portions of fruit and vegetable portions per day. This variable was then group mean centred to remove between-group differences and allowed a focus on individual differences (Sommet, 2021; Heck, 2022). Confounding variables used were child's sex and mother's education level. We computed a group mean centred predictor variable in SPSS for mother's education as a confounding factor for use in multilevel modelling. The dependent variables were fruit and vegetable portions eaten per day and having obesity or not.

Statistical methods

Initial characterisation and data quality checks were performed for the variables to be included in the analysis (Ruddle, 2024). A primary model for multilevel linear regression was used to assess the overall impact of food preparation skills and nutrition education on fruit and vegetable intake, accounting for the hierarchical structure of the data (individuals at level 1 nested within schools at level 2) (Heck, 2012; Heck, 2022). To explore whether specific food skills were differently associated with the outcome, we ran secondary models for each food preparation skill, since simultaneous inclusion of all skill domains risks multicollinearity, potentially obscuring associations. We considered Bonferroni adjustment for multiple comparisons but, given the correlation among skill domains, applied a false discovery rate approach as a more statistically appropriate and widely accepted method for controlling multiple comparisons (Rothman, 1990; Benjamini and Hochberg, 1995).

Whilst the ordinal variable for daily fruit and vegetable intake does not have equal intervals, in practice 5-point ordinal variables are often treated as interval with even spaced response options (Pessoa et al., 2015) and a linear approach is often recommended when there are 5 or more categories for an ordinal variable (Carifio and Perla, 2008; Norman, 2010; Rhemtulla et al., 2012; Sullivan and Artino, 2013; Heck, 2022). We did not use an additional country

level 3, as there were a small number countries (Bryan and Jenkins, 2015; Heck, 2022), especially as it is not recommended to run multilevel models with three levels in SPSS with large datasets (Heck, 2022).

Multilevel binary logistic regression was used to evaluate the likelihood of having obesity based on food preparation skills at home and nutrition education (which includes food skills) at school exposure. Primary analysis used a total score for food skills at home, group-mean centred, whilst secondary analysis explored whether particular food skills had different associations with the outcomes. Minimally adjusted models include random intercepts for schools, while fully adjusted models also controlled for mother's education level and sex. All pooled data analysis across countries included a weighting factor to account for the difference between country sample sizes.

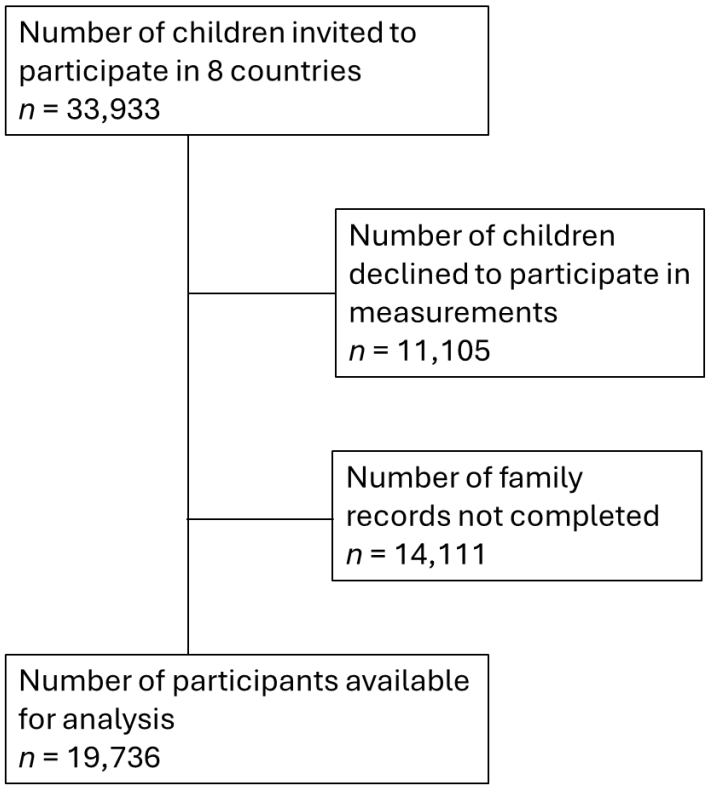


Figure 11 Study participant flow chart aligned with STROBE

Results

In total, 19,736 child participants from eight countries were included in the study. A summary of child descriptive statistics for the final included sample, food skills experience at home and obesity prevalence by country is shown at Table 13.

Table 13 Summary of child descriptive statistics for sample size, food skills experience and obesity prevalence by country

	Bulgaria	Denmark	Germany (Bremen)	Hungary	Kazakhstan (Almaty)	Lithuania	Republic of Moldova	North Macadonia	Total
Child's sex									
Boys	1566	248	574	2,270	836	1,601	1,475	1,300	9,870
Girls	1541	242	594	2,207	864	1,718	1,419	1,281	9,866
Total	3,107	490	1,168	4,477	1,700	3,319	2,894	2,581	19,736
Child's age									
Age 6	0	189	0	1,221	1	37	155	333	1,936
Age 7	3,107	275	190	2,110	295	2,394	2,434	2,200	13,005
Age 8	0	4	602	1,068	875	884	304	41	3,778
Age 9	0	0	364	67	488	0	1	5	925
Food skills at home									
Weighing	18%	63%	57%	39%	14%	29%	11%	24%	29%
Grating	29%	58%	38%	15%	26%	42%	31%	23%	28%
Mashing	56%	47%	31%	51%	23%	29%	27%	58%	42%
Washing	83%	74%	70%	33%	73%	73%	76%	52%	61%
Chopping	42%	81%	79%	47%	46%	72%	59%	28%	53%
Peeling	45%	80%	67%	47%	60%	46%	54%	32%	49%
measuring	19%	66%	54%	90%	16%	26%	15%	31%	43%
Obesity prevalence									
Boys	17%	5%	15%	14%	9%	10%	8%	17%	12%
Girls	14%	4%	7%	11%	4%	8%	7%	12%	8%
Portions of fruit and vegetables per day									
None	1%	0%	1%	2%	2%	1%	2%	3%	2%
Less than one portion	19%	8%	7%	18%	29%	16%	22%	29%	20%
1 to 2 portions	60%	58%	53%	64%	57%	65%	61%	56%	61%
3 to 4 portions	17%	28%	32%	14%	10%	16%	12%	9%	15%
5 or more portions	3%	6%	6%	2%	1%	1%	3%	3%	2%

Nutrition Education

Six out of eight countries collected data using the optional questions about type of nutrition education in schools. The results are shown in Figure 12, indicating a wide variability of provision across countries. We noted an anomaly in the data for North Macedonia, where all schools reported that their nutrition education included tasting fruit and vegetables, healthy eating information and food preparation skills but a small number also said that there was no nutrition education. Similarly, Republic of Moldova schools all reported that they provided health eating information, but a small number of schools also said that they did not provide any nutrition education. This may be due to a misinterpretation or translation variations for the words 'nutrition education' in the COSI survey.

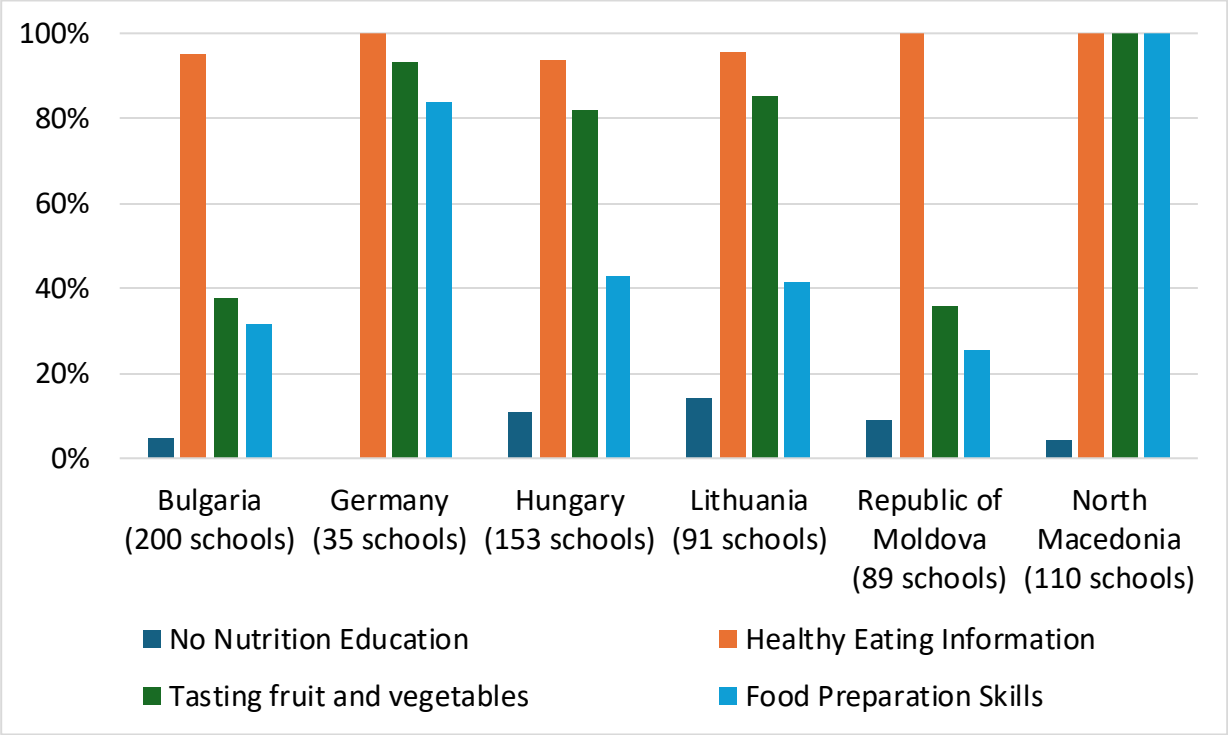


Figure 12 Types of nutrition education in six schools

Food preparation skills and portions of fruit and vegetables

The multilevel linear regression analysis showed that children's engagement in food preparation skills *at home* was significantly associated with their fruit and vegetable consumption, with each one-unit increase in food preparation skills above the group mean associated with a 0.09-point rise in daily portions of fruit and vegetable consumed using a 1-5 ordinal scale (95% CI: 0.09, 0.09, p <.01). Following established guidance supporting the treatment of ordered categorical outcomes as approximately continuous in regression modelling (Carifio and Perla, 2008; Norman, 2010; Sullivan and Artino, 2013), this change translates to roughly 0.65 extra portions over a week (0.09 portions / day x 7 days) and is approximate rather than a precise quantity, since scale categories are not evenly spaced. This interpretation offers a practical sense of the small dietary difference linked to higher food preparation skills, expressed in units meaningful for public health discussion. See Table 14.

Subsequent models analysed if there was an association using individual food skills as predictors. The results showed that all the skills experience at home had an association with fruit and vegetable portions. Mashing had the greatest effect with 0.19 portions per day, equating to approximately an additional 1.33 portions of fruit and vegetables consumed per week (0.19 portions / day x 7 days) for children who practise mashing at home in the preparation of family meals. (B = 0.19, 95% CI = 0.19,0.2, p <.001). This is a small effect but larger than for the Total Score Food Skills at Home.

Multilevel linear regression modelling was used to explore if there was an association between food preparation skills provided in nutrition education *at school* and portions of fruit and vegetable intake but no significant results were found. See Table 14.

Table 14 Food skills experience at home and school and association with daily fruit and vegetable portions

	Model 1 Unadjusted [b]					Model 2 Adjusted [c]				
		95% Confidence Interval			ICC [f]		95% Confidence Interval			ICC [f]
	Estimate	Lower	Upper	Sig.		Estimate	Lower	Upper	Sig.	
Food Skills at Home [a d]	0.099	0.096	0.101	<.001	0.243	0.093	0.09	0.096	<.001	0.248
Weighing [d]	0.158	0.149	0.167	<.001	0.235	0.147	0.138	0.156	<.001	0.24
Grating [d]	0.179	0.169	0.189	<.001	0.232	0.173	0.163	0.183	<.001	0.237
Mashing [d]	0.206	0.197	0.214	<.001	0.239	0.194	0.185	0.203	<.001	0.244
Washing [d]	0.185	0.176	0.194	<.001	0.231	0.167	0.158	0.177	<.001	0.237
Chopping [d]	0.181	0.173	0.19	<.001	0.233	0.175	0.167	0.184	<.001	0.238
Peeling [d]	0.111	0.103	0.12	<.001	0.236	0.098	0.09	0.107	<.001	0.241
Measuring [d]	0.054	0.042	0.066	<.001	0.24	0.061	0.049	0.073	<.001	0.243
Food Skills at School [e]	0.033	-0.051	0.118	0.442	0.169	0.033	-0.053	0.119	0.449	0.175

a Total Score of Food Skills experience at home (0-7) Group mean centred

b Unadjusted = school code as random effect to allow for clustering

c Adjusted = model includes country mother's education as covariate

d level 1 variable - COSI Optional Family Record Form, pooled data from 8 countries

e level 2 variable - COSI Mandatory School Record Form, pooled data from 6 countries

f ICC = Intraclass Correlation

Food preparation skills and obesity risk

The primary model using multilevel logistic regression analysis showed that overall, using the Total Score Food Skills at Home (0-7), children's experience of practicing food skills at home by helping to prepare family meals was weakly associated with increased odds of having obesity. The odds ratio was 1.02 (95% CI = 1.01, 1.03), showing increased odds of having obesity of 2.3% for each additional point scored in total score food skills at home. Multilevel binary logistic regression modelling, accounting for clustering at the school level using random effects, was used to explore if there was an association between food preparation skills provided as part of nutrition education in school and having obesity among children aged 6 to 9 years. The analysis showed that the odds of having obesity compared to not having obesity was 11% higher among children attending schools that provided food skills education, compared to those in schools without this type of nutrition education. (OR = 1.11, 95% CI = 1.08,1.14), see Table 15.

In the secondary analysis, multilevel logistic regression analysis showed that some food preparation skills (e.g. peeling) were associated with lower odds of having obesity in children aged 6 - 9 years and other skills increased the odds of having obesity (e.g. weighing, grating, mashing, chopping, washing). The adjusted odds ratio for peeling was 0.85 (95% CI: 0.83, 0.87), indicating the children who engage in peeling food ingredients were 15% less likely to have obesity compared to those children who did not engage in peeling. See Table 15.

Table 15 Food skills experience at home and school and risk of having obesity

		Model 1 unadjusted [b]					Model 2 adjusted [c]					
			95% CI			ICC [f]			95% CI			ICC [f]
		Odds Ratio	Lower	Upper	Sig.			Odds Ratio	Lower	Upper	Sig.	
Food Skills at Home [a d]	*n*	1.012	1.004	1.021	0.003	0.216	*n*	1.023	1.014	1.032	<.001	0.225
Weighing [d]	13,491	1.058	1.03	1.088	<.001	0.217	12,869	1.039	1.011	1.069	0.007	0.225
Grating [d]	13,491	1.093	1.061	1.127	<.001	0.217	12,869	1.092	1.059	1.127	<.001	0.226
Mashing [d]	13,492	1.024	0.999	1.051	0.063	0.216	12,870	1.056	1.029	1.084	<.001	0.224
Washing [d]	13,491	1.091	1.062	1.122	<.001	0.217	12,869	1.134	1.102	1.167	<.001	0.225
Chopping [d]	13,491	1.132	1.104	1.161	<.001	0.218	12,869	1.13	1.101	1.16	<.001	0.227
Peeling [d]	13,491	0.819	0.799	0.84	<.001	0.214	12,869	0.847	0.825	0.869	<.001	0.223
Measuring [d]	13,492	0.941	0.908	0.975	<.001	0.216	12,870	0.959	0.924	0.995	0.026	0.224
Food Skills at School [e]	14,197	1.124	1.098	1.15	<.001		13,470	1.11	1.084	1.137	<.001	

n Number of child participants included in the analysis

a Total Score of Food Skills experience at home (0-7) Group mean centred

b Unadjusted = school code as random effect to allow for clustering

c Adjusted = model includes child's gender and mother's education as covariates

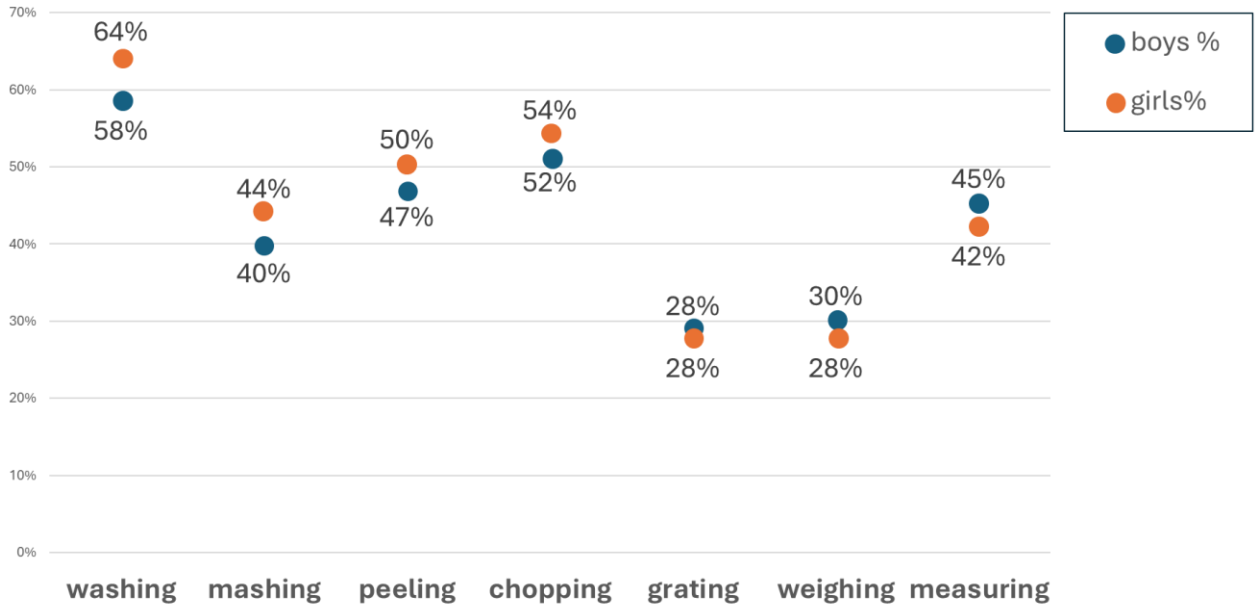
d level 1 variable - COSI Optional Family Record Form, pooled data from 8 countries

e level 2 variable - COSI Mandatory School Record Form, pooled data from 6 countries

f ICC = Intraclass Correlation

Significant sex differences were observed for several food preparation skills. Girls were more likely than boys to engage in washing (OR = 1.27, 95% CI: 1.18–1.36, p < 0.01), mashing (OR = 1.17, 95% CI: 1.09–1.25, p < 0.01), peeling (OR = 1.12, 95% CI: 1.05–1.20, p < 0.01), and chopping (OR = 1.09, 95% CI: 1.02–1.17, p < 0.01). Boys were more likely to participate in weighing (OR = 0.90, 95% CI: 0.84–0.97, p < 0.01) and measuring (OR = 0.89, 95% CI: 0.83–0.96, p < 0.01). Grating did not differ significantly between boys and girls (OR = 0.96, 95% CI: 0.89–1.04, p = 0.31). See Figure 13.

Figure 13 Sex differences in food preparation skills practised at home



Discussion

Higher experience of food preparation skills at home was significantly associated with a small, but significant increase in portions of fruit and vegetable intake. Each additional point score in food preparation skills was associated with a 0.09-point increase on a 5-point ordinal fruit and vegetable portions daily intake scale. Because the scale is ordinal, the numerical increase does not directly translate into portion counts. However, it suggests that more food skills experience in children is associated with a small but consistent increase in fruit and vegetable consumption. Overall, experience of food preparation skills at home and school is weakly associated with a slightly

higher risk of having obesity. For each additional point score in food preparation skills at home this was associated with an additional 2.3% increased odds of having obesity. Skills such as washing, chopping, grating, mashing, and weighing were linked to higher odds of obesity, ranging from 4% to 13% greater odds. In contrast, peeling and measuring were associated with lower odds, corresponding to 15% and 4% lower odds of obesity, respectively. Significant sex differences were observed in several food preparation skills. Girls were more likely than boys to engage in washing, mashing, peeling and chopping. Boys were more likely to participate in weighing and measuring.

Previous research into cooking interventions with children has focused on the outcomes of cooking confidence, increasing vegetable intake and childhood obesity reduction (Hasan et al., 2019; Brennan et al., 2021; Charlton et al., 2021; Dimple and Ramesh, 2023). However, the data analysis in the current study shows that in a larger observational study population, children who participated in more food preparation skills experience at home had a slightly higher odds ratio of having obesity. Children with an avid appetite, who are at risk of having obesity or already are living with obesity, are potentially more motivated by food and therefore more interested in food preparation activities at home (Carnell and Wardle, 2008). Chopping and mashing may increase palatability and easy consumption of foods, potentially leading to greater intake. Intrapersonal and external influences such as behaviour, biology, cognition, hedonics and traits may all play a part in children's appetite self-regulation and interest in being around food (Russell and Russell, 2025). In addition, parents self-reported data on children's food preparation activity may include the preparation of high-calorie meals.

Sex differences in cooking and food preparation skills in this age group have been previously found in cooking intervention studies in the United States of America (Cunningham-Sabo and Lohse, 2014; Cunningham-Sabo et al., 2023; Labbe et al., 2023). However, it was interesting to explore the differences in specific food preparation skills for this age group, in particular routine and precision types of food preparation skills. Girls were significantly more likely to engage in more routine type food preparation tasks such as washing, mashing, peeling and chopping. Boys were significantly more likely to engage in weighing and measuring, which might be perceived as more

precision types of food preparation skills. This evidence supports previous findings around gender roles in the home promoted in early childhood and it has been suggested that these habits and cooking behaviours are socially constructed through cultural norms with 'no other more gendered household task than cooking' (Dixey, 1996; Hartmann et al., 2013).

One explanation of why school nutrition which includes food skills is not associated with increased fruit and vegetable intake is that many countries in the current study did not include experience of vegetable-focussed food education in the curriculum. It is useful to compare the nutrition education policy of two countries that are outside the current study for contrast: Japan and Finland. For example, the Food Education Program in Japan is a nationally mandated initiative that integrates vegetable preparation into school nutrition education (Japanese Ministry of Agriculture Forestry and Fisheries) and this is aligned to the school meal program (Research Consortium for School Health and Nutrition, 2023). There is a strong emphasis on values within the 'Shokuiku' (Food education and nutrition), which was highlighted as an important contextual factor in a review of school food and nutrition policies by the WHO (World Health Organization, 2021b). Japan has a strong nutrition education policy linked to school meals and has an obesity prevalence of 4.4% (95% CI 3.4, 5.5) for children aged 5-19 years, compared to the world obesity prevalence for this age group of 8.2% (World Health Organization, 2024a). In Finland, the home economics curriculum emphasizes that vegetable preparation is part of sustainable food education. The entire school community is engaged in school meals with student participation assisting in school canteens as part of the curriculum (Food and Agriculture Organization of the United Nations). However, recent data from round 6 shows that the obesity prevalence for children aged 7-9 years in Finland is 13% (World Health Organization, 2024b).

In 2022, Smith et al. undertook a policy analysis of primary school curriculums in 11 countries on food literacy, and found that food preparation skills were most comprehensively taught in Slovenia, Iceland, Sweden, Scotland and Norway (Smith et al., 2022). North Macedonia, Germany and Denmark have participated in case studies for school meals, showing that there are national standards for school food but no official monitoring and evaluation

to ensure compliance (Food and Agriculture Organization of the United Nations; Food and Agriculture Organization of the United Nations, 2023; Food and Agriculture Organization of the United Nations, 2025). The Republic of Moldova has national standards for school food in place, and this is monitored by the National Agency for Public Health and by the Ministry of Education by entering data on the nutrition of children in early education institutions (for children under 7 years) using the Education Management System (Ministry of Health, 2025). Currently school meals from grades 1 to 4 are free in the Republic of Moldova and this has been extended to children up to grade 9 from September 2025 (Rodica Mazur, 2025). In Lithuania, the 'Swedish table model' was implemented between 2017 to 2024, enhancing school kitchen facilities and this showed an increase in vegetable and fruit intake in primary aged children. Children in the Kaunas district of Lithuania received a free lunch, and the policy on school meals is that it must be hot food, cooked on the same day (Petrauskiene, 2025). In Bulgaria, some basic aspects of nutrition are studied in different subjects, but they are not included in a separate subject in health education. In most schools, extracurricular activities or projects related to a healthy lifestyle are carried out, including basic aspects of nutrition. Sometimes culinary practices are included in such projects, but there are no regulated classes for food preparation skills . In Hungary, policies have focussed more on the regulation of food and drink for young people and promoting water consumption over sugar-sweetened beverages in schools (World Cancer Research Fund, 2023; MTI-Hungary Today, 2025; National Center for Public Health and Pharmacy, 2025).

In Cyprus, there has been a recent emphasis on promoting the Mediterranean diet with some studies showing that programmes involving cooking skills following mediterranean diet recipes was associated with increased vegetable intake in children (Markidou, 2025). It has previously been recognised that the amount of cooking skills hours in primary school is important, with at least 6 hours or more needed to make a small impact on vegetable intake in children (Vaughan et al., 2024). It is beyond the scope of the COSI survey to collect detailed information on the amount of food preparation skills experience at school. However, it is likely that contextual factors such political stability, public health policy, school meal standards and

monitoring will vary a lot between countries and that this will also impact on the amount and type of food skills experience in schools.

It is possible that food preparation skills experience at home is also associated with children and families who like food and enjoy both cooking and eating it. Although home cooking is often associated with healthier eating, it may also involve practices such as frequent use of processed ingredients, high-fat cooking methods, or large portion sizes. When parents prepare food with children, the activity may include baking or sweet treats, which supports family bonding and well-being but may not contribute to healthier dietary intake (Tani et al., 2021). Children who helped with the preparation of family meals were likely to eat slightly more fruit and vegetable portions than those who did not help and had a slightly higher risk of having obesity. Clearly risk of obesity is highly linked to a gene and environment interaction (Mateus Pellenz et al., 2022; Pellenz et al., 2025) and so a focus on cooking skills presents one aspect of the child's environment which is modifiable and therefore worth exploring further which specific food preparation skills might enhance dietary quality in children.

Several potential confounding variables were identified during the analysis, but these were not included in the final models because extensive missing data and incomplete values substantially reduced the effective sample size. The excluded variables are provided in Appendix D6 for transparency. The omission of these variables means that residual confounding cannot be ruled out, and the observed associations may partly reflect unmeasured influences.

Given the potential value of these findings, it is recommended that the WHO continue to include food preparation questions in future rounds of COSI. Retaining these items would support monitoring across countries and allow future analyses linking food preparation skills with broader wellbeing indicators already collected in COSI, including sleep, physical activity and psychosocial factors. This reflects international frameworks such as the WHO Commission on Ending Childhood Obesity (ECHO) (Nishtar et al., 2016), and UNICEF's child wellbeing models (United Nations Children's Fund, 2021), all of which emphasise the interconnected roles of lifestyle behaviours and psychosocial wellbeing in childhood obesity. Continued inclusion of these questions would therefore strengthen opportunities for policy assessment and future research.

Strengths and limitations

A strength of the study is the large sample size from a range of countries and a well-established protocol for data collection from the WHO COSI team including child measurements. This is the first time this data has been used to examine the relationship between food preparation skills and obesity risk for this age group with a large dataset.

A limitation of the study is the cross-sectional design. Whilst a Directed Acyclic Graph (DAG) was used to model causal structures for confounding variables and pathways in childhood obesity, cross-sectional studies only capture data at one point in time and are therefore this study is limited in the ability to identify causal relationships. Additionally, due to missing data for some of the optional questions it was not possible to add a few confounding variables. Some variables with potential causal links to childhood obesity prevalence such as sleep quality and other health factors could not be included in the analysis, either because the data was not collected in the survey, or because there was too much missing data for this to be successfully computed in the multilevel linear regression models. Imputation for missing data was considered, but for some variables (for example family income) it was not deemed to be missing at random, and therefore not appropriate for imputation (Heck, 2022).

A further limitation is that the COSI survey does not incorporate validated measurement tools for many research-relevant variables. For instance, children's food skills were assessed through parent reports in the Family Record Form, which may be less reliable than child self-reports.

Conclusions

Overall, in children aged 7-9 years the COSI round 6 survey shows that one in ten children is living with obesity in Europe (World Health Organization, 2024b). Ending childhood obesity remains an important priority for global public health and data from COSI plays an important role in both monitoring progress and informing policy-makers. This study has shown that experience of food preparation skills, especially those practiced at home, is modestly associated with increased dietary intake of fruit and vegetables. Surprisingly, most food preparation tasks were associated with a slight increase in obesity risk,

although this was a small effect. Experience of peeling was linked to 15% lower odds of having obesity. The observed sex differences in food preparation tasks emphasises the need for a review of nutrition education curricula in schools. Prioritizing skills such as peeling and mashing may increase fruit and vegetable intake in children.

Abbreviations

WHO: World Health Organization. COSI: Childhood Obesity Surveillance Initiative.

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Authors' contributions

KV is the lead investigator; she conceived the study, proposed the additional food skill questions for inclusion in the round 6 COSI survey in 2021, completed the pre-registration on Open Science Framework in 2024, analysed the data in SPSS, created all the figures and tables and wrote the first draft of the manuscript. VD, TH, KS, SA, AP, MVR and IS were the Principal Investigators in all the participating countries and had the lead responsibility for collecting the COSI survey data in round 6. MB at the WHO collated all the data for the COSI survey and conducted the data cleaning. JC and MH were the supervisors of KV at the University of Leeds and provided detailed comments on all draft manuscripts. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The code created and datasets analysed for the current study may be available upon request to the authors.

Ethics approval and consent to participate

Ethics approval for this study was granted on 29th October 2024, by the School of Business, Environment and Social Sciences Committee at the University of Leeds (The Secretariat, University of Leeds, LS2 9NL, UK; +44 (0)113 343 2876; researchethics@leeds.ac.uk), ref: 2121. Ethics approvals for the data collections in all countries participating in COSI was granted by local ethics committees. Parents gave consent and children assented to be measured.

Consent for publication

All authors have given consent for publication

Competing interests

The other authors declare that they have no competing interests.

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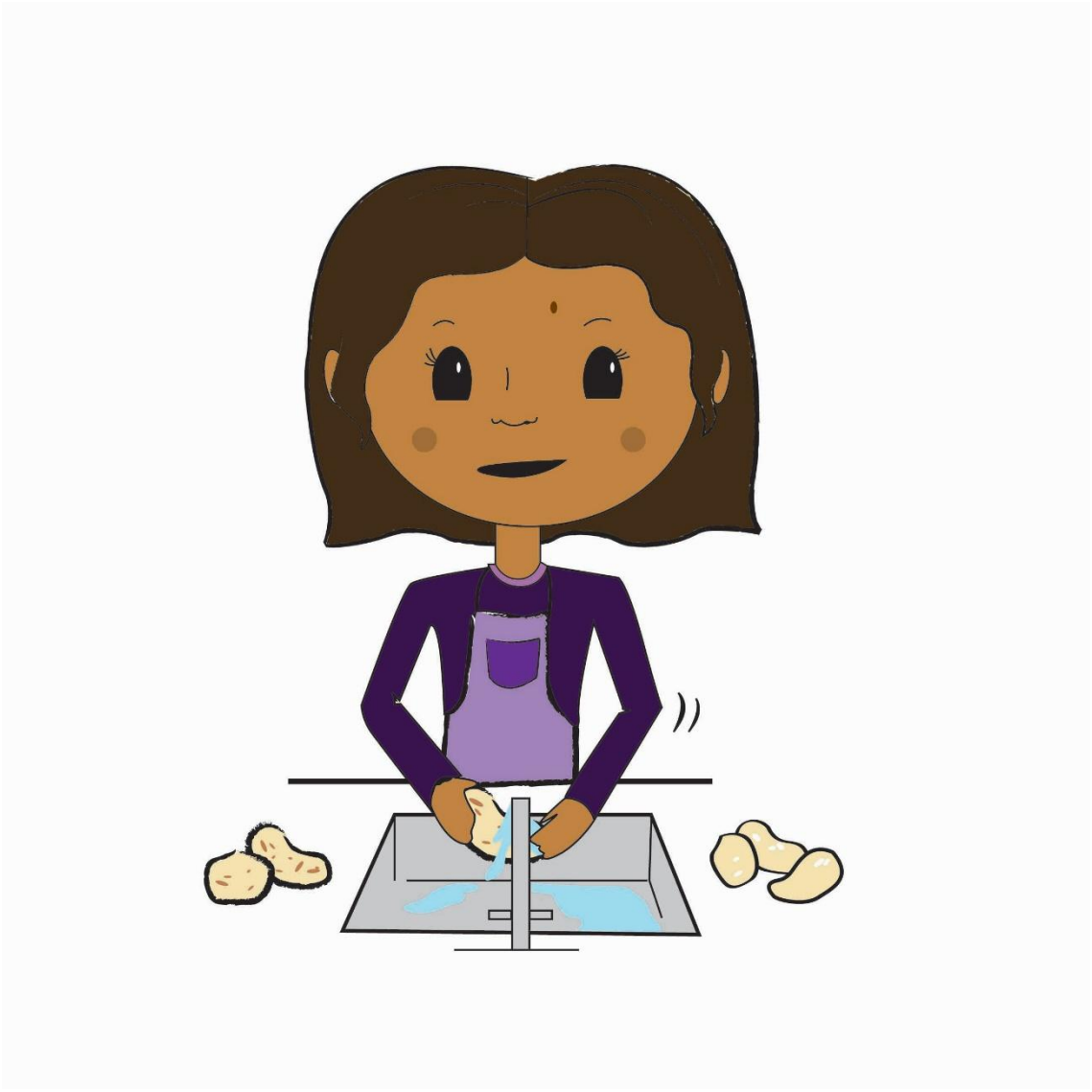


Chapter 6 Discussion and critical review

Introduction

Healthy diets in children, containing nutrient rich foods such as fresh fruit and vegetables, are associated with better health outcomes both in childhood and in adulthood (Nishida et al., 2004; World Health Organization, 2020). Studies have shown that poor dietary patterns are associated with cardiovascular disease (Umer et al., 2017; Khan Md. Murtaja Reza Linkon, 2023). WHO recommendations are that adults and children should eat at least 400g of fruit and vegetables per day in order to provide an adequate intake of dietary fibre and micronutrients (World Health Organization, 2020).

The WHO recognises that unhealthy diets are a key driver of overweight, obesity and diet-related NCDs and estimates this to be responsible for 11 million deaths every year (World Health Organization, 2022a). One in ten children are living with obesity in the WHO European Region (World Health Organization, 2024). However, childhood obesity may be a problem independent of healthy eating. Energy balance theory offers the explanation that obesity is caused by eating excess energy in relation to energy expenditure (Hill et al., 2012; Hopkins and Blundell, 2016) although the assumptions behind this have been challenged (Torres-Carot et al., 2022). Other perspectives on understanding obesity include genetic factors (Greenhill, 2020; Shkurat et al., 2023; Sun et al., 2025) or interaction between multiple environmental, lifestyle and biological factors (LonglTools, 2021; Pellenz et al., 2025).

Nutrition education policy has aimed to influence lifestyle factors through nutrition and health-promoting school curriculum, which includes food skills and food literacy (World Health Organization, 2021). The WHO Nutrition-friendly schools initiative promoted a school curriculum that includes healthy living and life-skills education with regular monitoring and evaluation of how well the education meets the objectives (World Health Organization, 2021). However, schools may lack the resources to deliver practical nutrition education which includes food preparation skills and so many countries may prioritise food knowledge over practical skills (Smith et al., 2022).

A need was identified to better understand what types of nutrition education are most effective in building cooking confidence and food

preparation skills in children and to better understand the relationship between cooking skills, food literacy and obesity in children aged 4 – 12 years. To address the research enquiry, this thesis had the following aim:

To explore associations between nutrition education, cooking skills and obesity prevalence in children aged 4 – 12 years.

The preceding chapters describe the research projects undertaken to achieve this aim and present the methods and findings in four published papers:

1. **Paper 1** (Chapter 2) – The impact of school-based cooking classes on vegetable intake, cooking skills and food literacy of children aged 4-12 years; A systematic review of the evidence 2001-2021.(Vaughan et al., 2024)
2. **Paper 2** (Chapter 3) – Trial protocol for evaluation of PhunkyFoods intervention in the UK. (Vaughan et al., 2022)
3. **Paper 3** (Chapter 4) – Evaluation of the school-based 'PhunkyFoods' intervention; a cluster randomised controlled trial in the UK (Vaughan et al., 2025).
4. **Paper 4** (Chapter 5) – A cross-sectional study of food preparation skills and obesity risk in European children aged 6 – 9 years from 8 countries – World Health Organization European Childhood Obesity Surveillance Initiative (COSI) 2022-2024 .

In this final chapter, novel findings are highlighted, results are critically evaluated in the wider research context, strengths and limitations are discussed and public health and future recommendations outlined.

Summary of findings

A systematic literature review investigated the impact of school-based cooking classes on cooking skills, food literacy and vegetable intake of children aged 4 – 12 years (Vaughan et al., 2024). A random effects meta-analysis found a small positive effect of cooking classes on cooking self-efficacy and a small positive effect on vegetable intake. Outcome scales for cooking self-efficacy were 'cooking self-efficacy', 'self-efficacy to cook' and 'cooking attitudes.' Outcome scales for the analysis of vegetable intake were 'veg servings per day', 'vegetable consumption', 'vegetable intake score' or 'number of vegetables

eaten at supper'. Reasons for these effects were explored with the dose of cooking hours and theoretical underpinning of programme designs being most likely. Cooking programmes with six or more cooking hours showed the greatest impact on outcomes. However, the certainty of evidence judgements (risk of bias, inconsistency, indirectness and imprecision) were rated very low for both cooking self-efficacy and vegetable intake, due to the quality of studies in this field. High quality randomised evaluations of cooking programmes are needed with consistent use of outcome tools for vegetable intake, food literacy and cooking competencies. This would also improve the consistency and precision of meta-analysis and therefore the certainty of evidence.

A randomised controlled trial evaluated the impact of the UK based PhunkyFoods programme on cooking skills, food literacy and fruit and vegetable intake of children aged 7 – 9 years in North Yorkshire (Vaughan et al., 2025). Existing measurement tools for these outcomes were used to allow for comparison with other similar studies to improve consistency and precision of meta-analysis. The trial was undertaken in 26 primary schools with 631 children participating. There were no significant effects of the intervention compared to the control on food literacy, cooking skills, vegetable intake or fruit intake. Girls scored significantly 2.8 points higher than boys in cooking skills at follow-up. It was found that the number of food preparation and cooking hours for each child participant was most likely insufficient to make an impact on cooking skills, food literacy or fruit and vegetable intake. Evaluating existing established programs is crucial for understanding their long-term effectiveness and sustainability. Recommendations to the PhunkyFoods programme were to increase number of food preparation hours and to increase number of children participating in food preparation hours. Since the trial, Purely Nutrition has actively promoted model fidelity of at least six hours of food skills for full classes in each year group for all participating schools in the PhunkyFoods programme. However, there is as yet no evidence of this taking place in the case study examples shown suggesting that competing priorities in the primary school curriculum in the UK remain a barrier to change (Purely Nutrition, 2025). This is why recommendations for more experiential learning and cooking lessons in primary schools by the UK Food Strategy and the Nutrition policy status in

England report must be revisited (Dimbleby, 2021; World Cancer Research Fund, 2023d).

A cross-sectional design study evaluated the relationship between food preparation skills and obesity risk in Europe using data from the WHO COSI. Data from 19, 736 from child participants across eight countries were analysed: Bulgaria, Denmark, Germany, Hungary, Kazakhstan, Lithuania, Republic of Moldova and Republic of North Macedonia. Multilevel linear regression models examined the relationship between food preparation skills practiced at home and school and daily vegetable intake, accounting for individuals nested within schools. Logistic regression was used to assess associations between experience of these skills and obesity risk. Increased experience of food preparation skills at home was associated with a small increase in daily fruit and vegetable intake; each one-point increment on the skills scale corresponded to a 0.09-point rise on a 5-point ordinal measure. Overall, combined food preparation experience at home and school was also associated with a marginally higher odds ratio (OR) of having obesity. Experience of peeling skills was associated with a lower OR of obesity. Similar to findings in the RCT in Yorkshire, significant sex differences were observed in food preparation skills in this age group. The COSI study showed that girls were more likely than boys to engage in tasks such as washing, mashing, peeling, and chopping, whereas boys more frequently reported involvement in weighing and measuring.

Table 16 Key findings, reasons, novelty and international conferences

Chapter	Key findings	Potential reasons	Novelty	Dissemination
2	Cooking lessons in primary schools can improve cooking confidence and vegetable intake – especially for programmes > 6 hours.	Food skills development and cooking confidence takes more than 6 hours to improve.	First study to comprehensively synthesis the available evidence on cooking confidence and vegetable intake with risk of bias, certainty of evidence and meta-analysis.	ISBNPA 14-17th June 2023, Sweden (Vaughan, 2023)
4	PhunkyFoods programme did not improve cooking confidence, food literacy or fruit and vegetable intake. Girls scored higher than boys in food literacy and cooking confidence.	Not enough food preparation and cooking hours in the programme. PhunkyFoods had small cooking clubs with 6-8 participants instead of whole classes. Food preparation in homes in UK undertaken largely by women – influencing role models for children.	First fully powered cRCT to evaluate the PhunkyFoods programme in the UK.	EASO 11-14th May 2025, Malaga (Vaughan, 2025b)
5	Food skills at home associated with slightly increased fruit and vegetable intake. Food skills at home associated with slightly higher odds of having obesity. Peeling is associated with 15% reduced odds of having obesity. Sex differences in food skills at home.	Preparing meals from scratch requires food skills. Home cooked meals from scratch uses fresh ingredients like fruits and vegetables. Children who are interested in food, with avid appetites, might want to participant in cooking activities at home. Peeling is mostly likely to involve cooking with vegetables and fruits, which may lead to intake of healthy diets. Food preparation in homes in EU countries undertaken largely by women – influencing role models for children. Girls have better motor skills than boys at this age group.	First study to use the WHO COSI data on this topic using the new food skills questions added to round 6.	ECOG 26-28th November 2025, Sweden (Vaughan, 2025a)

Comparison with other literature

Systematic review

The findings are consistent with two other similar systematic reviews on this topic (Hersch et al., 2014; Hasan et al., 2019). Hersch et al. previously found that school-based cooking classes may positively influence food preferences, attitudes and behaviours but concluded that study outcomes measurements varied widely making comparison difficult (Hersch et al., 2014). Hasan and colleagues found in their meta-analysis that cooking classes were not associated with improvements in anthropometric and cardiometabolic outcomes but their narrative review showed they were associated with improvements in cooking attitudes, self-efficacy and dietary intake in adults and children (Hasan et al., 2019) . Consistent with Vaughan et al. 2024 discussion on cooking interventions, Hasan also commented on limitations due to heterogeneity in outcomes for the studies analysed. Similarly, these reviews also found the longer interventions were more likely to show greatest effects.

Van der Horst et al. undertook a similar systematic review, although the criteria for inclusion published is different to the registered protocol from 2019 (Cunningham-Sabo, 2019; van der Horst et al., 2024). Their protocol indicated that a meta-analysis would be undertaken but their key findings (see table on page 884) showed limited data extraction for cooking skills, food acceptance and dietary intake for any of the studies. Surprisingly, Van der Horst reported that there were no validated cooking behaviours and ability tools for children, yet both CooC7 and CooC11 are validated cooking competence tools (Dean et al., 2021a) in the systematic review recommendations, which were used in the evaluation of PhunkyFoods trial protocol and results papers (Vaughan et al., 2022; van der Horst et al., 2024; Vaughan et al., 2024). Van der Horst et al. concluded that interventions were not successful in changing dietary intake or health indicators and that there were mixed results found for cooking knowledge and self-efficacy (van der Horst et al., 2024). However, no meta-analyses were reported to support these claims. Van der Host et al. reached the same conclusion regarding the challenges in range of outcomes and recommended that efforts should be made to standardize and improve measures in future studies on cooking lessons in schools.

PhunkyFoods evaluation

The PhunkyFoods evaluation shows similar results on cooking confidence outcomes to previous studies. Figure 14 shows an updated meta-analysis from the systematic review (Vaughan et al., 2024) on the impact of cooking lessons on cooking self-efficacy with the PhunkyFoods evaluation added. The studies showing greatest impact had more than 6 hours of cooking lessons, compared to PhunkyFoods clubs which had 4 hours. It is interesting to note that the PhunkyFoods study has the narrowest confidence interval and the highest weight in the meta-analysis, driven by the largest combined sample (n = 552) compared with the other studies. Furthermore, there is no indication that any of the other 6 studies (Cunningham-Sabo and Lohse, 2013; Ensaff et al., 2017; Zahr and Sibeko, 2017; Landry et al., 2019a; Maiz et al., 2021; Yoshii et al., 2021) used multilevel modelling to account for the clustering of schools and did not report the ICC for each primary outcome, which is a requirement in the CONSORT extension guidance for cRCTs (Campbell et al., 2012). Not accounting for clustering can underestimate variance, producing confidence intervals that are too narrow and overstating statistical significance (Campbell et al., 2000).

A risk of bias assessment highlights the areas where the PhunkyFoods evaluation compares favourably on quality with other similar studies (Sterne et al., 2019). The allocation sequence, for trial arms was ambiguous for the Cunningham-Sabo study, since it does not report how the four schools were randomly assigned to either the intervention or comparison groups and did not show a PRISMA flow diagram (Cunningham-Sabo and Lohse, 2013). The PhunkyFoods evaluation showed a PRISMA flow diagram for clarity on the research journey for participants. Some concerns arise in the analysis of the Cunningham-Sabo study in domain 5 on the reporting of results because there was no prospective publishing of a trial protocol with analysis plan. The LA Sprouts study highlighted high risk of bias in the reporting of outcomes judgement using the risk of bias ROB2 tool, since two papers on the same study measured the Cooking Self-Confidence outcome in a different way. (Davis et al., 2016; Landry et al., 2019b). The 2016 paper took an average score and then 2019 paper took a total score. This highlights that methodology for measuring the outcome changed after the data was collected. Similarly, the

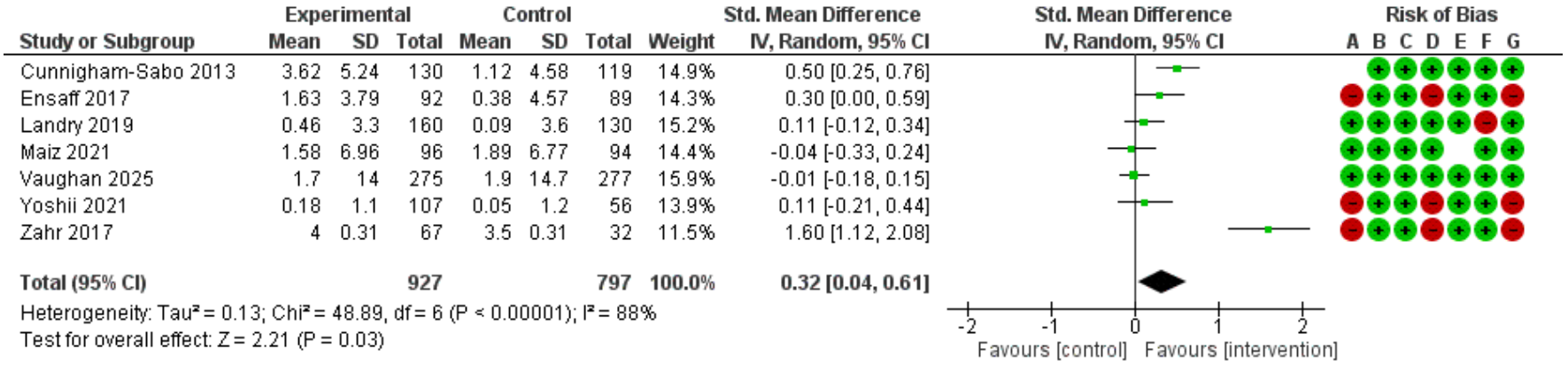
Maiz study was not pre-registered and no trial protocol is available. In comparison, The PhunkyFoods evaluation was pre-registered on a trials registry (Vaughan, 2021) before recruitment started, submitting a full trial protocol in January 2022 (Vaughan et al., 2022) in accordance with the Spirit Guidelines (Chan et al., 2013) and before recruitment to the study was completed in March 2022.

COSI study

This is the first cross-sectional study to analyse the relationship between food preparation skills in children and obesity prevalence in children aged 6 – 9 years. Whilst a previous study investigated parental inclusion of children in cooking activities in four countries, the researchers did not include child outcomes (Benson et al., 2022). It is therefore not possible to compare the results with previous literature on this topic.

It is interesting to note the similarity in findings regarding sex differences in food preparation skills between the PhunkyFoods evaluation and the COSI study. The PhunkyFoods evaluation found that girls scored 2.8 points higher than boys using the 11 food skills in the CooC11 Cooking Confidence tool designed by Dean et al. in 2021. For the COSI study, participants were asked if they did the 7 food skills in the CooC7 Cooking Confidence tool at home. Results showed girls were more likely than boys to engage in tasks such as washing, mashing, peeling, and chopping, whereas boys more frequently reported involvement in weighing and measuring.

Figure 14 Forest Plot showing PhunkyFoods evaluation with other similar studies evaluating cooking self-efficacy



Risk of bias legend
(**A**) Random sequence generation (selection bias)
(**B**) Allocation concealment (selection bias)
(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

Note: updated forest plot with PhunkyFoods Study added, adapted from Vaughan, K.L. et al., 2024

Critique of potential mechanisms

Dose-response relationships and programme fidelity

Findings from both the literature review and the randomised controlled trial specified the relevance of dose-response in cooking interventions. It has been suggested that > 6 hours of food skills for cooking classes is associated with better outcomes for cooking confidence. From an implementation science perspective, there may be considerable tension between achieving high programme fidelity to maximise potential for impact and working collaboratively in school settings where leadership faces competing demands in timetabling the national curriculum (Moir, 2018). The interplay of drivers such as opportunity, capability, motivations of schools to engage will likely impact on the take-up of programme fidelity. The dose-response factor may also account for the reason why nutrition education involving food skills in schools for the COSI cross-sectional study did not have an association with increased fruit and vegetable intake. It is possible that schools had insufficient food skills hours in the curriculum to make an impact on fruit and vegetable intake, or that the lessons did not prioritise fruit and vegetables in lesson plans.

A comparison of a life skill such as swimming to food skills in the UK national curriculum highlights the deficit. Schools are mandated to provide swimming and water safety lessons in Key stage 1 or 2. Year 6 pupils are required to swim competently for at least 25 metres by age 11 (Department for Education, 2013). The Association of Swimming Association (ASA) school swimming guide recommended at least 24 hours of lessons per child across key stage 2 to ensure these outcomes are met (Amateur Swimming Association, 2020). In contrast, there are no measured outcome requirements for food skills or recommendations for curriculum hours.

Although some commentators argue that future research should incorporate formal process evaluations to understand the “why” behind implementation challenges (Moore et al., 2015), the findings of this thesis suggest that such approaches may only partially illuminate the barriers identified here. Process evaluations can indeed provide useful insights into programme delivery and contextual influences, and this perspective is acknowledged. However, the limited number of hours currently dedicated to

nutrition education and cooking-skills lessons in primary schools appears to arise less from uncertainties in delivery processes and more from deeper structural misalignments in political sustainability, public value, and operational feasibility. Consequently, a strategic-systems perspective, as operationalised through Mark Moore's strategic triangle, may offer a more informative explanation of why implementation falters and where future research and policy attention might most effectively be directed. The strategic triangle is a diagnostic tool for public managers by aligning three critical dimensions to implementation: public value, legitimacy and support and operational capacity (Moore, 1997). Figure 15 offers an adaptation of the model to explain why there is currently not enough cooking lessons delivered in UK primary schools.

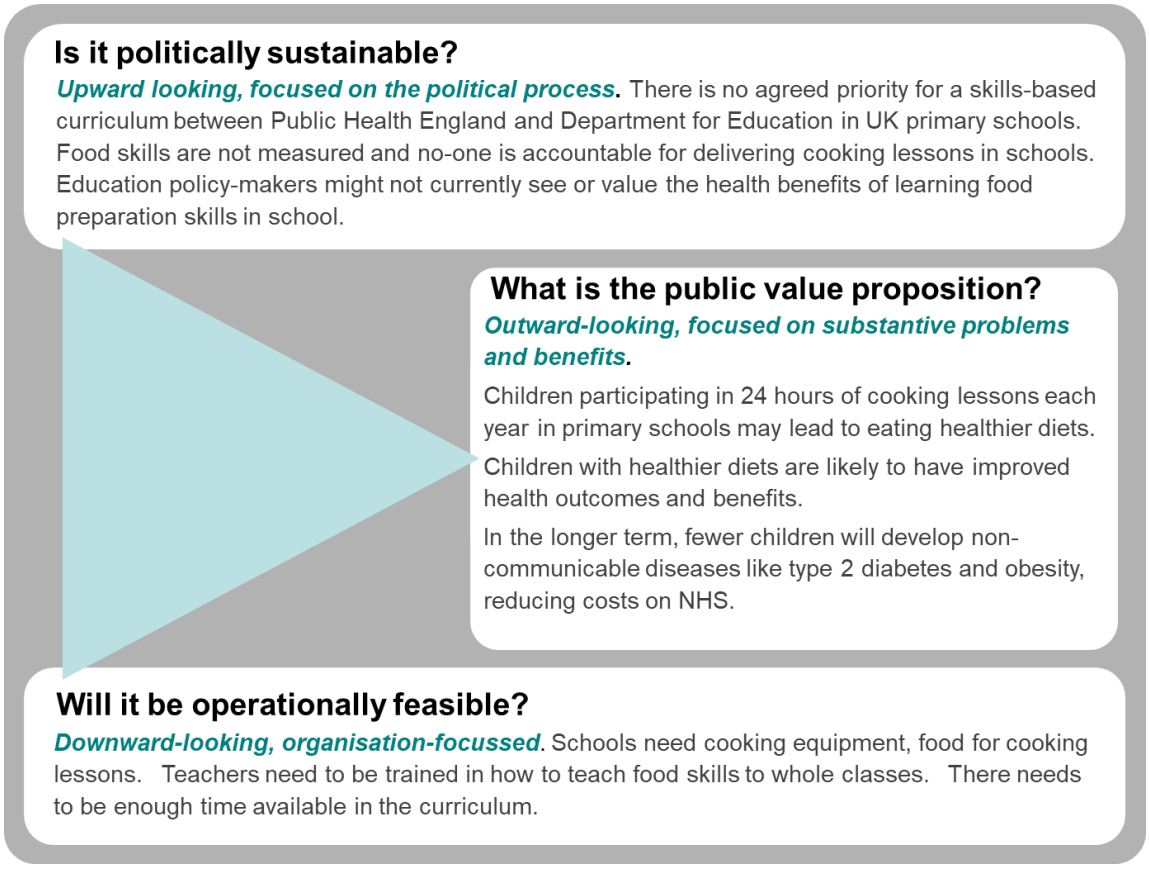


Figure 15 Strategic misalignments for enough cooking lessons in UK primary schools (adapted from M. Moore 1997)

This shows that, whilst the public value proposition element of the strategic triangle is accepted and articulated in policy documents such as the National

Food Strategy, the main barrier to implementing effective nutrition education that includes at least 24 hours of cooking lessons is due to political sustainability and operational feasibility.

Effects of peeling

It has been shown in chapter 5 that peeling was associated with 15% reduced odds of having obesity for children aged 6-9 years, from a sample size of 19, 736. It is likely that the protective effects of peeling shown in the COSI study is due to this skill being most uniquely and obviously associated with fruits and vegetables. Peeling foods with edible skins may reduce their fibre content (Meghwal et al., 2018), although the remaining portion still contributes to overall dietary fibre intake. Other skills such as mashing, chopping, measuring, grating and weighing could apply to other higher energy density food ingredients such as butter, sugar and flour used in baking. Whilst all food preparation skills are useful to create healthy nutritious meals with fresh fruit and vegetables, it is possible that school curricula should prioritise these skills within the context of preparing meals that include vegetables.

Theoretical Underpinning – BCT and experiential learning theory

The use of behaviour change techniques (BCTs) can help to improve the impact of interventions (Michie et al., 2011; Hollywood et al., 2018; JaKa et al., 2021; Verdonschot et al., 2023). Hollywood et al. found that most cooking interventions with long-term impact in adults identified between four and 10 BCTs relating to providing information, instruction and practice. In particular, the authors highlighted that BCT#1 (information on the consequences of the behaviour in general); BCT#20 (information on when and where to perform the behaviour) were used in at least half of successful interventions; BCT#21 (instruction on how to perform the behaviour) and BCT#26 (prompt practice / practical cooking) appeared across all interventions that were deemed successful in the long term (Hollywood et al., 2018). It is possible that there is limited use of these effective BCTs used in cooking interventions with children, that these have not formed the basis of the intervention development and that this may account for limited impact on food literacy, cooking skills and fruit and vegetable outcomes. From a pragmatic perspective, many researchers may

find it unwieldy and impractical to report trial intervention components with reference to BCTs, since the framework has 93 items and requires coder training to navigate effectively (JaKa et al., 2021; Chakraborty et al., 2022).

Chawner et al. found that children need repeated exposures to eating vegetables before they start to like them (Chawner et al., 2019; Chawner and Hetherington, 2021). Experiential learning model theory suggests that children may experience a range of food preparation situations during cooking lessons (both successful and unsuccessful) and the time to resolve these conflicts is necessary for learning to occur. Associative conditioning theory is also relevant in this context, since children learn cooking skills by becoming familiar with new skills, and by practicing them in a social environment where they feel safe and there is no threat or pressure (Wilkinson et al., 2025).

Policy landscape and the National Food Strategy

The international policy landscape shows that a healthy diet is consistently shown to be an important factor for preventing non-communicable diseases (World Health Organization, 2020). The NOURISHING policy index rated 28 out of 30 countries as “no policy”, “poor” or “fair” on giving nutrition education and skills (World Cancer Research Fund, 2023a). The Nutrition policy status in England report rated nutrition education and skills as fair, meeting below 50% of optimum design criteria established in the NOURISHING framework. Weaknesses highlighted included lack of measures to limit sugar-sweetened beverages in and around schools, and nutrition education in schools for teachers and health professionals (World Cancer Research Fund, 2023d). Further information is available at Appendix E1 from this report.

Experiencing the flavours of fruits and vegetables starts in utero (Ustun et al., 2022). It is recognised that developing a liking for fruits and vegetables in children needs to begin in early years and continue with younger children, since by adolescence it is more difficult to start liking vegetables (Birch and Marlin, 1982; Bawajeeh et al., 2020; Chawner and Hetherington, 2021; Bawajeeh et al., 2022). Sufficient curriculum time that provides opportunities for young children in an amenable context is enough to promote willingness to taste novel fruits and vegetables, even for children with neophobia (Wilkinson et al., 2025). The Flavour School research project showed an increased willingness to taste in the

context of playful exploration of novel foods with no expectation of having to eat the foods (Wilkinson et al., 2025).

Whilst willingness to taste and liking of vegetables is important in early years, developing food skills to prepare healthy nutritious meals in primary school is also important. Lavelle et al. found that children under 12 years and teenagers had the greatest confidence in their cooking and food skills, cooking attitudes and diet quality compared to other age groups in their cross-sectional study on learning cooking skills at different ages, highlighting the importance of learning food skills at an early age for skill retention (Lavelle et al., 2016). The policy landscape in the UK does not adequately drive implementation and monitoring of a high quality food skills education. Curriculum constraints in primary schools in the UK mean that food skills education is being neglected since school leadership teams prioritise reading, writing and mathematics assessments (Dimbleby, 2021). Despite recommendations to introduce more food skills into the school curriculum, no changes have been made in the UK since 2015 (Public Health England, 2015). Early findings from the current curriculum review for UK schools shows no signs moving towards a skills-based curriculum in primary schools, with a preference for knowledge-based curriculum (Curriculum and Assessment Review, 2025).

Sex differences

Sex differences in cooking skills, food literacy, fruit intake and obesity prevalence in children are widely recognised (Cunningham-Sabo and Lohse, 2014; Oleschuk, 2019; Spinelli et al., 2021; World Health Organization, 2022b; Vaughan, 2025b). Identifying differences between sexes consistent with previous literature supports the idea that our measures were valid. Cultural dimensions such as dietary norms and thinness / overweight perception as a potential mechanism and to partially explain and understand differences, for example a drive for thinness in preadolescent and adolescent girls (Striegel-Moore et al., 1995; Gondoli et al., 2011). Candler et al. found that 24% of the variance in thinness in girls was at country level after adjusting for individual covariates and showed that socioeconomic and cultural factors play a major role (Candler et al., 2017).

It has also been shown that girls have more developed motor skills than boys at this age group, which may also explain some of the difference in

perceived cooking competence in the PhunkyFoods trial and the food skills in the COSI study (Dean et al., 2021b). It is unclear whether sex differences in motor skills for cooking activities in this age group is due to biological developmental differences or due to different exposure to these skills arising from gender norms.

Country differences

The COSI dataset shows that there are large differences in obesity prevalence across countries (World Health Organization, 2022b; World Health Organization, 2024). The prevalence of obesity from the round 5 report ranged from 1% in Tajikistan to 19%in Cyprus. In the COSI cooking study which used round 6 data with 8 countries, the lowest prevalence of obesity was Denmark with 3.5% for girls and 4.9% for boys. The Republic of Moldova and Kazakhstan also showed lower childhood obesity prevalence rates compared to other countries. All 8 countries showed higher prevalence of obesity for boys than girls.

Extensive research on obesity and diet in Denmark may account for the public health policy context and low obesity prevalence rates compared to other countries (Jensen et al., 1982; Jensen et al., 1990; Matthiessen et al., 2001; Matthiessen et al., 2008; Andersen et al., 2012; Rasmussen et al., 2020; Gribsholt et al., 2025). The Nutrition policy status in Denmark report from the NOURISHING policy index rated public awareness about food and nutrition as excellent, meeting all aspirational standards in the framework. No policies were identified specifically for cooking skills, however, training for educators on nutrition was rated good, meeting 99% of policy design criteria (World Cancer Research Fund, 2023c).

The highest prevalence was Bulgaria with 17.4% for boys and 13.6% for girls. Fewer longitudinal data sets are available on the prevalence of overweight and obesity in Bulgaria and there has not been the same policy drive to improve diets and reduce obesity (Ivanova et al., 2008; Todorova, 2022). Recent research highlighted the link between obesity and diabetes but conclusions did not include any public health recommendations to reverse this trend (Krastev et al., 2022). The Nutrition policy status in Bulgaria report from the NOURISHING policy index rated food affordability and purchase incentives and restrictions on food advertising to young people as poor. No policies were

found for nutrition education in curriculula, training for educators or health professionals, cooking skills, training schools in growing food or training for caterers (World Cancer Research Fund, 2023b).

In contrast to some of the countries in our study, it is widely recognised that Japan has a strong cultural tradition of valuing healthy food in school environments (Global Child Nutrition Foundation, 2024), which may be a factor influencing Japan's very low childhood obesity rate of 2% (World Population Review, 2025) .

Food balance sheets can be useful for international comparison and analysis of diet trends over time but the quality of data may vary due to the reliability of input processes (Thar et al., 2020). The Mediterranean Diet, (which includes high consumption of plant foods, low consumption of meat and diary and olive oil as the main source of fat) is considered a healthy dietary pattern and associated with better health outcomes (Serra-Majem et al., 2006) and a sustainable lifestyle model (Dernini et al., 2017). Da Silva et al. used food balance sheets to show that there was a shift away from the mediterranean diet from in most of the 41 countries in their study (da Silva et al., 2009). Their study showed that between 1961-1965 Bulgaria had a Mediterranean adequacy index (MAI) of 2.68 and between 2000-2003 the MAI was 1.2. Since Denmark showed a MAI score of 0.63 between 1961 and 1965 and a MAI score of 0.64 between 2000-2003, this suggests that adherence to the Mediterranean Diet is only one factor of many that may be contributing to rises in obesity prevalence. A wider approach is needed to more fully understand the extent of drivers impacting on obesity prevalence.

Systems maps and ecological systems perspectives

A systems approach for obesity involves mapping drivers of childhood obesity and actions across a network of stakeholders. In Denmark, a systems thinking approach was used to create a systems map (see Figure 16) showing the dynamic interrelations between factors such as 'diet and dietary habits', 'family', physical activity and active living', 'screen, media and sleep', 'mental health and well-being' and 'competencies of professionals and decision-makers' (Ryom et al., 2025). A similar approach to mapping causality of childhood obesity has been undertaken in the UK, but has additional factors such as 'commercial factors' and 'food access' (Ndlovu et al., 2025). Interestingly, both the Denmark

systems map and UK Local Authority Childhood obesity map omit any biological drivers, which are now known to be highly relevant to childhood obesity (Greenhill, 2020; LonglTools, 2021; Shkurat et al., 2023; Chen et al., 2024; Sivakumar et al., 2024).

The systems thinking approach highlights the complexity of drivers and actions across a variety of stakeholders and offers a rationale for why simplistic causal diagrams on childhood obesity may not adequately capture all the potential confounders in regression analysis. Directed acyclic graphs (DAGs) are often used to identify potential confounding variables for research but may only present a limited number of unobserved variables and prohibits cycles and feedback loops in systems maps (Tennant et al., 2021). Whilst DAGs aim to clarify causal associations in cross-sectional studies such as the COSI study, systems thinking may more accurately represent the complexity of understanding public health challenges such as obesity.

Ecological systems theory widens the lens further, by adding in the broader cultural, economic and policy contexts of food environments and public health issues. One example is the GENIUS network in the UK, that brought together a holistic team of academics, non-academics and stakeholders to conduct a network analysis of the school food system in the UK (Woodside et al., 2024). From this wider perspective, our understanding of children's cooking skills, fruit and vegetable intake and obesity prevalence can viewed more comprehensively by considering different layers: microsystem (home and school settings, e.g. parent diets), mesosystem (home – school communication, e.g. school lunch policies), exosystemic (external environments such as neighbourhood food availability and time available for cooking healthy meals), macrosystem (e.g. national dietary guidelines and food marketing regulations, taxation on unhealthy foods) and chronosystems (changes in any of the systems that change routines, for example Covid 19) (Vandenbroeck, 2007; Hawkins et al., 2009; Davison et al., 2013; Benazizi-Dahbi et al., 2025).

However, despite the advantages of wider systems approaches to understanding how difficult public health challenges such as childhood obesity and school food are, pragmatism and a narrower focus might be needed to make progress in solving it. Systems theories can help us to understand the bigger picture and see where nutrition education, cooking skills and obesity

prevalence in children are situated. From an ecological systems perspective, proximal outcomes such as cooking skills and cooking confidence at the micro- and mesosystem levels may be the most appropriate primary focus for cooking research, while distal outcomes like dietary quality and obesity prevalence reflect longer-term influences across exosystemic and macrosystem layers.

It has been argued in this thesis that children's food skills are an essential environmental component of the bigger picture to influence the development of life-long healthy dietary habits. By designing high quality randomised controlled trials employing widely used validated measuring tools to operationalise a smaller number of these variables, it is possible to test new and existing nutrition education and cooking interventions to measure impact and compare the effects.

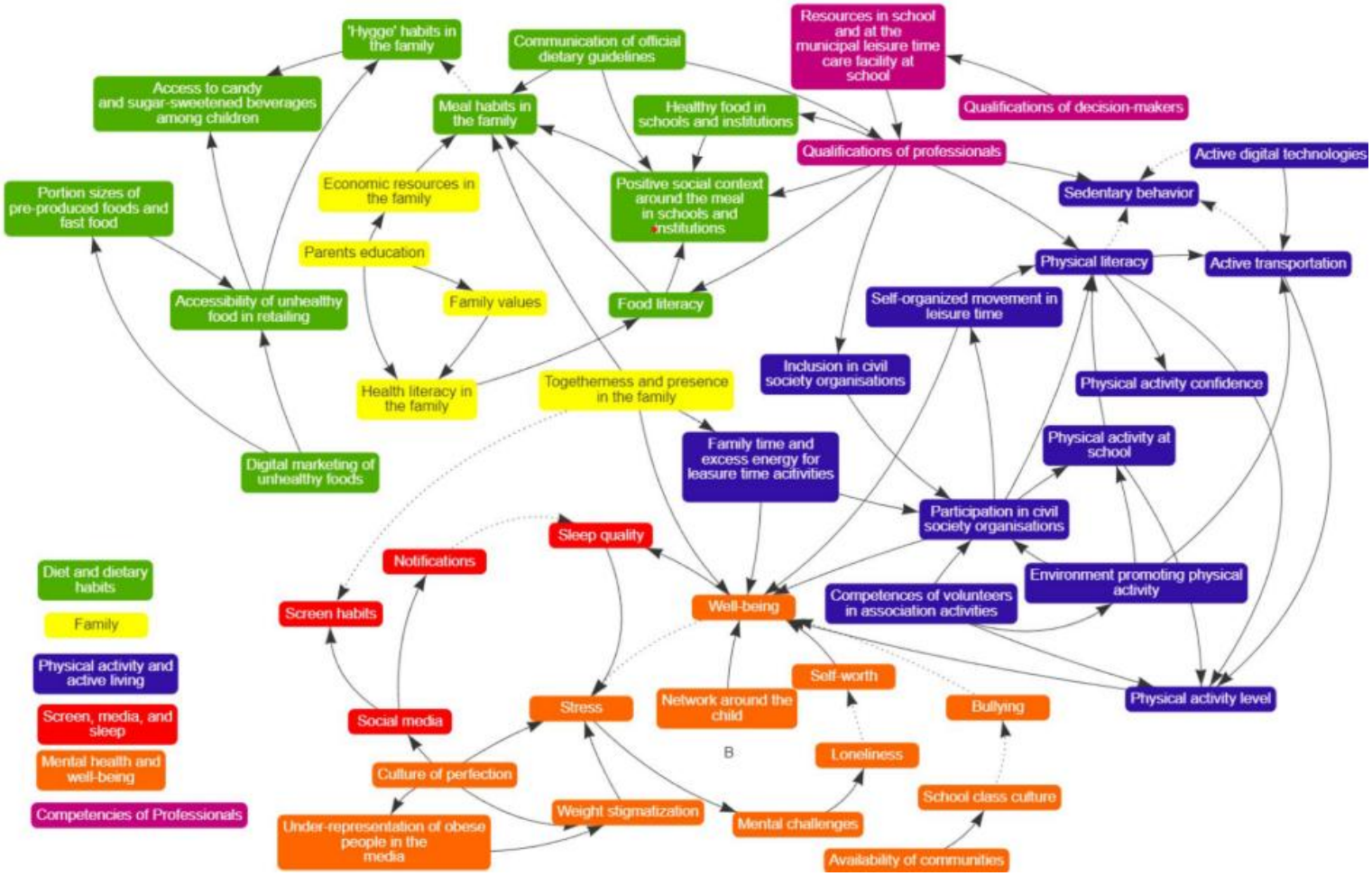


Figure 16 System map drivers of childhood obesity in Denmark- Figure 3 from (Ryom et al., 2025)

Pragmatic reflections on nutritional education research

Conducting this research has highlighted several practical considerations that may be useful for future studies in school settings. Piloting the Food Literacy Tool and Cooking Competence Survey demonstrated that paper-based formats were more appropriate for this age group, as children were still developing writing skills and teachers preferred paper administration. Although paper surveys increased researcher workload due to manual scoring and higher printing costs, they also enabled real-time checking for missing information, such as date of birth, which would have been more difficult with digital administration. In retrospect, attempting to administer these tools online would likely have introduced additional scheduling challenges and technological barriers for some schools.

Reflections on dietary assessment and recruitment also informed methodological learning. The paper-based CADET tool was less effective in the presence of researchers, with evidence of over-reporting, consistent with findings that online versions may reduce this bias. Future studies may therefore benefit from digital administration of CADET where feasible. In addition, the initial eligibility criterion requiring a minimum class size of 20 inadvertently excluded rural schools. Removing this requirement in future protocols would support more inclusive recruitment and ensure representation of diverse school contexts. These reflections highlight the value of pragmatic decision-making in school-based research and the importance of adapting methods to the realities of educational settings.

Critique of study strengths and methods

The strength of the systematic review is that 21 studies on cooking lessons in schools were examined for risk of bias, summary effects and certainty of evidence and meta-analysis was produced for cooking confidence and vegetable intake. The PhunkyFoods evaluation strengths were the pre-registered cluster randomised controlled trial methodology and successful recruitment of 26 schools and 631 child participants in North Yorkshire. This increased the power of the statistical analysis and narrowed the confidence intervals for the results. The strength of the COSI study was the collaboration with the World Health Organization COSI team on introducing the new

questions about food skills to the round 6 survey and the sample size of 19,736 participants from 8 countries. A further strength is that this is the first time the round 6 data has been used to examine the relationship between food preparation skills at school and at home and obesity risk for this age group.

Critique of potential limitations

The systematic review included quasi experimental studies to allow for sufficient studies and potential meta-analysis. The disadvantage of including quasi-experimental studies is the increased risk of bias and lower certainty of evidence. However, the advantages of including 21 studies and meta-analysis outweighed this.

In the PhunkyFoods trial, full blinding was not possible, as pupils and facilitators were necessarily aware of their participation in cooking and food literacy activities, increasing the risk of performance and detection bias (Phillips et al., 2022). A longer intervention period of 18 months for PhunkyFoods trial may have provided sufficient time to show an impact on the primary outcomes of food literacy and cooking skills. However, a pragmatic approach was taken to allow for sufficient time from start to completion so that this was possible to complete this within the time available for the PhD.

The COSI round 6 survey does not include validated tools for measuring cooking skills, since this was deemed impractical to implement the whole of the CooC7 tool. Instead, in 2021, 7 skills from this tool were identified as binary variables that could be used in a cross-sectional study in 2024, should this data later become available to the researcher. In hindsight, this was a good decision, since the COSI team agreed to add them to the round 6 survey, and agreed to share the data for analysis in 2024.

Policy implications: education and health

There are important policy implications for education and health from these findings. There is an urgent need to prioritise skills in the primary education curriculum, in particular food preparation skills. It has previously been mentioned that the recommendation from the World Cancer Research Fund is that the nutrition education and skills curriculum should be for 5 hours a week in primary and secondary schools (World Cancer Research Fund, 2023e) . This aspiration target equates to 195 hours a year, and such provision is likely to be

operationally unfeasible alongside other curriculum demands in England. However, a realistic and impactful target would be a minimum of 24 hours per year in Key Stages 1–3 devoted to food skills. This could be delivered as 12 x 2-hour lessons across the 39-week school year in England. Priority should be given to the preparation of savoury dishes using vegetables, including peeling, which has been shown to be associated with healthier dietary patterns.

The 2015 curriculum in the UK must be updated with reference to the work done on children's food skills by Dean et al. (Public Health England, 2015; Dean et al., 2021b; Dimbleby, 2021) and with recommendations by the World Cancer Research Fund (World Cancer Research Fund, 2023d; World Cancer Research Fund International, 2023). It is likely that a whole paradigm shift is needed in the primary curriculum in the UK to a skills model, to allow sufficient space in the curriculum for this to happen. For too long, the emphasis has been on knowledge and not on important life skills that can lead to healthy diets. This is at a health cost for children, whose obesity prevalence doubles from year 1 to year 6 in UK primary schools (NHS Digital, 2023).

Training for educators on nutrition in schools in England was rated poor by the NOURISHING policy index report (World Cancer Research Fund, 2023d). See Appendix E1. There is an additional need to provide the infrastructure to deliver this skills-based curriculum: teaching kitchens in primary schools and teacher training. The workforce in primary schools should be trained to teach and asses these food skills: washing, chopping, grating, measuring, weighting, peeling and mashing through key stage 1 and key stage 2, using the guidelines prepared by Dean et al. for age appropriate food preparation activities (Dean et al., 2021b).

It is also recommended that future rounds of COSI continue to use the food preparation skills questions at home and at school, with more countries choosing to add these optional questions.

Conclusions

This thesis has investigated nutrition education from 21 studies in children aged 5-12 years, evaluated the PhunkyFoods intervention in 26 UK primary schools and analysed the relationship between food preparation skills and obesity in children aged 6 – 9 years in 8 European countries. Whilst it is recognised that food skills, food literacy and fruit and vegetable intake are a small part of the wider picture for childhood obesity, the results of research projects in this thesis have shown that cooking classes for children can improve their skills and vegetable intake. However, there needs to be sufficient time in the primary school curriculum, at least 24 hours a year, every year throughout primary school education, to make a difference on these outcomes. The focus for lessons plans should be food preparation skills with vegetables, especially peeling. Policy makers in education and health responsible for primary school education are urged to review the curriculum to make sure that food preparation skills are given sufficient priority and monitoring in order to make progress on improving the diets of children and tackling childhood obesity.

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100g
Flour

Appendix A Chapter 2 Supplementary material

A1 Systematic Literature Review: concepts and search documentation

1. Cooking or food preparation or food technology or food literacy
2. Primary school or elementary school

OVID EMBASE search 26th January 2022		
1	(cooking or "food technology" or "food preparation" or "food literacy").tw.	19,971
2	cooking/	16,617
3	1 or 2	25,898
4	(primary school* or elementary school*).tw.	27,267
5	schools/	60,042
6	4 or 5	82,547
7	3 and 6	512
8	limit 7 to yr="2000 -Current"	495

OVID Medline search 21st January 2022		
1	(cooking or "food technology" or "food preparation" or "food literacy").tw.	19,492
2	Cooking/	13,527
3	1 or 2	27,086
4	(primary school* or elementary school*).tw.	24,918
5	Schools/	45,873
6	4 or 5	64,429
7	3 and 6	363
8	limit 7 to yr="2000 -Current"	308

EBSCO Cinahl search 26th January 2022		
S8	S7 Limiters - Published Date: 20000101-20221231	178
S7	S3 AND S6	188
S6	((MH "Schools, Elementary")) OR (S4 OR S5)	26,182
S5	(MH "Schools, Elementary")	5,356
S4	TX (primary school* or elementary school*)	26,182

EBSCO Cinahl search 26th January 2022		
S3	((MH "Cooking")) OR (S1 OR S2)	16,903
S2	(MH "Cooking")	8,552
S1	TX cooking or "food technology" or "food preparation" or "food	16,903

EBSCO ERIC search 26th January 2022		
S8	S3 AND S6 Limiters - Date Published: 20000101-20211231	214
S7	S3 AND S6	471
S6	S4 OR S5	126,928
S5	TX "primary school*" or "elementary school*"	126,928
S4	DE "Elementary Schools"	10,629
S3	S1 or S2	4,554
S2	(DE "Cooking Instruction") OR (DE "Foods Instruction") OR (DE "Nutrition Instruction")	3,509
S1	TX cooking or "food technology" or "food preparation" or "food	1,887

Appendix B Chapter 3 Supplementary material

B1 Logic Model for PhunkyFoods

Logic Model for PhunkyFoods

Problem (why?)	→	Intervention Description (what?)	→	Implementation Activities (how?)	→	Implementation Outcomes (how well?)	→	Final Outcomes (pupils, staff and parents)
School food environment ● School meals and packed lunches do not meet nutrition guidelines. ● School Food Policy does not promote a whole school approach to health. **Teachers** Teachers lack access to training, resources and confidence in teaching a relevant curriculum for food literacy and cooking skills.		**Active ingredient 1: Whole setting staff training** in the PhunkyFoods Programme , plus additional CPD opportunities available e.g., National Level 2 Award in Nutrition and Health of School Aged Children | Food Prep in the Classroom | Setting Up and Running a Cook Club. **Active ingredient 2: Whole Setting Audit** (Health Check) and action planning support around the Whole School Approach to Health. **Active ingredient 3: Policy Setting/Updating** e.g., Whole School Food Policy | Packed Lunch Policy.		**Training** ● Whole School staff training on the PhunkyFoods Programme. ● Individual teaching staff training to support CPD awards and accreditation. ● Skills training on food preparation delivery. ● Cooking skills and healthy eating workshops and training for parents. **Coaching** ● Modelling delivery of whole school activities and workshops. ● Coaching support for SLT and GB to update school food policy. ● Coaching for individual teachers for co-delivery of the classroom-based activities. ● Coaching support for pupils - Phunky AMBASSADORS.		**Short term (3 months)** *Fidelity:* ● Staff demonstrate willingness to engage in the Phunky Foods programme through active ingredients 1 – 2. *Acceptability:* ● School completed a Whole Setting Audit (health check). ● Whole school (or key stage) teaching staff have undertaken the training. *Reach:* • Whole school commitment to use PhunkyFoods curriculum and resources.		**Short term (3 months)** Increased confidence and competence of teaching staff in planning and delivery of healthy lifestyle activities through the active ingredients.

Logic Model for PhunkyFoods

Problem (why?)	→	Intervention Description (what?)	→	Implementation Activities (how?)	→	Implementation Outcomes (how well?)	→	Final Outcomes (pupils, staff and parents)
Students ● Public Health data (NCMP) shows that obesity levels double from Y1 to Y6 in Primary Schools[1]. ● Students lack food literacy, cooking skills, which leads to poor diet choices[2]. ● Diet choice behaviours contribute to poorer health outcomes.		**Active ingredient 4: Whole School Activities** e.g., assemblies, pupil workshops on a range of topics relating to Phunky FOOD (Eatwell guide, Strive for 5, Drain your Drinks, Bag-A-Breakfast, Top Teeth, A Healthy Lunch, Snack Attack, Food Waste), Phunky FIT (Get Active) and Phunky MINDS (Resilience, Feelings, Relationships, Anti-Bullying). **Active ingredient 5: Experiential curriculum or Classroom-based Activities[3]** e.g., D&T Scheme of Work | PSHE Scheme of Work | Topic Based Activities | PPA-solution (healthy eating and physical activity) | Phunky15 (physical activity) | Mindful Moments.		**Monitoring** ● Records of visits to schools. ● Action Plan monitoring through health checks. ● Activity record of parental engagement. ● Annual Schools Survey report. ● Evaluate all training and workshops.		**Medium term (6 – 18 months)** *Fidelity:* Staff show understanding of how to use the curriculum materials and can deliver healthy eating and physical activities to children using the resources. Embedded use of schemes of work in the curriculum (1 – 2 years). SLT agree to review and update the School Food Policy (active ing.3). School selects from optional active ingredients 4 – 8 for delivery. SLT identify staff for additional coaching support where appropriate. Acceptability Annual schools' surveys show the teachers are responding to the programme. Pupil surveys show high acceptability of the programme. *Reach:* All children in school receiving positive healthy lifestyle messages. Parents receiving positive communications about healthy lifestyle messages.		**Medium term (6 – 18 months)** ● Increased pupil engagement in food literacy curriculum. ● Increased pupil confidence in cooking skills and behaviours. ● Pupils show improved food choices at lunchtimes. ● Improved dietary behaviours of pupils. ● Support staff accredited. ● Parents engaged with healthy lifestyle messages and support children and the school culture and ethos of healthy lifestyles. ● Parents sending healthy lunch boxes to school.

[1] NHS DIGITAL. 2020. *National Child Measurement Programme, England 2019/20 School Year* [Online]. Available: https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/2019-20-school-year [Accessed].

[2] DIMBLEBY, H. 2021. National Food Strategy: The Plan. UK.

[3] CHARLTON, K., COMERFORD, T., DEAVIN, N. & WALTON, K. 2020. Characteristics of successful primary school-based experiential nutrition programmes: a systematic literature review. *Public Health Nutr*, 1-21.

Logic Model for PhunkyFoods

Problem (why?)	→	Intervention Description (what?)	→	Implementation Activities (how?)	→	Implementation Outcomes (how well?)	→	Final Outcomes (pupils, staff and parents)
Parents Obesity and overweight in the UK is increasing, particularly in families in areas of high deprivation. The dialogue between parents and schools in relation to health can be problematic and could be supported with facilitation. Some parents may not have access to recipes and confidence to cook nutritious meals at home. Family dietary attitudes, behaviours and priorities may need to change in order to improve health outcomes.		**Active ingredient 6: Extra-curricular Activities** e.g., Breakfast Club | Cookery Club | Gardening Club | After-schools Club. **Active ingredient 7: Student-Led Activities** e.g., Phunky AMBASSADORS (delivering key healthy lifestyle messages through peer-to-peer learning. **Active ingredient 8: Parent Engagement Activities**[4] e.g., Parent/Child Cook Clubs | Parent Workshops | Parent Stay and Play Sessions | Parent Health Promotion Events | Parent Communication Material (newsletter text; email snippets; display assets).		**Education materials** ● Resources e.g., giant floor playmats (Eatwell Guide | Eat A Rainbow), food models, flashcards, storybooks with healthy eating themes, music/songs with healthy eating themes, activity workbooks (Social History of Food; Religion and Food). ● Online portal access to curriculum and extra curricula resources to support active ingredients. ● Online website access to recipes.		**Long term (2+ years)** *Fidelity:* ● Whole school commitment to delivering healthy eating and physical activities across all key stages using the embedded schemes of work and curriculum activities. ● School committed to working with parents with high quality parent engagement activities planned throughout the year. ● SLT has updated the School Food Policy and is actively monitoring to ensure that School Food Environment meets national nutritional guidelines. ● Phunky AMBASSADORS programme embedded in school.		**Long term (3-5 years)** Reduction in Y6 childhood obesity and overweight measured by NCMP.

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B2 Child Consent examples for evaluation of PhunkyFoods

UK Food Literacy Survey BASELINE – Key Stage 2

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Key Stage 2 Food Literacy Survey

This survey is part of a research project with Phunky Foods and the University of Leeds. The questions are based on academic research about Food Literacy[1]. We want to find out about food literacy for children at Primary Schools. No individual names will be used as part of our research. We anonymise the data using individual numbers instead of names so that no person can be identified.

Please put a tick in the box if you are happy for this survey to be used for research. ☺ ☐

About you

Name of your school: ☐

Your name: ☐

	Day	Month	Year
What is your date of birth?			

What school year are you in now? ☐

	Day	Month	Year
What is today's date?			

UNIVERSITY OF LEEDS

Key Stage 2 Child Survey – cooking skills

This survey is part of a research project with Phunky Foods and the University of Leeds. The questions are based on academic research on cooking skills[1]. We want to find out about food literacy and cooking skills for children at Primary Schools. No individual names will be used as part of our research. You can ask a teacher to help you to complete this survey.

Please put a tick in the box if you are happy for this survey to be used for research. ☺ ☐

About you

Name of your school: ☐

Your name: ☐

What is your date of birth? Day ☐ Month ☐ Year ☐

What school year are you in now? ☐

What is today's date? Day ☐ Month ☐ Year ☐

School of Food Science and Nutrition
Faculty of the Environment

UNIVERSITY OF LEEDS

Cooking in Yorkshire

CONSENT FORM FOR HEAD TEACHERS

Declaration of Consent	Please circle either YES or NO
1. I have read and understood the information sheet entitled 'Headteacher Information Sheet – Cooking in Yorkshire Project, and I have had a chance to discuss the study and to ask questions.	YES / NO
2. I have had satisfactory answers to all of my questions.	YES / NO
3. Who has explained the study to you?	
4. In acting for my school, I understand that I am free to withdraw from engaging from the study: At any time. Without having to give a reason.	YES / NO
5. I understand that the research depends on opt-out consent from parents/guardians and permit the study to go ahead on this basis.	YES / NO
6. If I have any questions or concerns about the research, I know I can contact Dr Charlotte Evans via email C.E.L.Evans@leeds.ac.uk	YES / NO
7. I accept the terms and conditions of this study and consent that the research, as described, be undertaken with the cooperation of my school.	YES / NO

8. HEAD TEACHER
Signature of Head
Name (BLOCK LETTERS)

9. INVESTIGATOR
I have explained the study to the named Head Teacher and they have indicated their willingness to allow the study to take place with the cooperation of their school.
Signature of Investigator.....
Date.....
Name (BLOCK LETTERS) .....KAREN VAUGHAN
Date.....

This project was reviewed by the Ethics Committee at the University of Leeds and approved on 30th August 2021: AREA 21-011

School of Food Science and Nutrition
Faculty of the Environment

UNIVERSITY OF LEEDS

Parent information Sheet

Cooking in Yorkshire Project	Parent Information Sheet

It is important to be aware of information that is provided by the Department of Food Science about the general terms and conditions that apply with respect to the processing of personal data. Please consult:- ***Privacy Notice for Research***

1) Background

The University of Leeds would like to invite you to allow your child take part in the following research project, which is a Randomised Control Trial design.
Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or you would like further information.
Please note that if, in the course of our study, we discover something that raises concerns about your child's safety or the safety of others, we are obliged to seek further expert help and advice.

2) What is the purpose of the study?

The purpose of the study is to find out how the PhunkyFood programme impacts on dietary habits, nutrition knowledge and cooking skills for children in primary schools. Research shows that good nutrition and maintaining a healthy weight in childhood helps to prevent obesity and diet-related ill health later in life.

3) Why is my child being invited to take part?

Your child has been chosen to participate because we are recruiting Key Stage 2 children in schools that are starting the PhunkyFoods programme either in May 2022 or May 2023.

4) Do I have to agree to allow my child to be tested?

No, participation is optional. If you decide that you would like your child to be part of the study, you do not need to do anything. You can opt out of the study by contacting the school via telephone or email. If you change your mind at any point during the study, you will be able to withdraw your child's participation without having to provide a reason.

5) What will my child be asked to do?

Your child will be asked to complete two fun surveys about food and cooking twice: once in March 2022 and once in March 2023.

6) Where will the research sessions take place?

Research will take place at school. Every effort will be made to ensure that the research sessions are as enjoyable and relaxed as possible for the children. The surveys are designed for children and the class teacher or researcher will be available to help read out any questions in the survey if needed. It will take around 50 minutes in total.

Cooking in Yorkshire Project	Parent Information Sheet

7) Who will run the testing sessions?

Your child's class teacher, a member of the Research Team or a PhunkyFoods facilitator will hand out the surveys for children to complete in classroom.

8) What will parents be asked to do?

For all the participating children in the study, we would like to collect information from parents to help us understand more about the sample. We would like to invite you to complete a food diary about the eating habits of your child (taking ~10 minutes in total). We will ask you to complete this food diary twice: once in March 2022 and again in March 2023.

9) Will you share my child's data with 3rd parties?

No. Data will be accessible to the Research Team at the University of Leeds only.

Audio recordings

There will be no audio recordings made.

10) Will you transfer my child's data internationally?

No.

11) Will my child be identified in any research outputs?

No.

12) Questions or concerns

If you have any questions about this information sheet or concerns about how your child's data is being processed, please contact Dr Charlotte Evans.

Contact Details: Dr Charlotte Evans
School of Food Science
G11 Stead House, University of Leeds, Leeds LS2 9JT
E-mail:

This project was reviewed by the Ethics Committee at the University of Leeds and approved on 30th August 2021: AREA 21-011

Appendix C Chapter 4 Supplementary material

C1 Key Stage 2 Food Literacy Survey

UK Food Literacy Survey FollowUp – Key Stage 2

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Key Stage 2 Food Literacy Survey

This survey is part of a research project with Phunky Foods and the University of Leeds. The questions are based on academic research about Food Literacy[1]. We want to find out about food literacy for children at Primary Schools. No individual names will be used as part of our research. We anonymise the data using individual numbers instead of names so that no person can be identified.

Please put a tick in the box if you are happy for this survey to be used for research. ☺ ☐

About you

Name of your school:	
Your name:	
What is your date of birth?	Day / Month / Year
What school year are you in now?	
What is today's date?	Day / Month / Year

[1] Amin SA, Lehnerd M, Cash SB, Economos CD, Sacheck JM. Development of a Tool for Food Literacy Assessment in Children (TFLAC). J Nutr Educ Behav. 2019 Mar;51(3):364-369. doi: 10.1016/j.jneb.2018.12.006. PMID: 30851841.

Food Literacy Survey: Student Instructions

Hello,

Thank you for agreeing to complete the Food Literacy Survey!

What is Food Literacy?

Food literacy is the knowledge and skills you use every day to make choices about food. This includes cooking, gardening, eating, and more.

How to Take this Survey

Read each question and mark the answer that you think is correct. If you have a question, please raise your hand.

After the Survey

There are 34 questions in the survey. After you are finished turn your survey back to the front page facing up and wait for further instructions.

Questions #1-3: There are many skills needed to cook and prepare the food we eat every day. Please circle the answer based on whether you can do each skill "all by yourself", "with a little help", "with a lot of help", or "not at all".

1. **I can use a knife to cut up food into smaller pieces, like cutting a cucumber or carrot into slices**
   a) All by myself
   b) With a little help
   c) With a lot of help
   d) Not at all

2. **I can crack an egg into a bowl**
   a) All by myself
   b) With a little help
   c) With a lot of help
   d) Not at all

3. **I can use a measuring jug to measure ingredients, like milk or flour**
   a) All by myself
   b) With a little help
   c) With a lot of help
   d) Not at all

Questions #4-6: Which kitchen tool is used for each activity? Please circle the kitchen tool that matches each description.

On Page 5, you will find pictures of each kitchen tool to help you answer these questions.

4. Picks up hot food safely.

a) Oven glove

b) Chopping board

c) Peeler

d) I don't know

5. Removes skin from fruit or vegetable.

a) Spoon

b) Spatula

c) Peeler

d) I don't know

6. Rinses food and drains liquid from solid food.

a) Peeler

b) Colander or strainer

c) Measuring jug

d) I don't know

Pictures of kitchen tools to help you answer questions #4-6.

Food safety is how we protect the foods we eat every day from germs, like bacteria and viruses, that can make people sick.
Please answer questions #7-9 about Food Safety:

7. **To make sure that the foods we eat are safe, which of the following should be clean before cooking? Circle all the items below that should be clean before cooking.**

   a) Hands

   b) Chopping board

   c) Floor

   d) Cooking utensils (like a spatula or wooden spoon)

   e) I don't know

8. **Some foods are only safe to eat if they have been cooked first. Circle all the foods below that should be cooked first before eating.**

   a) Oranges

   b) Raw chicken

   c) Carrots

   d) Cheese

   e) Eggs

   f) I don't know

9. **Circle True or False:**

When preparing meals, raw meats (like raw hamburger) should not touch other foods (like salad or fruit) until the raw meat has been cooked.

True **OR** False

10. You are choosing foods to put in your lunch bag or on your lunch tray. For the main meal and two side dishes, circle the option (a OR b) that would make the <u>healthiest</u> meal.

Main Meal (circle a OR b)

a. Pepperoni pizza OR b. Turkey sandwich on brown bread

Side Dish 1 (circle a OR b)

a. Sweet potato fries OR b. Broccoli

Side Dish 2 (circle a OR b)

a. Apple slices OR b. Chocolate pudding

11. Oscar is a Year 6 student who would like to buy a snack from the shop near his school before he gets on the bus at the end of the day. Which snack would be the <u>healthiest</u> for Oscar to choose? (<u>circle ONE</u>)

a) Cheese and onion crisps

b) Oatmeal raisin cookie

c) Carrot sticks

d) Crackers

e) I don't know

12. An adult is taking you to a restaurant for dinner and asks you what you would like to drink. Which would be the healthiest drink to order (<u>circle ONE</u>)

a) Water

b) Fizzy drink (like Coke or Sprite)

c) Diet fizzy drink (like Diet Coke or Sprite Zero)

d) Lemonade

e) I don't know

13. Which of the following things are not needed for a fruit or vegetable to grow?

a) Soil

b) Sunlight

c) Water

d) Garden tools

e) I don't know

Questions #14-16: The vegetables we eat every day come from different parts of vegetable plants.

Draw a line to match each vegetable to the plant part it comes from.

14. Broccoli

Root

15. Carrot

Leaves

16. Spinach

Flowers

Questions #17-19: Some foods come from animals.

Draw a line to match each food listed below to the animal that it comes from.

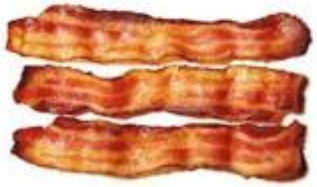
17. Honey

Pigs

18. Cheese

Cows

19. Bacon



Bees

Supply Chain

20. Harriet is a Year 4 student who lives in the city and likes to eat eggs for breakfast. What are the steps an egg goes through to get Harriet's breakfast plate?

Draw a line to match up steps 1 – 5 to the picture that describes each step. Remember, the picture that comes first is step 1.

STEP 1

The carton of eggs travels to the supermarket or shop.

STEP 2

Harriet or a family member purchases the eggs.

STEP 3

A hen lays an egg at a farm.

STEP 4

Harriet or someone in her family cooks the egg to eat.

STEP 5

The eggs are washed and packaged in a carton.

Finding Nutrition Information

21. A box of cereal has a lot of information and pictures on it. Where on the box below would you find the best source of information about how healthy the food is?

a) On the front of the box

b) On the side of the box

c) I don't know

Front of Box

Side of box

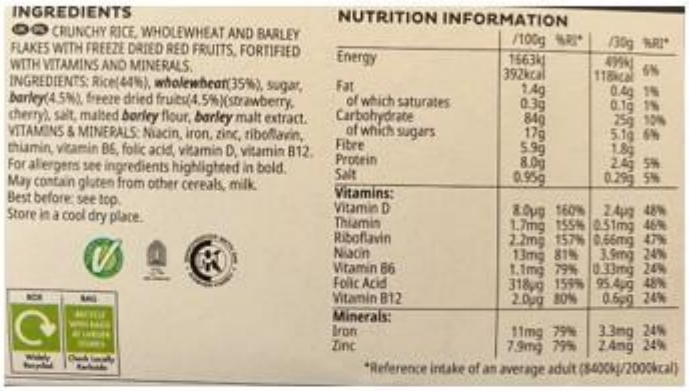
22. It is recommended that you eat foods that are low in sugar. Based on the Nutrition Fact labels of two different cereal packets shown below, circle which one is lower in sugar.

a) Cereal packet A

b) Cereal packet B

c) I don't know

Cereal A



INGREDIENTS

CRUNCHY RICE, WHOLEWHEAT AND BARLEY FLAKES WITH FREEZE DRIED RED FRUITS, FORTIFIED WITH VITAMINS AND MINERALS.

INGREDIENTS: Rice(44%), ***wholewheat***(35%), sugar, ***barley***(4.5%), freeze dried fruits(4.5%)(strawberry, cherry), salt, malted ***barley*** flour, ***barley*** malt extract.

VITAMINS & MINERALS: Niacin, iron, zinc, riboflavin, thiamin, vitamin B6, folic acid, vitamin D, vitamin B12.

For allergens see ingredients highlighted in bold.

May contain gluten from other cereals, milk.

Best before: see top.

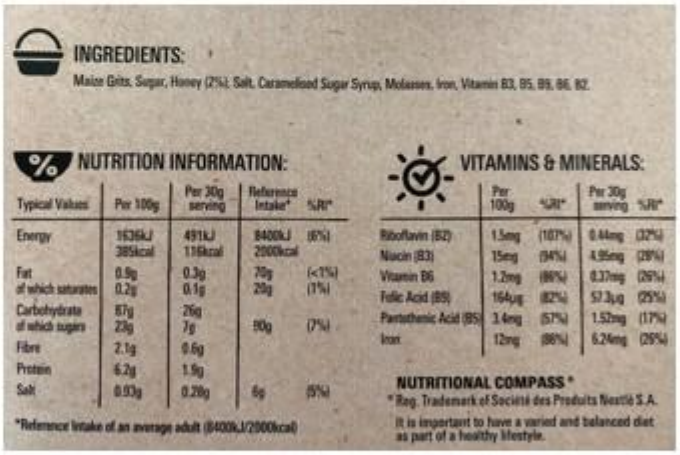
Store in a cool dry place.

NUTRITION INFORMATION

	/100g	%RI*	/30g	%RI*
Energy	1663kJ 392kcal		499kJ 118kcal	6%
Fat	1.4g		0.4g	1%
of which saturates	0.3g		0.1g	1%
Carbohydrate	84g		25g	10%
of which sugars	17g		5.1g	6%
Fibre	5.9g		1.8g	
Protein	8.0g		2.4g	5%
Salt	0.95g		0.29g	5%
Vitamins:				
Vitamin D	8.0µg	160%	2.4µg	48%
Thiamin	1.7mg	155%	0.51mg	46%
Riboflavin	2.2mg	157%	0.66mg	47%
Niacin	13mg	81%	3.9mg	24%
Vitamin B6	1.1mg	79%	0.33mg	24%
Folic Acid	318µg	159%	95.4µg	48%
Vitamin B12	2.0µg	80%	0.6µg	24%
Minerals:				
Iron	11mg	79%	3.3mg	24%
Zinc	7.9mg	79%	2.4mg	24%

*Reference intake of an average adult (8400kJ/2000kcal)

Cereal B



INGREDIENTS:

Maize Grits, Sugar, Honey (2%), Salt, Caramelised Sugar Syrup, Molasses, Iron, Vitamin B3, B5, B9, B6, B2.

NUTRITION INFORMATION:

Typical Values	Per 100g	Per 30g serving	Reference Intake*	%RI*
Energy	1536kJ 365kcal	491kJ 116kcal	8400kJ 2000kcal	(6%)
Fat	0.9g	0.3g	70g	(<1%)
of which saturates	0.2g	0.1g	20g	(1%)
Carbohydrate	87g	26g		
of which sugars	23g	7g	90g	(7%)
Fibre	2.1g	0.6g		
Protein	6.2g	1.9g		
Salt	0.93g	0.28g	6g	(5%)

*Reference intake of an average adult (8400kJ/2000kcal)

VITAMINS & MINERALS:

	Per 100g	%RI*	Per 30g serving	%RI*
Riboflavin (B2)	1.5mg	(107%)	0.44mg	(32%)
Niacin (B3)	15mg	(94%)	4.95mg	(28%)
Vitamin B6	1.2mg	(86%)	0.37mg	(26%)
Folic Acid (B9)	164µg	(82%)	57.3µg	(25%)
Pantothenic Acid (B5)	3.4mg	(57%)	1.52mg	(17%)
Iron	12mg	(86%)	6.24mg	(26%)

NUTRITIONAL COMPASS *

* Reg. Trademark of Société des Produits Nestlé S.A.

It is important to have a varied and balanced diet as part of a healthy lifestyle.

Food and Your Body

23. Circle the best answer. The energy you get from eating healthy foods helps you to _____.

a) Move and play

b) Build muscles and bone

c) Keep your heart pumping blood

d) All of the above

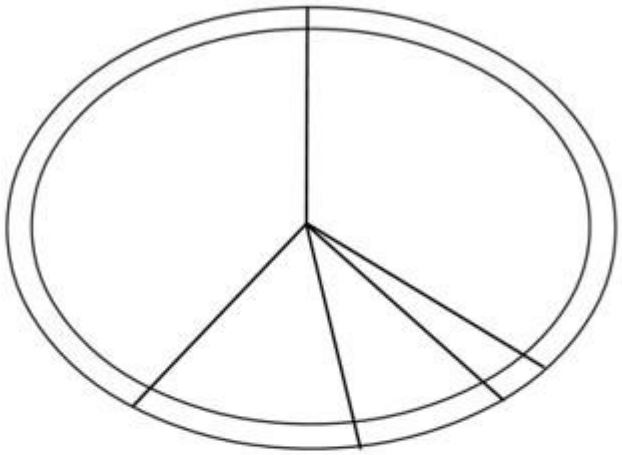
e) I don't know

Food Groups

Questions #24-29: To stay healthy, it is important that we eat foods from five different food groups. Please draw a line to match each food below with their food group.

24. Banana	Does not fit in a food group
25. Grilled chicken	Vegetable
26. Green beans	Dairy
27. Brown bread	Carbohydrate
28. Cheese	Protein
29. Fruit-flavoured sweets	Fruit

30. A healthy meal should have a variety of foods from the five food groups. One of the best ways to plan a healthy meal is to be sure which of the food groups makes up 1/3 (a third) of your plate?



a) Dairy

b) Carbohydrate

c) Protein

d) Fruit and vegetables

e) I don't know

Eating with friends and family

Questions #31-34: Circle the letter to choose whether you think that you could do the following things to eat more fruit and vegetables.

31. **For meals and snacks at home I can try a vegetable that an adult serves me.**
    a) I think I can do this.
    b) I am not sure I can do this.
    c) I don't think I can do this.

32. **For meals and snacks at home I can try a fruit that an adult serves me.**
    a) I think I can do this.
    b) I am not sure I can do this.
    c) I don't think I can do this.

33. **When eating lunch with a friend I can eat fruit even if my friend is not.**
    a) I think I can do this.
    b) I am not sure I can do this.
    c) I don't think I can do this.

34. **When eating lunch with a friend I can eat vegetables even if my friend says they are "yucky".**
    a) I think I can do this.
    b) I am not sure I can do this.
    c) I don't think I can do this.

STOP! You have finished taking the survey. Thank you! Please turn this survey over with the front page facing up and wait until an adult gives more instructions.

C2 Key Stage 2 Child Survey Cooking Skills

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Key Stage 2 Child Survey – cooking skills

This survey is part of a research project with Phunky Foods and the University of Leeds. The questions are based on academic research on cooking skills[1]. We want to find out about food literacy and cooking skills for children at Primary Schools. No individual names will be used as part of our research. You can ask a teacher to help you to complete this survey.

Please put a tick in the box if you are happy for this survey to be used for research. ☺ ☐

About you

Name of your school: ☐

Your name: ☐

What is your date of birth? Day ☐ Month ☐ Year ☐

What school year are you in now? ☐

What is today's date? Day ☐ Month ☐ Year ☐

[1] Dean, M., Issartel, J., Benson, T., McCloat, A., Mooney, E., McKernan, C., Dunne, L., Brennan, S. F., Moore, S. E., McCarthy, D., Woodside, J. V., & Lavelle, F. (2021). CooC11 and CooC7: the development and validation of age appropriate children's perceived cooking competence measures. The International Journal of Behavioral Nutrition and Physical Activity, 18(1), 20–20. https://doi.org/10.1186/s12966-021-01089-9

COOKING SKILLS SURVEY

Question 1

This child is washing vegetables. Do you do this?

□ Yes
□ No

Question 2

A is really good at washing

B is not that good at washing

Which are you MOST like?

□ I am a lot like A
□ I am a little like A
□ I am a bit like A and B
□ I am a little like B
□ I am a lot like B

Question 3

This child is stirring/mixing ingredients. Do you do this?

□ Yes

□ No

Question 4

A is not that good at stirring/mixing

B is really good at stirring/mixing

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

Question 5

This child is mashing. Do you do this?

□ Yes
□ No

Question 6

A is really good at mashing

B is not that good at mashing

Which are you MOST like?

□ I am a lot like A
□ I am a little like A
□ I am a bit like A and B
□ I am a little like B
□ I am a lot like B

Question 7

This child is measuring liquids. Do you do this?

□ Yes
□ No

Question 8

A is not that good at measuring liquids

B is really good at measuring liquids

Which are you MOST like?

□ I am a lot like A
□ I am a little like A
□ I am a bit like A and B
□ I am a little like B
□ I am a lot like B

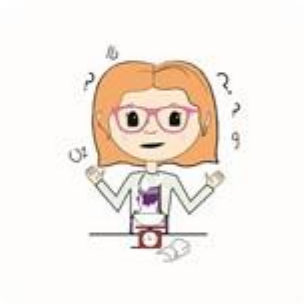
Question 9

This child is weighing ingredients. Do you do this?

□ Yes
□ No

Question 10

A is really good at weighing



B is not that good at weighing

Which are you MOST like?

□ I am a lot like A
□ I am a little like A
□ I am a bit like A and B
□ I am a little like B
□ I am a lot like B

Question 11

This child is chopping. Do you do this?

□ Yes
□ No

Question 12

A is not that good at chopping

B is really good at chopping

Which are you MOST like?

□ I am a lot like A
□ I am a little like A
□ I am a bit like A and B
□ I am a little like B
□ I am a lot like B

Question 13

This child is grating. Do you do this?

□ Yes

□ No

Question 14

A is really good at grating

B is not that good at grating

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

Question 15

This child is peeling. Do you do this?

□ Yes

□ No

Question 16

A is not that good at peeling

B is really good at peeling

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

Question 17

This child is using a tin opener. Do you do this?

□ Yes

□ No

Question 18

A is really good at using a tin opener

B is not that good at using a tin opener

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

Question 19

This child is using the oven. Do you do this?

□ Yes

□ No

Question 20

A is not that good at using the oven

B is really good at using the oven

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

Question 21

This child is using the stove/hob. Do you this?

□ Yes

□ No

Question 22

A is really good at using the stove/hob

B is not that good at using the stove hob

Which are you MOST like?

□ I am a lot like A

□ I am a little like A

□ I am a bit like A and B

□ I am a little like B

□ I am a lot like B

You have finished!

C3 CADET fruit and vegetables home diary

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CADET: Child and Diet Evaluation Tool *Fruit and Vegetables*	Home Diary

This diary belongs to:

Name:	
Year Group:	
School:	
Today's date:	

Dear Parent or Carer,

This diary will record the amount of fresh fruit and vegetables that your child eats for 24 hours - from 9am today to 9am tomorrow.

- All you need to do is to tick the fruit and vegetables your child eats at home and at school.
- If you child ate with someone else after school, ask your child or your child's carer what they ate and tick if fruit and vegetables if they were consumed.

HOW TO FILL IN THE CADET FRUIT AND VEGETABLES DIARY

- Starting with the column headed "**Lunch (at school)**" ask your child what they ate at school and tick all the fruit and vegetables that they consumed for lunch that day.
- In the column headed "**Before tea (after school)**" tick all the fruit and vegetables that your child eats after finishing school today until their evening meal.
- In the column headed "**Evening meal/tea**", tick all the fruit and vegetables your child had for their evening meal.
- In the column headed "**After tea/during night**" tick all the fruit and vegetables your child had after their evening meal and during the night.
- In the column headed "**Breakfast/before school**", tick all the items of fruit and vegetables your child had at home before going to school the following morning.
- Make sure you ask your child if she/he ate any fruit or vegetables between leaving school and getting home. (if your child attended an after-school club, you should tick any fruit or vegetables your child consumed).

There are some additional questions that we would like you to complete at the end of the diary (page 6). When the diary is completed, please make sure it is placed in your child's bag and sent back to school in the envelop provided.

Here are some examples of how to fill in CADET.

Oscar had some cucumber on a sandwich at school so his mum ticked ☑ this food in the column '**Lunch (at school)**'

M	VEGETABLES & BEANS	Lunch (at school)	Before tea (after school)	Evening meal / tea	After tea / during night	Breakfast / before school
1	Cucumber	✓				
2	Tomatoes					

Oscar had a banana when he got home from school so his mum ticked ☑ the column '**Before tea (after school)**'

N	FRUIT	Lunch (at school)	Before tea (after school)	Evening meal / tea	After tea / during night	Breakfast / before school
1	Apple					
2	Pear					
3	Banana		✓			

Now complete the diary on pages 4 - 5 and questions on page 6

N	FRUIT	Lunch (at school)	Before tea (after school)	Evening meal / tea	After tea / during night	Breakfast / before school
1	Apple	☐	☐	☐	☐	☐
2	Pear	☐	☐	☐	☐	☐
3	Banana	☐	☐	☐	☐	☐
4	Orange, satsuma etc.	☐	☐	☐	☐	☐
5	Grapes	☐	☐	☐	☐	☐
6	Melon	☐	☐	☐	☐	☐
7	Pineapple	☐	☐	☐	☐	☐
8	Strawberry, raspberry etc.	☐	☐	☐	☐	☐
9	Peach, nectarine, plum, apricot, mango	☐	☐	☐	☐	☐
10	Kiwi	☐	☐	☐	☐	☐
11	Fruit salad (tinned or fresh)	☐	☐	☐	☐	☐
12	Other fresh fruit	☐	☐	☐	☐	☐
13	Dried fruit	☐	☐	☐	☐	☐

M	VEGETABLES & PULSES	Lunch (at school)	Before tea (after school)	Evening meal / tea	After tea / during night	Breakfast / before school
1	Cucumber	☐	☐	☐	☐	☐
2	Tomatoes	☐	☐	☐	☐	☐
3	Celery	☐	☐	☐	☐	☐
4	Coleslaw	☐	☐	☐	☐	☐
5	Other salad vegetables, e.g. lettuce	☐	☐	☐	☐	☐
6	Stir-fried vegetables	☐	☐	☐	☐	☐
7	Broccoli, brussel sprouts, cabbage	☐	☐	☐	☐	☐
8	Carrots	☐	☐	☐	☐	☐
9	Cauliflower	☐	☐	☐	☐	☐
10	Peas, sweetcorn	☐	☐	☐	☐	☐
11	Mixed vegetables	☐	☐	☐	☐	☐
12	Celeriac / swede	☐	☐	☐	☐	☐
13	Peppers, red, green, yellow etc.	☐	☐	☐	☐	☐
14	Other vegetables	☐	☐	☐	☐	☐
15	Baked beans	☐	☐	☐	☐	☐
16	Lentils, Dahl	☐	☐	☐	☐	☐
17	Other beans	☐	☐	☐	☐	☐
18	Seeds, e.g. sunflower, sesame	☐	☐	☐	☐	☐

The following questions are about what you and your child think about eating fruit and vegetables. Please tick the closest answer.

		Yes always	Yes, most days / often	Sometimes	Seldom	Never
1	We nearly always have different kinds of fruit at home.	☐	☐	☐	☐	☐
2	How often do you buy specific fruit / vegetables because your child asks for them?	☐	☐	☐	☐	☐
3	How often do you cut up fruit and vegetables for your child to eat between meals?	☐	☐	☐	☐	☐
4	I eat fruit / vegetables every day.	☐	☐	☐	☐	☐
5	How often do you eat fruit / vegetables together with your child?	☐	☐	☐	☐	☐
6	Do you have to persuade your child to eat fruit / vegetables?	☐	☐	☐	☐	☐
7	How often do you have to ask your child to eat their fruit or vegetables?	☐	☐	☐	☐	☐

Thank you very much for completing the CADET fruit and vegetables diary. Please place the completed diary in the envelope provided and return to the school office.

C4 Intervention Delivery Additional Information

Of the 13 intervention schools, 12 completed the staff training and 11 completed the health check and action planning activities. Five schools went beyond the first two 'active ingredients' and undertook a review of school policies on school food and packed lunches.

Eleven out of thirteen schools participated in the Phunky Ambassadors programme, which involved mentoring pupils to deliver key healthy lifestyle messages through peer-to-peer learning. Twelve out of 13 schools participated in whole school assemblies and pupil workshops on a range of topics relating to PhunkyFoods. Examples of whole school activities were: 'food waste', 'drain your drinks', 'snack attack' and 'strive for 5'. For the 'food waste' topic in one school, year 5 (children aged 9 – 10 years) ambassadors were trained on food waste and delivered a presentation to the whole school via an assembly. The ambassadors then led a food waste audit across the whole school in one day and provided a summary report on their findings in another assembly. In another school, year 5 ambassadors delivered an assembly on 'drain your drinks' and the importance of good hydration, the comparisons of sugar content in certain drinks and what this means for health. The 'strive for 5' assembly was delivered by year 5 ambassadors for a whole school on the importance of eating 5 portions of fruit and vegetables per day and pupils were encouraged to "eat a rainbow" of different coloured fruits and vegetables. The 'snack attack' message was delivered in some schools in whole assemblies with ambassadors trained to deliver the key messages about the amount of sugar children should have as well as learning about recommended healthy snacks that could be eaten from the UK Eatwell Guide [1].

Twelve schools participated in the experiential curriculum classroom-based activities with healthy eating topics, for example 'supercrunch', 'strive for 5', 'healthy lunches' and cooking tasks linked to the religious education curriculum. In one school, year 5 ambassadors were involved in delivering a parent engagement session in a year 1 (children aged 5 – 6 years) class. This included an introduction to the Eatwell and Strive for 5 messages and demonstrating safe chopping techniques. The 'healthy lunches' classroom activity involved a recap on healthy lunches messages from assembly and

demonstration of safe chopping skills. Children made a healthy bagel in the shape of a face snack using cream cheese and prepared vegetables. In one school, world curriculum topics were linked to cookery sessions in the classroom and this included making South Asian foods such as samosas, aloo chaat, ranoli fruit patterns and mango lassi. In these classroom sessions, ingredients were linked back to the UK Eatwell Guide and children developed their food preparation skills using the claw and bridge cutting technique[2].

Seven schools participated in an afterschool cooking club delivered by the EDCs, most often this included parents. In one school the club ran for four weeks and different families attended each week. Families worked together to make pizza dough and chop ingredients to put on the pizzas. Another school had a cook club that ran for four weeks for year 5/6 children (aged 9 – 11 years), during which children developed their cutting, measuring, grating, peeling and kneading skills and followed recipes to make pizza, spring rolls, bread and orange shortbread. In one school six families attended four weekly sessions (involving 12 children and 10 adults each week) and made “dare devil” and super salmon dips with vegetable and pitta snacks, vegetable pizzas, bread rolls and tuna cous cous salad. At another school, seven families attended four weeks of cook club and made recipes to facilitate a wide range of different skills to be practiced: the bridge and claw safe cutting technique, weighing, measuring, mixing, peeling grating and kneading. For more information about the recipes, see the Supplementary Materials and the PhunkyFoods website.

1. England N. The Eatwell Guide. 2022 [updated 29 November 2022]; Available from: https://www.nhs.uk/live-well/eat-well/food-guidelines-and-food-labels/the-eatwell-guide/.

2. PhunkyFoods. Knife Skills: BRIDGE. YouTube2020.

Appendix D Chapter 5 Supplementary material

D1 Correspondance with World Health Organization

COSI Team for addition of survey questions

UNIVERSITY OF LEEDS

WHO Collaborating Centre for Nutritional Epidemiology
School of Food Science and Nutrition,
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Leeds LS2 9JT

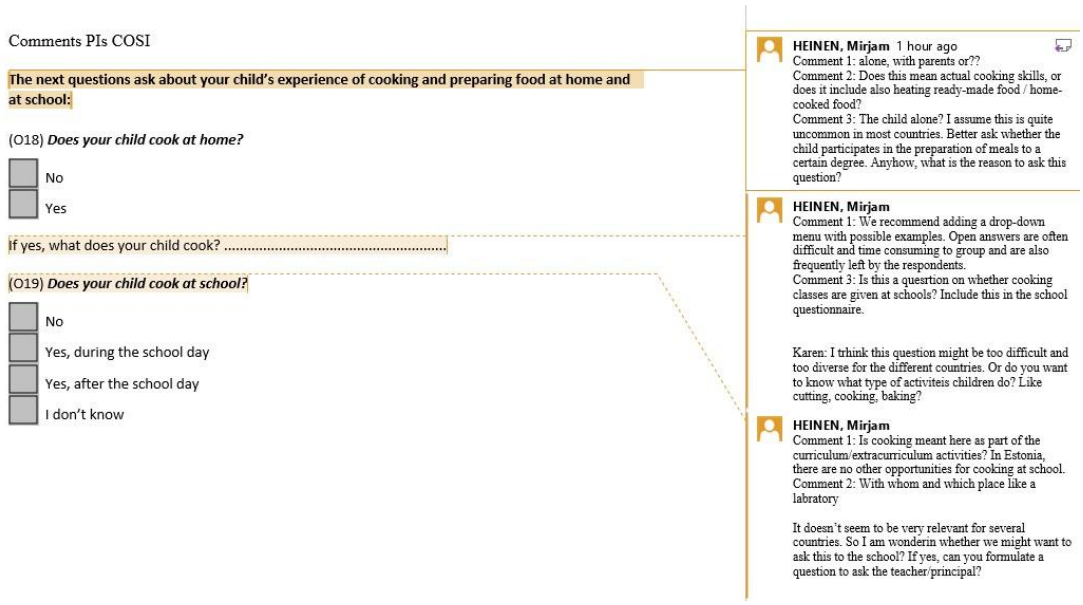
Mirjam Heinen
WHO European Office for Prevention and
Control of Noncommunicable Diseases (NCD Office)
Moscow, Russian Federation

5th September 2021

Dear Mirjam

Many thanks for your response to the proposed additional COSI questions that I sent on the 7th of July. These are very helpful comments and I appreciate you and your colleagues taking the time to consider them. I hope the following addresses all the issues raised.

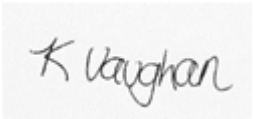
Comments on initial questions



Response

As you suggest, I propose that we ask **the school** about the type of nutrition education that the school provides, rather than the parents. This could be after the existing question 12, which asks if the curriculum includes nutrition education. It would be interesting to find out which countries offer sensory education for nutrition education as this has been shown to increase fruit and vegetable intake (Nekitsing et al., 2019; Chawner and Hetherington, 2021).

I have also re-worded the parent questions and added a drop-down menu, as suggested, with appropriate food preparation skills for children aged 6 – 7 years (Dean et al., 2021a). There is a concern that due to the changing food environment, and availability of convenience food high and fat salt and sugar, many children are not learning the food preparation skills that will enable them to cook nutritious meals using fresh ingredients (World Health Organization, 2020a; Dimbleby, 2021a). The reason to ask if children are helping with food preparation at home is that this may lead to them to be more interested in food and help them to develop their cooking skills (Dean et al., 2021c; Dimbleby, 2021a). It would be interesting to explore which countries are teaching young children food preparation skills and to test the hypothesis that this is associated with higher vegetable intake and lower obesity levels using the COSI survey data.



Kind regards, Karen.

Karen Vaughan MBA, MPA, MSc, MBPsS
PhD Student Researcher

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D2 Nutrition education questions on the Round 6 COSI School Record Form

Country			Year		School code			

WORLD HEALTH ORGANIZATION EUROPE	**SCHOOL RECORD FORM** **EUROPEAN** **CHILDHOOD GROWTH SURVEILLANCE** **INITIATIVE**	**COUNTRY LOGO/NAME**

INFORMATION ON SCHOOL ENVIRONMENT (continued)

(O11) **In your opinion, how safe are the routes to and from school for most pupils to walk or ride a bicycle?** ***(Please circle the appropriate number)***

Extremely safe *Extremely unsafe*

1 2 3 4 5 6 7 8 9 10

(M7) **Does your school curriculum include nutrition education, either given as a separate lesson or integrated into other lessons?**

◯ Yes (*If you answered 'Yes', please proceed to question O12*)

◯ No (*If you answered 'No', please proceed to question M8*)

(O12) **If yes, tell us what type of nutrition education your school provides** *(tick all items that apply)*

◯ Healthy eating information

◯ Tasting of fresh fruit and vegetables

◯ Learning food preparation skills (e.g. weighing, grating, mashing, washing, chopping, peeling, measuring).

◯ Other *(please specify)* _____

D3 Food preparation questions on the Round 6 COSI Family Record Form (O20 and O21)

Childhood Obesity Surveillance Initiative
Data collection procedures

Country	Year	School	Gr	Cl	Child code

The next questions ask about your child's experience of preparing food at home.

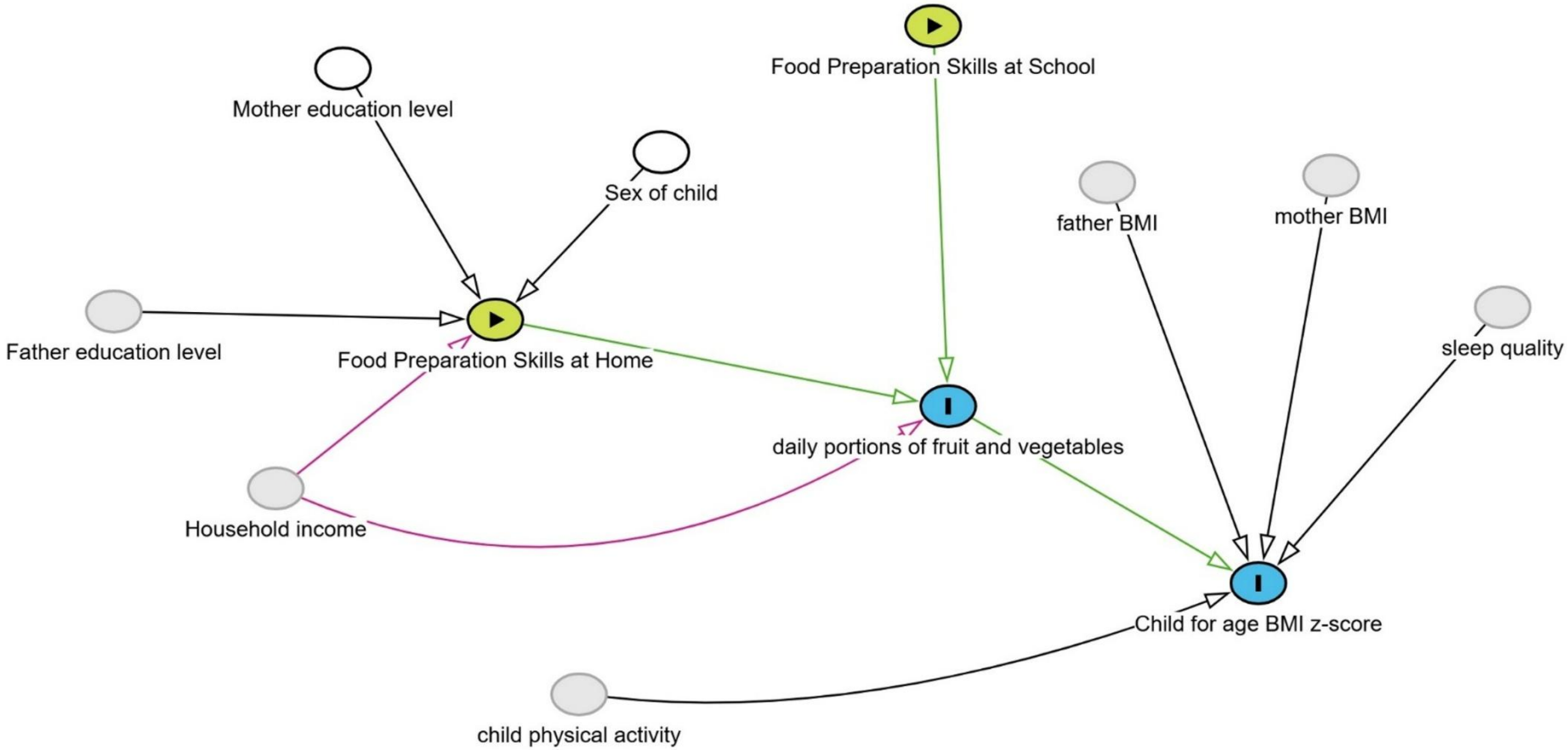
(O20) **Does your child help to prepare family meals at home?**

- ◯ No (*if no, please proceed to question O22*)
- ◯ Yes (*if yes, please proceed to question O21*)

(O21) **If yes, please tell us about the food preparation activites that your child helps with at home** *(please, tick all items that apply)*

- ◯ Weighing
- ◯ Grating
- ◯ Mashing
- ◯ Washing
- ◯ Chopping
- ◯ Peeling
- ◯ Measuring

D4 Directed Acyclic Graph for COSI Cooking Study



D5 Data definitions for variables and sample size included

Variable	Number	Level	Description	Values	Measurement
Obesity	19,428	Individual	Outcome variable – has obesity or not calculated from BMI-for-age z-score (≥ +2 SD from WHO growth reference)	0 = no,1 = yes	Dichotomous
Daily fruit and vegetable intake	19,398	Individual	Outcome variable with 5 ordered categories	1,2,3,4,5	Ordinal
Group mean centred food skills at home	13,708	Individual	Predictor variable – group mean centred from total food skills at home. Original ordinal scale for total food skills at home scored 0,1,2,3,4,5,6,7.	-3.9 to 5	Scale
Weighing	13,708	Individual	Predictor variable – binary, weighs at home or not	0 = no,1 = yes	Dichotomous
Grating	13,708	Individual	Predictor variable – binary, grates at home or not	0 = no,1 = yes	Dichotomous
Mashing	13,709	Individual	Predictor variable – binary, mashes at home or not	0 = no,1 = yes	Dichotomous
Washing	13,708	Individual	Predictor variable – binary, washes at home or not	0 = no,1 = yes	Dichotomous
Chopping	13,708	Individual	Predictor variable – binary, chops at home or not	0 = no,1 = yes	Dichotomous
Peeling	13,708	Individual	Predictor variable – binary, peels at home or not	0 = no,1 = yes	Dichotomous
Measuring	13,709	Individual	Predictor variable – binary, measures at home or not	0 = no,1 = yes	Dichotomous
Food skills at school	14,432	School	Predictor variable – binary, school provides practical food skills education or not	0 = no,1 = yes	Dichotomous
Group mean centred mother's education level	18,761	Individual	Confounding variable – group mean centred from mother's education level. Original ordinal scale for mother's education level scored 1,2,3,4,5.	-3.58 to 3.3	Scale
Sex	19,736	Individual	Confounding variable – male or female	1 = boys, 2 = girls	Dichotomous

D6 Covariates not used

Variable	Number	Level	Description	Values	Measurement
Minutes of play at the weekend	16,941	Level 1	Confounding variable. Minutes of play at the weekend.	0 to 520	Scale
Group mean centred minutes of play at the weekend	16,941	Level 1	Confounding variable – group mean centred from minutes of play at the weekend. Original minutes of play at the weekend – no ordered categories information available.	-306.39 to 352.11	Scale
Earnings	10,410	Level 1	Confounding variable. categories ordered from highest 1 to lowest 4. 1 = we easily pass the month with our earnings. 2 = We pass the month without serious problems with our earnings. 3 = We have trouble meeting the ends of month with our earnings. 4 = We barely meet the ends of the month with our earnings.	1 to 4	Ordinal
Group mean centred earnings	10,410	Level 1	Confounding variable – group mean centred from Earnings.	1 to 3.78	Scale
Minutes of PE at school	17,441	Level 2	Confounding variable of minutes of PE classes each week provided by the school – no ordered categories information available.	0 to 450	Ordinal
Mother's BMI	13,632	Level 1	Confounding variable	11 to 64	Scale
Father's BMI	12,326	Level 1	Confounding variable	9 to 63	Scale

D7 STROBE Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Appendix 3
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-9
		(*b*) Describe any methods used to examine subgroups and interactions	n/a

	Item No	Recommendation	Page No.
		(*c*) Explain how missing data were addressed	8, 20
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	10
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Appendix 3
Outcome data	15*	Report numbers of outcome events or summary measures	16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14,16
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	12--20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21

	Item No	Recommendation	Page No.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23

Appendix E Chapter 6 Supplementary material

E1 Nutrition policy status in England, NOURISHING policy index, May 2023

Nutrition policy status in England

NOURISHING policy index
May 2023

This country snapshot presents detailed results of the **NOURISHING policy index** [1] for England. It highlights strengths and weaknesses in the design of national government nutrition policies. This snapshot supplements the policy index results with an in-depth look at the quality of policy design in each country. Full policy index results are outlined in the NOURISHING policy brief, which compares England to 29 other European countries.

Main messages

1. England takes a comprehensive approach to national nutrition and diet-related policy actions by implementing policies across the ten policy areas of the NOURISHING framework. Two policy areas received a good assessment: limits or removal of specific nutrients in food products (I1), and increasing public awareness of healthy eating through communication campaigns and social marketing based on food-based dietary guidelines (I2).
2. Within policy areas, weaknesses and gaps were identified in advertising and marketing unhealthy foods to young people, including in or around schools and through point-of-sale measures, product packaging or sponsorship (R). Further, lack of measures targeting the food and drinks available in the immediate vicinity of schools and to limit sugar-sweetened beverage provision in schools impacted otherwise well-designed food standards on food available in schools (O). More can be done to strengthen existing rules and incentives to improve the retail environments (S), as well as to improve nutrition education in schools for teachers and health professionals (G).
3. Greater attention should be given to improving food system coherence with health by strengthening public food procurement policies (H) as a poor assessment was achieved. Improvements should be made in advertising to young people (R), nutrition advice and counselling in healthcare settings (N2) and nutrition education and skills (G) beyond a fair assessment.

Overview of policy status

NO POLICIES IDENTIFIED | POOR | FAIR | MODERATE | GOOD | EXCELLENT

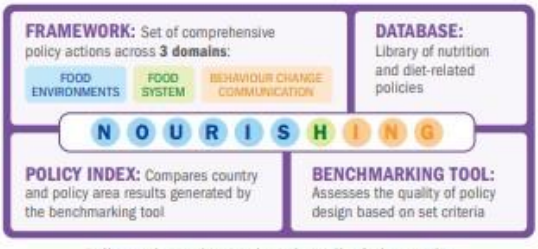
N	Nutrition label standards and regulations on the use of claims and implied claims on food	MODERATE
O	Offer healthy food and set standards in public institutions and other specific settings	MODERATE
U	Use economic tools to address food affordability and purchase incentives	MODERATE
R	Restrict food advertising and other forms of commercial promotion	FAIR
I	Improve nutritional quality of the whole food supply	GOOD
S	Set incentives and rules to create a healthy retail and food service environment	MODERATE
H	Harness supply chain and actions across sectors to ensure coherence with health	POOR
I	Inform people about food and nutrition through public awareness	GOOD
N	Nutrition advice and counselling in healthcare settings	FAIR
G	Give nutrition education and skills	FAIR

This snapshot is based on national level policies only, which include UK-wide and England-only policies issued by the UK government. Policies issued by provincial, regional or local governments are outside the scope of this project. Page 2 highlights which policy areas assess UK-wide or home nation policies.

Methods

TThe NOURISHING policy index methods are fully explained in the associated **policy brief**. In short, the policy index combines values for a) policy presence, and b) policy design for 41 benchmarks.

The benchmarks are applied to policies in the **NOURISHING database** [2], collected through a comprehensive scan in 30 European countries, including England.



Policy tools used to produce the policy index results

* Policy actions assessed include UK-wide policies

Nutrition policy status in England

Breakdown of policy index results

(For full details on the policy design criteria, consult the policy brief)

✕ No policy identified	Meets up to 75% of policy design criteria
Meets up to 25% of policy design criteria	Meets up to 99% of policy design criteria
Meets up to 50% of policy design criteria	Meets all aspirational standards

N	Nutrients on back of pack*	Meets up to 50% of policy design criteria
	Front of pack labels*	Meets up to 99% of policy design criteria
	Warning labels	✕
	Rules on nutrient claims	Meets up to 99% of policy design criteria
	Rules on health claims*	Meets up to 99% of policy design criteria
O	Food and drink available in schools, including restrictions on unhealthy foods	Meets up to 99% of policy design criteria
	Measures relating to sugar-sweetened beverage provision in schools	✕
	Fruit and vegetables initiatives in schools	Meets up to 75% of policy design criteria
	Food and drink available in immediate vicinity of schools	✕
	Unhealthy food in out-of-education locations	Meets up to 99% of policy design criteria
U	Health-related food taxes or tariffs	Meets all aspirational standards
	Income related subsidies or initiatives to increase affordability and accessibility of healthy food	✕
	Targeted subsidies or initiatives to increase affordability and accessibility of healthy food	Meets up to 75% of policy design criteria
R	Marketing to young people through advertising*	Meets up to 75% of policy design criteria
	Direct marketing to young people*	Meets up to 75% of policy design criteria
	Marketing through sponsorship to young people	✕
	Marketing to young people through point of sale measures	✕
	Marketing to young people through product placement and branding	Meets up to 75% of policy design criteria
	Marketing to young people through product design and packaging*	✕
	Marketing in/or around schools	✕
I	Limit or removal of specific nutrients in food products*	Meets up to 99% of policy design criteria

S	Planning restrictions regarding food service outlets around schools	Meets up to 75% of policy design criteria
	Planning restrictions on food service outlets	Meets up to 50% of policy design criteria
	Initiatives to increase the availability of healthier food in stores and food service outlets	Meets up to 50% of policy design criteria
H	Measures to support food producers to increase healthy food and decrease unhealthy food in the supply chain	✕
	Measures to support food manufacturers to increase healthy food and decrease unhealthy food in the supply chain	✕
	Measures to support food retailers to increase healthy food and decrease unhealthy food in the supply chain	✕
	Governance structures for multi-sectoral/stakeholder engagement*	Meets up to 50% of policy design criteria
	Nutrition standards for public procurement	Meets up to 75% of policy design criteria
	Supporting urban agriculture in health and planning policies	✕
	Community food production	✕
I	Development and communication of food-based dietary guidelines*	Meets up to 75% of policy design criteria
	Public awareness, mass media and informational campaigns and social marketing on healthy eating*	Meets up to 75% of policy design criteria
N	Nutrition advice and counselling in primary care	Meets up to 75% of policy design criteria
	Nutrition advice and counselling in school healthcare setting	✕
G	Nutrition education in curricula	Meets up to 75% of policy design criteria
	Training for educators	Meets up to 25% of policy design criteria
	Training for health professionals	✕
	Cooking skills	Meets up to 75% of policy design criteria
	Training in schools in growing food	✕
	Training for caterers	✕

Note: The policy landscape in any country evolves over time. These findings reflect our knowledge as of May 2023. To see latest results and for further technical information on the policy indexes, please consult our website: **wcrf.org/our-policy-work**. For feedback or suggested updates, please email **policy@wcrf.org**. More info in the CO-CREATE project can be found at **co-create.eu**

[1] Policy index: **wcrf.org/nutrition-policy-index** [2] Policy database: **policydatabase.wcrf.org**

World Cancer Research Fund International

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CO-CREATE